Genoveva Vargas-Solar
EDITOR

CRITICAL FACTORS IN INDUSTRY 4.0

A Multidisciplinary Perspective

El Colegio de Chihuahua
Institución Pública de Investigación y Posgrado

Calle Partido Díaz 4723
Colonia Progresista, C.P.32310,
Ciudad Juárez, Chihuahua, México
Tel. 52 6566390397

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Coordinación editorial: E. Liliana Chaparro Vielma
Corrección: Carolina Caballero Covarrubias
Cubierta y diagramación: Karla María Rascón González

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Prologue

This book is a compilation of works that present different perspectives associated with Industry 4.0 in the organizational environment in Mexico and the world. Research on the maquiladora industry—the main economic activity in Ciudad Juárez—predominates, nonetheless, *Critical Factors in Industry 4.0: a Multidisciplinary Perspective* also addresses topics on Small and Medium Enterprises (SMEs) and in particular research associated with the future perspective of human capital, focusing on labor contexts, social responsibility, technology transfer, systems for competitiveness, human resources development, among other concepts associated with Smart Manufacturing, Industrial Internet of Things (IoT) and Industry 4.0.

Critical Factors in Industry 4.0: a Multidisciplinary Perspective consists of 21 chapters of research findings of the influence the maquiladora industry has on the citizens of Ciudad Juárez. Although the topics of the contributions are varied, they can be grouped into generic classifications such as: Human Capital, Industry 4.0, Organizational Productivity and Competitiveness.

The significance of the human factor within the maquiladora industry is presented throughout the first chapters. These chapters propose practices such as the development of a career and life plan in order to improve the employee's potential and meet organizational objectives more efficiently. The book shows an analysis of the influence of emotional intelligence and leadership on employee turnover, as well as the precariousness of employment in terms of instability, social protection and low salaries suffered by workers today. Finally, under the same Industrial topic, the authors expose how poor management decisions affect job motivation, role stress and job satisfaction.

The chapters: "Design of a rotating prototype for arm enhancement on an exoskeleton", "Intelligent Humidifier for Humidity Control in a Smart City using IoT and Type-2 Fuzzy Logic", "Essential factor in the survival of high-tech SMEs: Relational capital in the Machining Industry of the Juárez", "Chihuahua, Future determination of programmed obsolescence and how to determine future paradigm shifts in Generation Z technology consumption factors using an innovative metaheuristics", "Side Effects of the 4.0 Industry on Generation Y: A review of technological changes from an automotive labor perspective at Continental in Ciudad Juárez", "Automatic recognition for models of detection of arachnid bites in images through the use of Deep Learning", are associated with the welfare of the working age population and their expectations in their jobs regarding professional satisfaction and performance relationship in Industry 4.0. In these chapters, a solution based on AmI and Implementation of a Convolutional Neural Network for the detection of avian pests in citrus crops using smart drone propose the practice of Corporate Social Responsibility (CSR) and Lean Manufacturing (SM) philosophies as opportunities to increase market competitiveness. This group of authors focus on an analysis of the results of applying CSR in Small and Medium Enterprises, taking into consideration the large number of this type of companies in Mexico. On the other hand, in reference to Lean Manufacturing, or LEM, the purpose of the research is to show the advantages it provides to companies so that it is conceived not only as a tool, but also as an important business advantage.

The book closes with chapters associated with applications to improve the life of the population in a Smart City. The story of The history of a goldsmith-type manufacturing style that has perished addresses two aspects that are fundamental to the survival and growth of the companies: technological development and innovation in the maquiladora industry. In the first case, the Innovation Capacity Index is taken as a basis, an evaluation of this system is proposed in order to determine an adequate method to classify the level, innovation and development in the industry. On the other hand, on the subject of service quality, the authors present the case study of an organization under the paradigm of a Smart City with the purpose of making the company aware of the type of service it is providing and what are the possible improvements to it.

More than a compendium of knowledge, this book offers an original, dynamic and precise tour that allows the reader to access the social, environmental and economic issues derived from administrative actions. *Critical Factors in Industry 4.0: a Multidisciplinary Perspective* shows the Ciudad Juarez-El Paso border as a strategic place for business activity, exhibiting a place conducive to socioeconomic, political and tourism growth where various stakeholders do their best to contribute to the economy of both the region and the country.

Jack Welch mentions that "Management is about managing in the short term, while developing long term plans". Thus, this work intends to show specific solutions in the organizational area of Industry 4.0 without overlooking the long term, leaving evidence in the theoretical contribution that may be of vital importance to future generations. The process of information gathering, review, joint work, and document correction results in a work that methodologically can be replicable to other areas of knowledge. This information will undoubtedly be of great help for management specialists. As Henry Mintzberg (internationally renowned management expert) once said, "Organizational management focused on Industry 4.0 is, above all, a practice where art, science and innovation of technology meet".

I hope that whether by reference, recommendation or simple coincidence, the reader may find this research useful, enjoy it, and that it may inspire them to find a solution to the problems that Industry 4.0 present these days.

Dr. Alberto Ochoa
Compiler

CHAPTER 1

Smart Industry: The 4.0 Data Centric Revolution[1]

Genoveva Vargas-Solar[1,5,*], José Luis Zechinelli-Martini[3,5], Javier A. Espinosa-Oviedo[4,5]

[1]University Grenoble Alpes, CNRS, Grenoble INP, LIG, France1 [3]Fundación Universidad de las Américas Puebla, Mexico [4] University of Lyon [3], France [5]French Mexican Laboratory of Informatics and Automatic Control

**Corresponding author: genoveva.vargas@imag.fr*

Abstract Industry 4.0 integrates technologies and concepts related to cyber-physical systems and the Internet of Things (IoT) that monitor industrial systems and manufacturing processes letting them communicate and cooperate in real time. The virtuous integration of communication and information technologies (ITC), together with connected (robotic) machines (IoT) and industrial processes leads to smart industry. Indeed, in smart industry sensing systems monitor physical entities to collect data and create a virtual copy of the physical world (i.e., digital twin or "datified version) to make

1 This project was done and funded by the FP 7 project CASES https://cordis.europa.eu/project/id/29493, as part of a collaboration with the Nanjing Aeronautics and Astronautics University and the Southeast University in Nanjing, China.

decentralized and automatized decisions. This chapter discusses the type of data produced within smart industry, the way it is collected from robotic and connected entities and how it can be used for (semi) automatizing industrial manufacturing processes running in flow shops. It introduces the architecture of a service based smart flow shop based on communication and software layers that integrate physical entities. Each physical entity is seen as an intelligent and autonomous service that embeds programs for letting it evolve in manufacturing flow shops implementing industrial processes. Thus, the physical world composed of connected things and the digital universe consisting of computing, storage and memory resources are combined for automatizing and possibly optimizing complex industrial interconnected processes and thereby making factories smart.

Keywords: Industry 4.0; digital twin; datification; smart industry, smart manufacturing, manufacturing as a service

Introduction

Industry 4.0 (or the fourth industrial revolution) is a collective term embracing a number of contemporary automations, data exchange, and manufacturing technologies[2]. According to Industry 4.0, industrial production will be characterized by the strong personalization of products produced under highly flexible (large series) production conditions. In order to achieve this flexible and personalization of industrial production, manufacturing facilities need to use production planning and scheduling systems to increase productivity, reduce production costs, save energy, and reduce emissions CO_2 emissions. For example, in Siemens3 (Siemens, 2021), Volkswagen laboratories4 (Volkswagen Industry 4.0, 2021) the boss, and her employees watch every aspect of the industrial process through tablets and only intervene when problems arise. The virtuous integration of communication and information technologies (ITC) together with connected (robotic) machines (IoT) as in AWS IoT, 2021, and industrial processes leads to smart industry. In smart industry, sensing systems monitor physical processes, collect data and create a virtual copy of the physical world, a “datified” version of it, to make decentralized and automatized decisions (Qi Q. et al., 2018) IoT is critical to the industry’s future. IoT describes the vast network of Internet-enabled devices that facilitate the transfer of information

2 https://en.wikipedia.org/wiki/Industry_4.0

3 https://theleadershipnetwork.com/article/benchmark-your-industry-4-0-transformation-against-siemens

4 https://www.volkswagen-newsroom.com/en/stories/industry-40-we-make-it-happen-4779

from one location to another. The Industrial Internet of Things (IIoT) represents a subset of the IoT (Qi Q. and Tao F., 2018). Having more widespread deployment of sensors and computer networks across the manufacturing sector an accumulation of data available for manufacturers' arises. Technology that digitalizes all the relevant entities in a company (IT, sensors, actuators, etc.), refers to digital twin (Grieves, M., 2014).

The concept of digital twin was first introduced by (Grieves, M., 2014). In general, virtual models of physical objects are created in a digital way to simulate their behaviors in real-world environments (Hochhalter J. *et al., 2018)*. Therefore, the digital twin is composed of three components: the physical entities in the physical world, the virtual models in the virtual world and the connected data that links the two worlds. The combination of digital twin and data opens the possibility of taking care of non-functional aspects like personnel from different areas, costs, etc. With this automatic management of industry based on collected data and online decision making, industrial processes become flexible and it is possible to modify processes to respond to new or very particular needs.

This chapter discusses the type of data produced within industrial processes running in smart industry flow shops, the way it is collected from robotic and connected entities and how it can be used for (semi) automatizing these processes. It introduces the architecture of a service based smart flow shop (manufacturing as a service) centered on communication and software layers that integrate physical entities. Each physical entity is seen as an intelligent and autonomous service that embeds programs for letting it evolve in smart factory flow shops implementing industrial processes. Thereby, the physical world composed of connected things and the digital universe consisting of computing, storage and memory resources are combined for automatizing—and possibly optimizing—complex industrial interconnected processes, thus, making factories smart.

Accordingly, the chapter is organized as follows: Section 2 characteristics of Industry 4.0 data, Section 3 discusses how data can contribute to designing a smart data centric factory as a result of approaches and strategies based on data science that address industrial processes data analytics and foresight. Moreover, it introduces concepts behind our cloud service-based smart factory, namely, (i) smart sustainable flow shop scheduling, (ii) flow shop as a service, and (iii) the simulator and proof of concept TigerFlow that we implemented. Section 4 discusses research and applied perspectives of Industry 4.0.

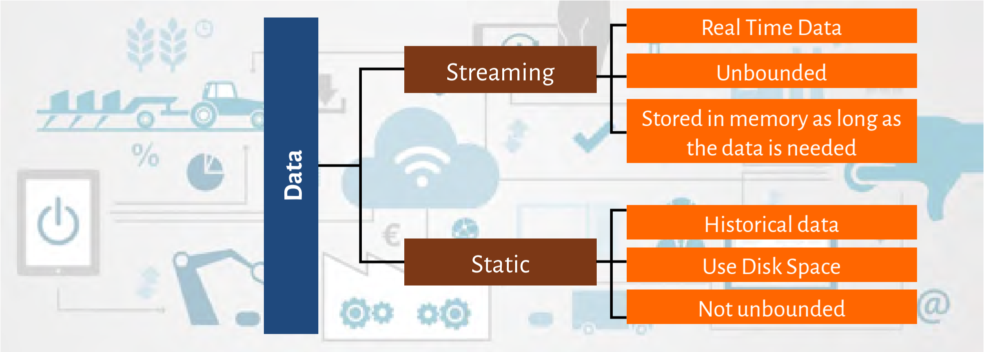
Data in Industry 4.0

Considering that Industry 4.0 involves trillions of physical facilities controlled by computing devices to collaboratively work together, the critical dimensions for a successful data centric automation of industrial processes requieres scalability, security, resiliency, and efficiency. With the extensive amount of data generated by the large number of heterogeneous devices, data management and analytics techniques are expected to play an important role. Thus, growing numbers of manufacturers are using data today to uncover hidden opportunities for improving their supply chain as well as for enhancing production efficiency and quality. Common examples of data centric applications include predictive analytics and control loop performance monitoring (CLPM) software as well as digital twin simulation solutions. These applications allow manufacturers to uncover hidden insights that have the potential for significant reliability and performance gains. Data is not limited to manufacturing in its use. In the context of Industry 4.0, large and increasing data sets are stored digitally and available for analysis. In manufacturing data refer to the data generated from the product lifecycle, such as design, manufacturing—which are also featured with V's properties—high volume (huge quantities of data), variety (the data itself comes in different forms and is generated by diverse sources), velocity (the data is generated and renewed at very high speed), and value (huge value hidden in the data). Manufacturing data generally concerns: (Qi Q. et al., 2018)

- Manufacturing resources, including: a) equipment data collected from smart factories by IoT technologies, with respect to the real-time performance, operating condition, etc., b) material and product data collected from themselves and service systems, such as performance, inventory and context of use, c) environmental data such as temperature, humidity, air quality etc.
- Management data from manufacturing information systems (e.g., manufacturing execution system (MES), enterprise resource planning (ERP), customer relationship management (CRM), supply chain management (SCM), product data management (PDM), computer aided systems e.g., computer aided design (CAD), computer aided engineering(CAE), and computer aided manufacturing (CAM). Such data include, designing scheme, order dispatch, material distribution, production planning, marketing and sales, service management, and finance, among other things.
- Internet data, including a) user data collected from the ecommerce platforms (e.g., Amazon, Walmart, and Taobao) and social networking platforms (e.g., Twitter, Facebook, LinkedIn, and YouTube) including users comments, preference, and behaviors, etc.; b) public data from open Web sites (e.g., governments and public service websites).

Data sets consist in any combination of structured and unstructured data types typically warehoused in databases and data lakes, other sources of unorganized, textual data like journal articles, internal wiki-articles and any image on the Internet. Lightening quick computers equipped with advanced analytical software are used to tap into these disparate data sources for the purpose of identifying non-obvious patterns and trends.

Figure 1 Data in Industry 4.0.



Source: Own elaboration adapted from literature.

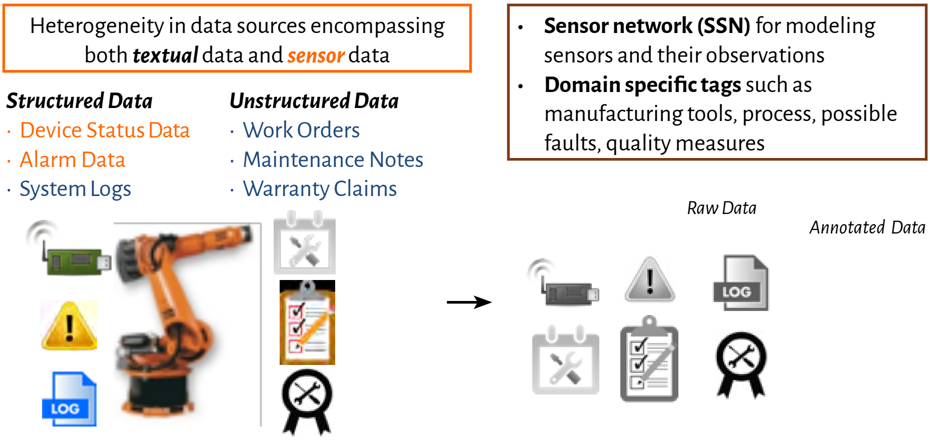
From a technical perspective, data in Industry 4.0—as in other smart environments—can be classified in static and streaming (see Figure 1). "Static data" refers to historical data and information produced as a result of the execution of business and industrial processes, occupying disk space and possible volume incrementation over time. "Streaming data" concerns continuous information collected in real-time from entities participating in industrial production processes, such as those produced by entities in shop floors. These type of data is characterized by their velocity, its volume and their variety. Diversity of collected information is caused by the heterogenous hardware transmission. Variety is now addressed by transforming data into pivot representations thanks to Internet of Things (IoT) platforms provided by vendors like Microsoft5 (Microsoft IoT hub, 2021), Amazon6 (AWS IoT, 2021), or Google7 (Google cloud IoT.

Streams are normally stored in memory as long as data is required and it is later backed up in storage supports. By all means, an intelligent strategy must be defined for each type of streams to achieve a balance between volume and data loss. In order to exploit data collected from the different entities in industrial organizations and pro-

5 https://azure.microsoft.com/fr-fr/services/iot-hub/
6 https://aws.amazon.com/iot-core/features/?nc1=h_ls
7 https://cloud.google.com/solutions/iot

cesses, it is important to study the data formats in which information is produced given the heterogeneity of data sources that creates textual and sensor signals. In general, the life cycle of data begins from it stemming raw from different producers with very simple structures. It later is transformed into annotated and processed data sets (Figure 2, cleaned, discretized, normalized, completed). Raw lowly structured data can refer to device status data, alarm data and system logs, whereas unstructured data include work orders, maintenance notes, warranty claims that are textual data.

Figure 2 *Data types produced and consumed in Industry4.0*



Source: *Own elaboration adapted from literature.*

Streams are transmitted through sensors interconnected by networks (SNN) that provide the communication platform that permits observations to be collected from their providers. Once raw data has been processed, they are tagged with domain specific annotations such as manufacturing tools and processes along with possible faults and quality measures. In Industry 4.0, industrial data silos range from ERP and industrial control systems to traditional documents, both digital (spreadsheets) and in paper format too. Silo issues need to be solved by people who understand the gaps, can formulate a strategy and fully comprehend the process. Therefore, they need data analytics algorithms that allow a higher production of services, as well as the optimization of processes in the support for decision-making in industries. These advanced analytics methods can make it possible to implement evidence and experience-based decision-making strategies, including adjusting industrial processes, policies, and evolving factories control and management to make them smart.

Data has an unprecedented impact on industrial processes like manufacturing processes, that include aspects such as (i) acceleration and optimization of product design; (ii) smart production planning; (iii) industrial process monitoring and their optimal and flexible control to make them reactive particularly in the presence of faults. Product design is shifted to data and analysis-driven design through the analysis of data about user behaviors and market trend. Therefore, analyzed data can help designers accurately quantify customer demands, translate customer voices to product features and quality requirements (Liu Y. et al., 2013). As a result, the product design is significantly accelerated and optimized. Data can also improve the planning speed and accuracy by enabling smart production planning. Based on the relationship of the global data (e.g., available resources and capacities information, material data, technological parameters, and constraints), the global and optimized planning program can be rapidly generated, improving the planning speed and accuracy. Real-time data enable process monitoring, so that the manufactures can keep track of the changes to develop optimal operational control strategies (Wang L. et al., 2004). Moreover, through data analysis, the product quality control and improvement are embedded into every step from raw material to finished product. An example of this is the early warning of quality defects, and rapid diagnosis of root causes of malfunctions, can be accomplished in real time to guarantee quality. Data changes passive industrial and manufacturing processes thanks to prediction (Kusiak A. et al., 2009). By collecting and analyzing massive data from smart devices or products, it is possible to monitor their current state, diagnose faults (Huo Z. et al., 2008) and optimize operation process for active preventive manufacturing (Wan J. et al., 2019).

Towards smart data centric factory

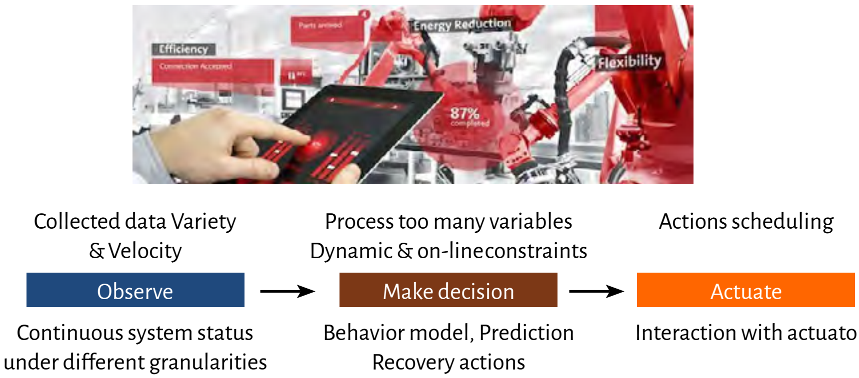
To a large extent, Industry 4.0 has been enabled by the collection of massive amounts of data, the development of advanced data applications and the nearly ubiquitous nature of the IIoT. With a futuristic orientation, Industry 4.0 is transitioning manufacturing to a semi, or fully, autonomous mode of operation. Production staff will increasingly be relieved of their responsibilities of performing unsafe physical and repetitive tasks. Industry 4.0 fosters a vision of the 'smart factory' that works according to three main components (see Figure 3):

1) Continuous observation of system status under different granularities as a result of collected data characterized by their variety and velocity.
2) Producing smart factory's behavior models, prediction of this behavior given specific internal and external events or situations and recovery actions. This

implies processing a great deal of variables taking into consideration dynamic and on-line constraints for developing timely decision making.

3) Interaction with actuators guided by scheduling actions to control the physical elements sitting in a smart factory where from the input of raw material to the output of finished products, the whole manufacturing process is managed and optimized through digital twin (Rosen R. et al., 2015)

Figure 3. *Autonomic smart factory.*



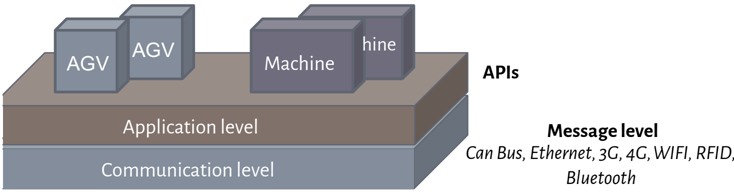
Source: *Own elaboration adapted from literature.*

Technically, a smart factory draws together:

- Cyber-Physical Systems: monitor physical processes, create a virtual copy of the physical world and make decentralized decisions.
- Internet of Things: objects communicate and cooperate with each other and with humans in real time.
- Internet of Services: internal and cross-organizational services are offered and utilized by participants of the value chain.

These technologies are put together into a general smart factory infrastructure architecture consisting in three levels as shown in Figure 4.

Figure 4 *Industry 4.0 general infrastructure stack*



Source: *Own elaboration adapted from literature.*

- Communication level: exposes the communication protocol, message structures, etc. In the case of smart factories, messages come from CAN buses, ethernet, 3G and 4G, Wifi, RFID and Bluetooth, which are all possible networks that interconnect physical entities composing a smart factory.
- Application level: abstracts the flow shop in term of entities, operation exposed by entities and the interaction among them.
- Smart factory connected physical entities for example machines and automated guidance vehicles (AGV) that can go through the physical space of a smart factory shop floors to take material from warehouses to machines and from one machine to the other.

Nonetheless, although data continues to flow across these layers, how could we synthesize actionable information from these data to enable intelligent decision making on time? The ultimate objective is to apply semantic, cognitive, and perceptual computing for deriving actional information to automate industrial processes with complex decision-making requirements and economic, time and quality performance objectives.

In the actual manufacturing execution stage, the real-time monitoring and adjustment of manufacturing process are realized through virtual-physical interaction and iteration (Xu, Li Da et al., 2019). The virtual models update themselves based on the data from the physical world, keeping track of the changes made. The problems are rapidly detected and the optimal solution is developed through simulation in virtual world. According to simulation in virtual workshop or factory, the manufacturing process is adjusted to achieve optimal manufacturing (e.g., accuracy, stability, high efficiency and product quality). To have insight of this general aim, we developed a solution for implementing a smart service-based flow shop based on data processing tools built within the FP7 CASES project (Tang D. et al., 2015). The objective was to propose a software-based architecture that can enable data collection, dissemination, processing, and analytics that can optimize flow-shop processes and that can dynamically handle exceptions. The virtual flow shop simulates and evaluates the different industrial strategies and planning until a satisfactory planning is confirmed.

Smart flow-shop scheduling

Flow shop scheduling is a class of scheduling problem with a workshop in which the flow control shall enable an appropriate sequencing for each job and for processing on a set of machines or with other resources *1, 2, ..., m* in compliance with given processing orders. Especially the maintaining of a continuous flow of processing tasks is desired with a minimum of idle time and a minimum of waiting time. Flow shop scheduling is a special case of job shop scheduling where there is strict order of all operations to be performed on all jobs. The scheduling problem can be stated as follows:

> *Given n machines and m jobs where each job contains exactly n operations. The i-th operation of the job must be executed on the i-th machine. No machine can perform more than one operation simultaneously. For each operation of each job, execution time is specified. Operations within one job must be performed in the specified order. The first operation gets executed on the first machine, then (as the first operation is finished) the second operation on the second machine, and so on until the n-th operation. Jobs can be executed in any order, however. The problem is to determine the optimal such arrangement, i.e., the one with the shortest possible total job execution makespan*[8].

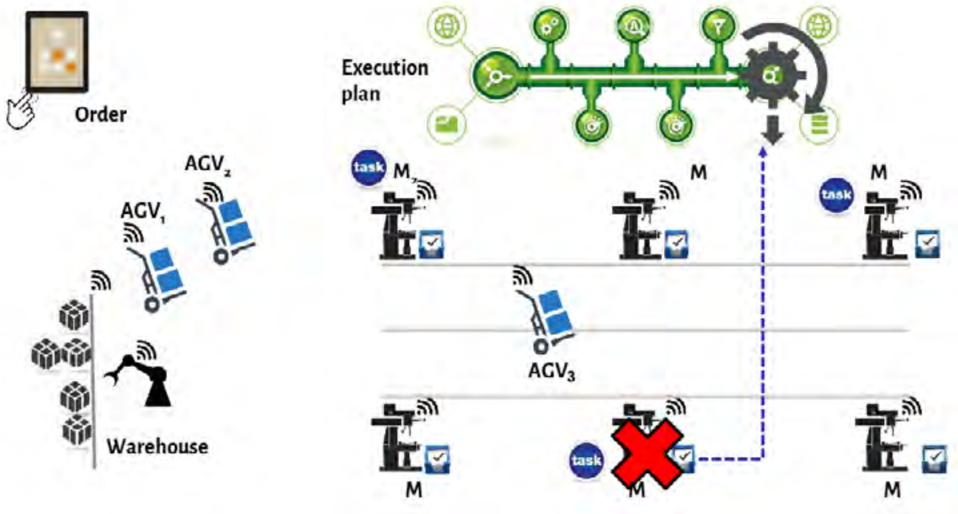
We have developed an experimental flow shop named TigerFlow where the scheduling is automatically done based on data collected from the workshop entities. Determination is delegated to a data centric analytics process and its sustainability relies on reducing energy consumption aside from timing requirements. As shown in Figure 5, our flow shop consists of three types of machines (robotic entities): manufacturing and mobile machines and AGVs. Cartesian plane and movement of the AGVs make it possible for status to be issued and accept orders.

Figure 5 *Manufacturing service-based flow shop (U. Aeronautics and Astronautics of Nanjing, Project FP7 CASES)*

Source: *Own elaboration adapted from literature.*

Orders are sent using a tablet application that serves to manage and pilot the whole flow shop. An order is decomposed into one or several jobs, where each job is fragmented into tasks that will be performed by the different flow shop elements, namely machines, AGVs and warehouse as material provider. To do this, the tasks composing a job are sorted and their execution is organized by an execution plan that defines the order in which tasks must be executed according to a global schedule that expresses jobs deadlines and derived deadlines to their tasks. The global schedule is built considering time, cost and energy consumption constraints and it can be understood as an optimisation problem addressed for example by (Dai, M., 2003; Reddy, B., 2006; Zheng, Kun et al., 2015).

Figure 6 Smart flow shop



Source: Own elaboration adapted from literature.

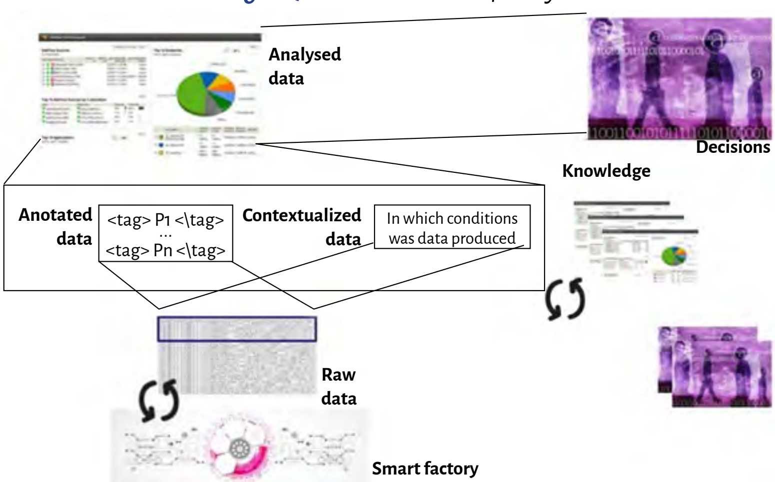
An important problem to deal with in a flow shop is managing (detecting, processing and recovering) exceptions. The challenge is to reschedule jobs trying to reduce impact on timing, cost and energy consumption objectives. During industrial processes, flood of data and alarms during a fault overwhelms operators to find and fix the problem in a timely manner[9]9. Moreover, economic losses generated by non-optimal fault management are very important. For example, around $44,000.00 USD per minute are lost when an auto plant stops due to failure. This is because around 86% maintenance is reactive (too late) or preventive (unnecessary) resulting in sub-optimal savings. As flow shops in smart industry need to satisfy availability around-the-clock, a highly scalable distribution system is desired in smart industry.

In our smart service-based flow shop, robotic entities (AGV, machines, warehouse arm) are data producers reporting on their execution, their internal status, their spatial position in the flow shop. These data are collected, analysed, and correlated to automatize the industrial process that they cooperatively execute. This enables dynamic decisions on the best way to organise activities and face internal and external events that can have impact on the execution of these industrial processes. The scheduling of the activities performed by these robotic entities is guided by cost, energy, and time objectives. The difficulty of tuning strategies to meet these objectives is a difficult challenge that cannot be done fairly in an artisanal manner. Furthermore, since objectives and external condition in which industrial processes are executed can change dynamically, scheduling must be continuously adjusted. This problem calls for automatic tools and reactive systems that can coordinate the execution of flow shops consisting of robotic entities. We have addressed this problem as a data analytics problem related to self-optimization strategies in a distributed environment (see Section 3.2). Therefore, we have proposed the notion of flow shop as a service described that provides a distributed architecture where robotic and connected entities composing a flow shop are continuous data producers that use internal and global data to make decision about their internal behaviour and about global industrial processes in which they are collaborating the flow shop. This proposal is described in the following section.

Flow shop as a service

Data management and analytics are critical components to efficiently and effectively dealing with data generated from smart factory flow shops. Big data algorithms allow a higher production of services as well as the optimization of processes in the support for decision making in industries. As said before, this has led to data centric smart factories that are designed as a set of connected entities, that can be machines, robotic elements, people, and software systems that interact through a data flow.

Figure 7 *Data centric smart factory*

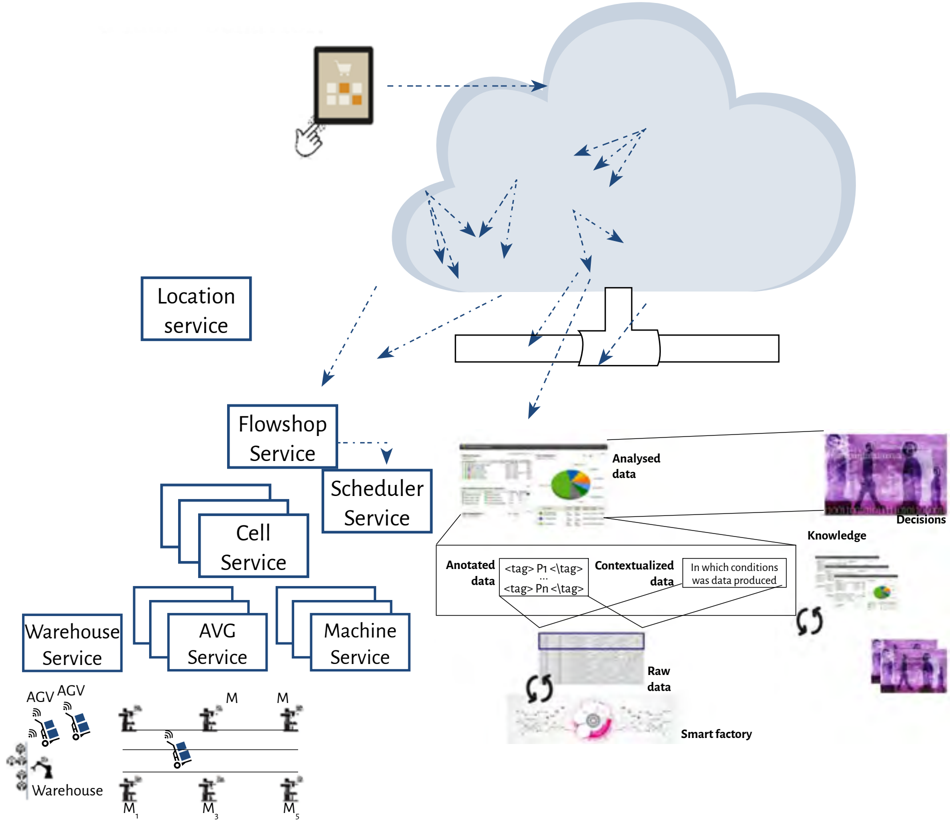


Source: *Own elaboration adapted from literature.*

The entities composing the smart factory (i.e., human, things, software) produce important volume of data at different paces (velocity), with different content and formats (variety) under different conditions (see Figure 7). Their processing and dissemination have different levels of criticality and calls for different processing and exploitation conditions. In all cases, smart factory entities are raw data producers that are collected by adapted collection infrastructures. Raw data is annotated and contextualized (semi)- automatically within complex data processing and feature engineering processes. Cleaned (missing and null values processed), annotated and contextualized data, mathematically profiled. These data are processed through data analytics workflows for generating models of the smart factory processes. These models provide a vision of the way industrial processes work and are interrelated among each other and how they face external and internal events (e.g., failures of machines, delays, changes in the orders, shortage of material). Data analytics processes can also include prediction for preventing anomalous events, failures, machine break downs, job scheduling problems. Using models and prediction results decision makers can use them to pilot the smart factory but it is also possible to build recommendation systems that can help to (semi)-automatize some of the smart factory processes. Data and knowledge are produced through these decision-making processes that can feed annotated and collected datasets and improve the data analytics processes which are recurrent and dynamic.

While this vision of the smart factory may seem futuristic it is unfolding all around the manufacturing realm in a systematic fashion. There has been an enabling element for this vision: the cloud. Thanks to the cloud and its "unlimited" resources provision, it has been possible to have digital representations of the entities of smart factories (thousands of entities) as services, to collect the data they produce by remotely monitoring data about their states, use greedy algorithms to diagnose and predict their reliable and faulty behavior.

Figure 8 Flow shop as a service general architecture



Source: *Own elaboration adapted from literature.*

Having a continuous and dynamic on-line view of the behavior of the industrial processes performed within the flow shops of a smart factory can be computationally expensive. Thus, it is necessary to use a scalable platform like the cloud, that can deal with these greedy workloads and that can dispatch computing resources while new or less entities adhere to the smart factory.

The convergence of digital twin and data can break the barriers among different phases of a product lifecycle and shortens the product development and verification cycle.

Moreover, embracing the concept service-oriented smart manufacturing namely, Manufacturing-as-a-Service (MaaS) (Qi Q. et al., 2018), is receiving extensive attention. As an effective means, services enable numerous large-scale manufacturing collaboration. Therefore, digital twin, big data and services can be united to promote smart manufacturing.

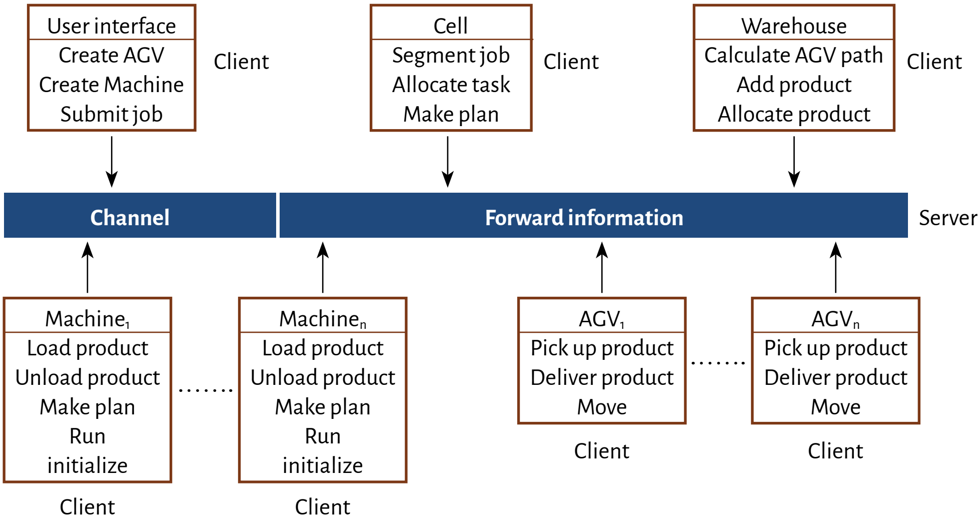
We have proposed a service-based flow shop (manufacturing as a service) where all entities of a flow shop have their associated service representation that collects data and continuously monitors the status of the entity (see Figure 8). Every service processes data to give continuous insight and foresight of the behavior of a flow-shop entity. Collected data does not only stem from the entity but from the interactions it established with other entities in the flow shop. A global flow shop system consumes data from all these entities to make decisions about the jobs that it should execute and the tasks it schedules and assigns to the entities of the flow shop. The coordination of the industrial process of the flow shop is delegated partially to a system that has a global vision of the status of the jobs performed in the flow shop. This system schedules activities according to optimization objectives related to time to market, cost and energy based on an internal scheduling algorithm (Zheng, Kun et al., 2015). The next section describes the implementation of a service based smart industry flow shop that we used as proof of concept to show the way data and digital twin can be combined to promote a reactive smart manufacturing.

Implementation and proof of concept

We designed and developed a smart service-based flow shop environment, named Tigerflow as proof of concept. The objective was to show how physical flow shop entities which are robotic entities running in a real flow shop can be connected to services that collect data about their status, position within the flow shop (for AGVs) and jobs. A global service coordinating all entities represents the flow shop processes and implements a scheduling algorithm for dealing with jobs and assigning tasks with time, cost and energy objectives.

The current version of TigerFlow is a service-based platform for simulating flow shops composed of machines and automated guided vehicle (AGVs). In a TigerFlow's flow shop, machines execute a collection of tasks to complete jobs associated to orders. AGVs move material from the warehouse to machines and from one machine to another so that machines have the necessary "input" for completing every task. In the current version of TigerFlow tasks are assigned to machines randomly but they can be assigned considering their task queues status, a queue is somehow the to-do list of each machine. Thus, task assignment can follow strategies like assign tasks to those machines that are idle (empty "to-do" list) or with the shortest "to-do" list. In the presence of machine failures, tasks are reallocated to other machines following a best effort approach. In TigerFlow entities communicate by exchanging messages over a network (see Figure 9).

Figure 9 TigerFlow general architecture



Source: *Own elaboration adapted from literature.*

When TigerFlow is initialized, it starts the following services (see Figure 9):

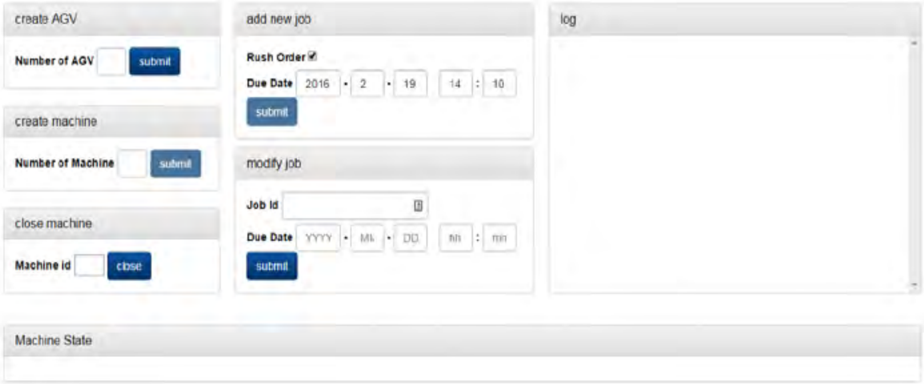
- Network: responsible of broadcasting flow shop messages.[10]
- Cell: in charge of allocating tasks to machines.
- Warehouse: responsible of providing material and dispatching AGVs to machines that carry material so that tasks can be executed by machines.

Configuring a flow shop

All entities in TigerFlow compose a flow shop. particularly machine and AGVs services (software representatives of the physical connected elements in the flow shop). Each entity in a flow shop has a queue of tasks to be performed and that are assigned according to a general schedule that implements an order (i.e., job). TigerFlow provides a Web UI for configuring a flow shop (localhost:3000). The interface offers buttons for adding *n* machines/AGVs to a flow shop (see Figure 10).

10 In its current version, TigerFlow simulates a CAN bus network.

Figure 10 Tigerflow flow shop configuration interface



Source: Own elaboration adapted from literature.

The figure shows the control board of TigerFlow where a flow shop designer can create the machines and AGVs that will compose the flow shop. The control board can be also used for creating and modifying jobs and it also shows a log that reports on the status of the execution of the jobs scheduled in the flow shop. For configuring a flow shop, a user creates AGV and machines. When a flow shop designer adds an AGV to a flow shop, TigerFlow creates an AGV service instance and adds it to the network. This can be seen in the Web UI in the log panel. In the same way, if a user adds a machine, TigerFlow, for simulation purposes, creates a *machine service instance* with 10 randomly tasks (executed one at a time) and add it to the network. The state of the flow shop after adding 2 machines and 1 AGVs to the flow shop is shown in Figure 11. As shown in the figure, for every machine that is created, TigerFlow provides interfaces for following the execution of the tasks assigned to every machine and also for observing the status of the machine (active, idle, stopped).

***Figure 11** Flow shop entities as services*

Machine State

Machine1

Task id	Processing time(s)	Estimated completion time	Real completion time	Due date
1000	6.596	2016-02-19 14:42:47.767	2016-02-19 14:42:47.789	2016-02-19 14:45:28.697
1001	2.869	2016-02-19 14:42:50.658	2016-02-19 14:42:50.659	2016-02-19 14:47:12.931
1002	11.381	2016-02-19 14:43:02.040	2016-02-19 14:43:02.050	2016-02-19 14:49:29.059
1003	34.781	2016-02-19 14:43:36.831	executing	2016-02-19 14:51:19.064
1004	23.39	2016-02-19 14:44:00.221	waiting	2016-02-19 14:48:02.463
1005	21.812	2016-02-19 14:44:22.033	waiting	2016-02-19 14:45:36.281
1006	32.454	2016-02-19 14:44:54.487	waiting	2016-02-19 14:50:18.830
1007	0.451	2016-02-19 14:44:54.938	waiting	2016-02-19 14:49:03.361
1008	7.698	2016-02-19 14:45:02.636	waiting	2016-02-19 14:49:15.895
1009	30.867	2016-02-19 14:45:33.503	waiting	2016-02-19 14:49:46.485

Machine2

Task id	Processing time(s)	Estimated completion time	Real completion time	Due date
2000	32.892	2016-02-19 14:43:14.429	executing	2016-02-19 14:47:48.154
2001	25.827	2016-02-19 14:43:40.256	waiting	2016-02-19 14:50:33.304
2002	18.516	2016-02-19 14:43:58.772	waiting	2016-02-19 14:50:09.552
2003	9.382	2016-02-19 14:44:08.154	waiting	2016-02-19 14:44:23.130
2004	41.458	2016-02-19 14:44:49.612	waiting	2016-02-19 14:49:16.990
2005	33.359	2016-02-19 14:45:22.971	waiting	2016-02-19 14:45:44.238
2006	46.588	2016-02-19 14:46:09.559	waiting	2016-02-19 14:49:38.546
2007	11.646	2016-02-19 14:46:21.205	waiting	2016-02-19 14:48:06.208
2008	10.501	2016-02-19 14:46:31.706	waiting	2016-02-19 14:50:31.119
2009	9.842	2016-02-19 14:46:41.548	waiting	2016-02-19 14:51:30.290

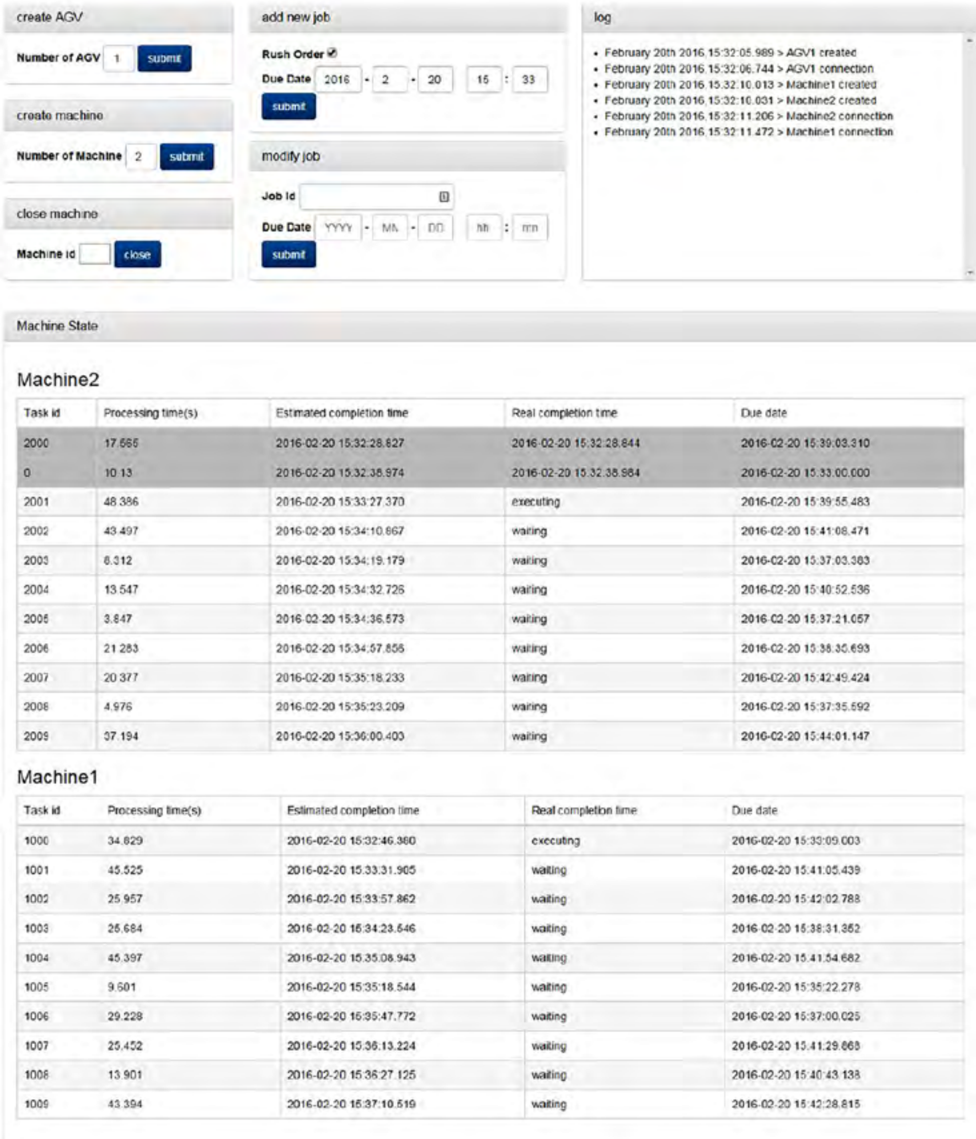
***Source:** Own elaboration adapted from literature.*

Scheduling machine tasks

A task has an *ID*, an *estimated processing time*, an *estimated completion time* and a *due date*. A task can be in one of three states at runtime: waiting, executing, or executed. A new task is assigned to a machine and it is added at the end of task queue of this machine. The progress of every task can be followed in the Web UI.

New jobs are submitted in the 'add new job' panel as normal or rush orders. The tasks of a normal job are scheduled according to the deadlines of other tasks being already executed and scheduled in the flow shop. A rush order means completion time can be earlier than the due dates or close to due dates of already scheduled tasks. In such case the global scheduler of TigerFlow ensures that several rush order will not cause starvation of already scheduled tasks. Figure 12 shows the state of the flow shop after submitting a rush order.

Figure 12 *Flow shop state after the submission of a rush order*



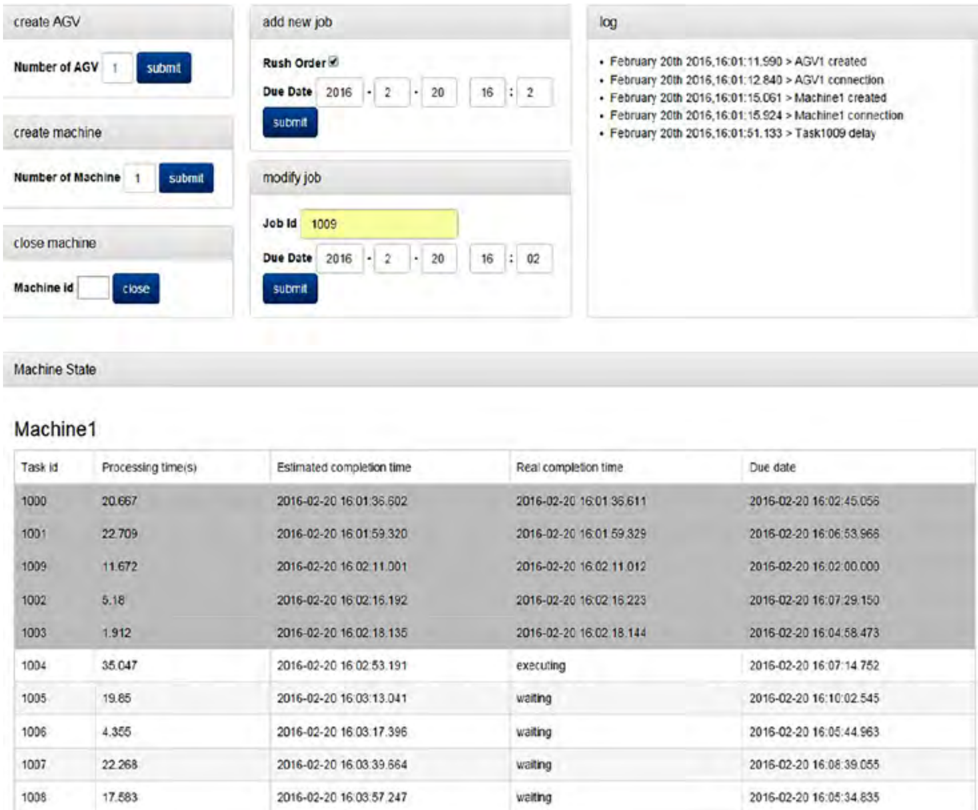
Task id	Processing time(s)	Estimated completion time	Real completion time	Due date
2000	17.665	2016-02-20 15:32:28.627	2016-02-20 15:32:28.644	2016-02-20 15:39:03.310
0	10.13	2016-02-20 15:32:38.974	2016-02-20 15:32:38.984	2016-02-20 15:33:00.000
2001	48.386	2016-02-20 15:33:27.370	executing	2016-02-20 15:39:55.483
2002	43.497	2016-02-20 15:34:10.867	waiting	2016-02-20 15:41:08.471
2003	8.312	2016-02-20 15:34:19.179	waiting	2016-02-20 15:37:03.383
2004	13.547	2016-02-20 15:34:32.726	waiting	2016-02-20 15:40:52.536
2005	3.847	2016-02-20 15:34:36.573	waiting	2016-02-20 15:37:21.057
2006	21.283	2016-02-20 15:34:57.856	waiting	2016-02-20 15:38:35.693
2007	20.377	2016-02-20 15:35:18.233	waiting	2016-02-20 15:42:49.424
2008	4.976	2016-02-20 15:35:23.209	waiting	2016-02-20 15:37:35.592
2009	37.194	2016-02-20 15:36:00.403	waiting	2016-02-20 15:44:01.147

Task id	Processing time(s)	Estimated completion time	Real completion time	Due date
1000	34.829	2016-02-20 15:32:46.360	executing	2016-02-20 15:33:09.003
1001	45.525	2016-02-20 15:33:31.905	waiting	2016-02-20 15:41:05.439
1002	25.957	2016-02-20 15:33:57.862	waiting	2016-02-20 15:42:02.788
1003	25.684	2016-02-20 15:34:23.546	waiting	2016-02-20 15:38:31.352
1004	45.397	2016-02-20 15:35:08.943	waiting	2016-02-20 15:41:54.682
1005	9.601	2016-02-20 15:35:18.544	waiting	2016-02-20 15:35:22.278
1006	29.228	2016-02-20 15:35:47.772	waiting	2016-02-20 15:37:00.025
1007	25.452	2016-02-20 15:36:13.224	waiting	2016-02-20 15:41:29.668
1008	13.901	2016-02-20 15:36:27.125	waiting	2016-02-20 15:40:43.138
1009	43.394	2016-02-20 15:37:10.519	waiting	2016-02-20 15:42:28.815

Source: *Own elaboration adapted from literature.*

The panel 'modify job' can be used to modify the job's due date. If the job matches the delay condition that due date is one minute later than estimated completion time, the job is rescheduled. Figure 13 shows the state of the flow shop after modifying a job.

Figure 13 *Flow shop state after the modification of a job*



Source: *Own elaboration adapted from literature.*

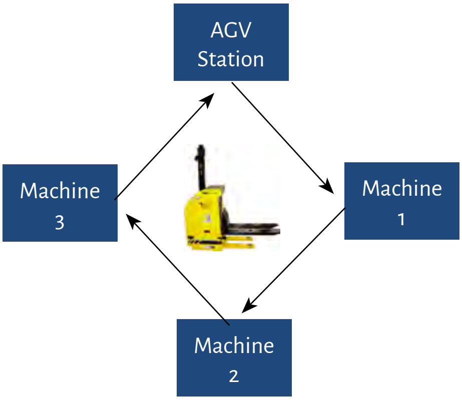
Recovering from machine failures

In our smart factory flow shop, faulty behavior of machines has impact on the execution of industrial processes in flow shops. Machine temporal or recurrent faulty behavior generate exceptions to be handled in the flow shop. The fault management problem is stated as follows. Given an exceptional situation that impacts the execution plan, the rescheduling process consists in:

- Reallocating its tasks to other machines according to: number of pending tasks, energy consumption, cost.
- Choosing an AGV to deliver/pick up input material and products from/to warehouse-machine according to cost and spatial position.
- Monitoring the global execution state: task initial/termination time, delays, exceptions.

The AGV schedule has to be also taken into consideration because AGV's are in charge of transporting material necessary to execute jobs from the warehouse to machines and across machines. Several AGV's go around the workshop and they have to be organized so that they ensure material available timely for machines to execute their jobs. For example, suppose AGV_1 has to transport material to $Machine_1$, the procedure to be executed would be as follows (see Figure 14): (1) AGV_1 moves to $Machine_1$; (2) AGV unloads material into $Machine_1$; (3) AGV moves to $Machine_2$; (4) AGV moves to $Machine_3$; (4) AGV moves to AGV station.

Figure 14 *AGV execution plan example*

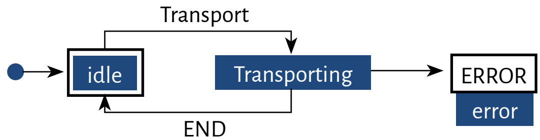


Source: *Own elaboration adapted from literature.*

Thus, the AGV has a runtime behavior that can be described as follows (see Figure 15):

1) When an AGV is started it enters the idle state.
2) On a transportation request is received, it enters the transporting state: (i) If an error occurs during transportation the AGV enters the error state (final); (ii) If an AGV ends transporting material (i.e., is back into the AGV station) it re-enters the idle state.

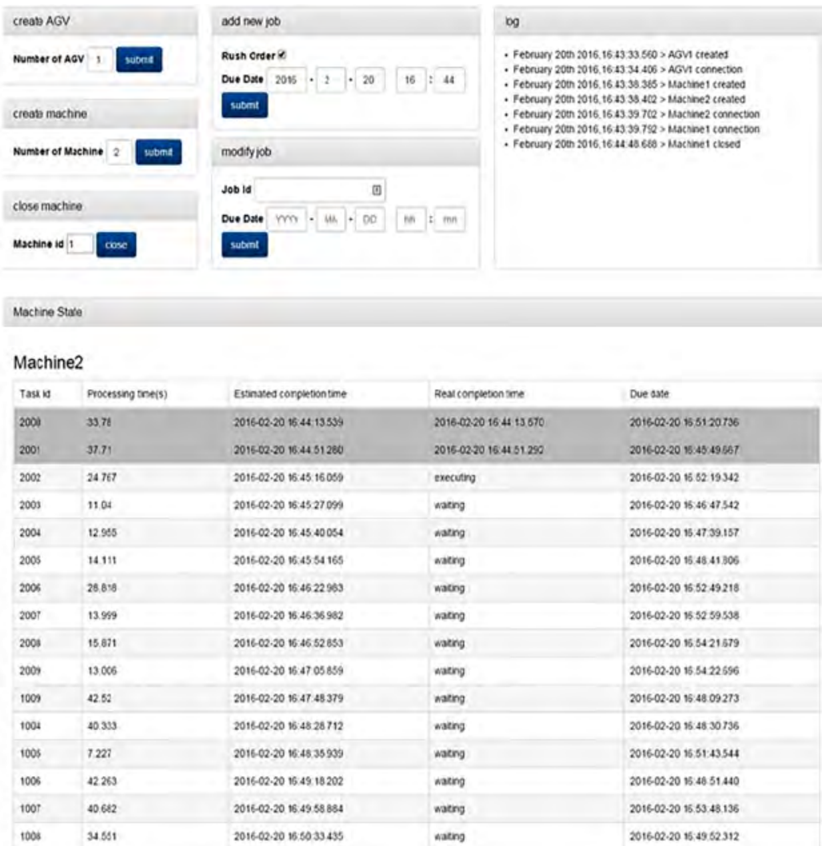
Figure 15 *AGV internal execution loop*



Source: Own elaboration adapted from literature

When a machine breaks down, all tasks in its task queue will be allocated to other machines. In our experimental setting, we simulate machine failures using the 'close machine' panel for stopping a machine. Figure 16 shows the state of the flow shop after a machine failure. Note that the status of machine 1 in the TigerFlow panel is declared as stopped (left upper side of the figure).

Figure 16 *The flow shop on the presence of failures*



Task id	Processing time(s)	Estimated completion time	Real completion time	Due date
2000	33.78	2016-02-20 16:44:13.539	2016-02-20 16:44:13.670	2016-02-20 16:51:20.736
2001	37.71	2016-02-20 16:44:51.280	2016-02-20 16:44:51.290	2016-02-20 16:45:49.667
2002	24.767	2016-02-20 16:45:16.059	executing	2016-02-20 16:52:19.342
2003	11.04	2016-02-20 16:45:27.099	waiting	2016-02-20 16:46:47.542
2004	12.955	2016-02-20 16:45:40.054	waiting	2016-02-20 16:47:39.157
2005	14.111	2016-02-20 16:45:54.165	waiting	2016-02-20 16:48:41.806
2006	28.818	2016-02-20 16:46:22.983	waiting	2016-02-20 16:52:49.218
2007	13.999	2016-02-20 16:46:36.982	waiting	2016-02-20 16:52:59.538
2008	15.871	2016-02-20 16:46:52.853	waiting	2016-02-20 16:54:21.679
2009	13.006	2016-02-20 16:47:05.859	waiting	2016-02-20 16:54:22.696
1009	42.52	2016-02-20 16:47:48.379	waiting	2016-02-20 16:48:09.273
1004	40.333	2016-02-20 16:48:28.712	waiting	2016-02-20 16:48:30.736
1005	7.227	2016-02-20 16:48:35.939	waiting	2016-02-20 16:51:43.544
1006	42.263	2016-02-20 16:49:18.202	waiting	2016-02-20 16:48:51.440
1007	40.682	2016-02-20 16:49:58.884	waiting	2016-02-20 16:53:48.136
1008	34.551	2016-02-20 16:50:33.435	waiting	2016-02-20 16:49:52.312

Source: Own elaboration adapted from literature.

This causes that the tasks that were originally assigned to machine 1 to be re-assigned to machine 2. The figure shows the status of the "to-do" list of machine 2 with the newly assigned activities ordered according to their due dates. As the manufacturing process become more complex, it is difficult to quickly identify the problems arising in the manufacturing process by traditional ways. Problems in smart industry flow shops can be reflected by data. Digital twin used to design our flow shop has helped us notice the correlation and dynamic adjustment between manufacturing planning and implementation, as well as promote faults prediction, diagnosis and maintenance in digital way. Thereby, we have shown that digital twin and data play complementary roles in the smart factory flow shops.

Existing work: discussion

Machine health maintenance is the most straightforward application of data analytics in smart factory flow shops. Most existing manufacturing strategies assume continuous device readiness and optimal performance, which is not true in a real-life manufacturing environment. Any physical machine will wear out during its operation and needs timely maintenance to keep them properly running. However, due to the different workload and working environment, the same type of machines might stop working at different times. Although the intrusive examination on machines is more accurate to understand their healthy states, it requires to stop machines and excessive human labors on examinations. Instead, data analytics methods can be more cost-effective for this problem. When a machine starts to malfunction, it has some abnormal events associated with it, such as higher temperatures, larger vibration, and different power consumption. As these indirect but related information is easier to be collected by different sensors, predictive analytical methods can utilize this information to predict machine failures. This prediction can significantly reduce the number of unnecessary intrusive examination on machines. Because predictive analytical methods only have indirect information and the abnormal value generated by sensors might be caused by sensor failures instead of real machine states, it can never be perfect, and increasing their prediction accuracy is critical to reduce the number of unnecessary interventions (Grieves, M., 2014). Different from traditional optimization problem with all the information in a central server, it is an increasing need to make decision based on local information but still globally optimal strategies. In (Maggio, M. et al., 2012), authors studied different self-optimizing autonomic strategies to accomplish a given goal in a dynamically changing environmental conditions and demands. They found adaptive and model predictive control systems can produce good performance, especially in a priori unknown situations. (Wang S. et al., 2015) integrated the autonomous agents with feedback and coordination and proposed a contract net protocol negotiation mechanism to cooperation with each other. Authors in (Bogdan, 2015) studied the goal- oriented self-organization algorithms to optimize design cost functions in a distributed fashion and induce an overall degree of autonomy.

Conclusion: Perspectives of the Role of Data Science for Making Industry Smart

This chapter discussed issues regarding data for enabling Industry 4.0 and smart factory industrial processes management. Having a data-centered analysis of the problems and challenges that introduced Industry 4.0 exhibits the necessity to study data with respect to different perspectives. Therefore, the first chapter characterized data produced within smart factories processes. These variety of data are produced with different characteristics, and approaches by specific hardware (sensors, connected things and machines), and software, and passive and active participation of people. Data collections are phenomenological observations of industrial processes running within a smart factory that can be managed and analyzed for modeling processes behavior for having insight of its dependencies with others and the way the whole system can be affected by internal and external events. Furthermore, we exhibited how to create insight and foresight of important situations happening in smart factories processes. For example, computing trajectories and delivery strategies of AGVs evolving in the flow shop; foresight of job scheduling; detecting and dealing with machine failures and processes exceptions; and possible implications of external events on the cost, energy and time objectives of the jobs executed in a flow shop.

The vision of Industry 4.0—acquisition, integration, and analysis of data to improve industrial processes within complex production environments—is leading to smarter factories. Industry 4.0 and particularly smart factory blurs the boundary between databases, machine learning, visualization and even bridges the gap between different disciplines (e.g., computer sciences and industrial and mechanical engineering). Data analysis is responsible for examining all the data required by smart manufacturing, while digital twin makes up the drawbacks that data cannot simulate by synchronously visualizing physical processes. Therefore, the convergence of digital twin, data and service, is of great significance to smart manufacturing. Since industry 4.0 is still in its preliminary stage, most current research efforts focus on the system infrastructure perspective of data to make smart factory industrial processes work. Fewer attention has been paid to the data analytics perspective to make industrial processes more efficient and cost effective. Even in the intensively studied system infrastructure perspective, most research is related to a relatively simple smart factories within one company or organization. Future solutions are expected to deal with more and more research towards more advanced industrial processes across companies/organizations. In the few studies related to the data analytics perspective of data, most are related to machine failure prediction to improve system resiliency and self-optimization in a distributed environment, which can still be considered as the efforts to make the system work. In order to revolutionize Industry 4.0, a few techniques still need to be explored. Such as the hybrid indexing structure for multimode data, the knowledge fusion across heterogeneous data sources, exploratory visualization for industrial processes, the integration of algorithms of different domains and intervention-based analysis.

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CHAPTER 2

Facial Recognition & Fingerprint Based Authentication System for Industry 4.0 Cybersecurity

Francisco Enríquez[1,*], Jesus Silva[1], Salvador Noriega[1], Gabriel Bravo[1], Erwin Martínez[1]

[1]Universidad Autónoma de Ciudad Juárez, Instituto de Ingeniería y Tecnología
Av. del Charro no. 450 N, Col. Partido Romero, Ciudad Juárez, Chihuahua.
[*]Corresponding Author: fenrique@uacj.mx

Abstract. There is a growing demand for the use of digital information in present times. Thus, new challenges on cybersecurity like fending off attacks on vulnerabilities in current data storage systems. Industry 4.0 integrates technologies that handles private digital information, thus, the issues with cybersecurity are in the spotlight. The physical infrastructure—composed of: computers, routers, servers, switches, etc.—is one of the main aspects to consider. Its protection can be guaranteed through different means like the usage of biometric technologies to restrict access to a predetermined area, which is becoming crucial and stands out among other security techniques like the use of security guards, lockable doors, and those with electronic key access, etc. The application of digital image processing for facial and fingerprint recognition is presents throughout this work. Nonetheless, this chapter ends with two low-cost proposals to control access to a given area that take advantage of facial and fingerprint recognition authentication technology.

Keywords: Cybersecurity, Fingerprint, Facial Recognition, Lattepanda, Biometry.

Introduction

The term cybersecurity is thoroughly revised in (Craigen et al., 2014), there, Craigen defines "cybersecurity" as "*[an] organization and collection of resources, processes, and structures used to protect cyberspace and cyberspace-enabled systems from occurrences that misalign de jure from de facto property rights*". This definition not only covers most of the ideas raised by various authors specialized in the cybersecurity field, but it also illustrates that a part of cybersecurity is access control to an installation that works with Information Technology (IT). Organizations such as the Information Technology Industry Council (ITI), the entity responsible for integrating cybersecurity principles for industry and government in the United States of America, comprises the world's leading technology companies. "*the Information Technology (IT) Industry refers generally to the technology industry, namely providers of computer and computer network hardware and software.*" (Council, 2011). Which basically consists of the hardware and software to be used in the IT. Although the software has security systems such as firewall, antivirus, etc., access to authorized personnel to the hardware is important to complement the IT security.

Three security components are mentioned in (Bishop, 2003):

1) **Requirements** (where the safety objectives are determined and they must answer the question "*What do you expect security can do for you*?")
2) **Policy** (determines the sense of security and must respond the question "*What steps do you take to reach the goal set out above?*")
3) **Mechanisms** (enforce policy and must answer the question"*What tools, procedures, and other ways do you use to ensure that the above steps are followed?*".

Moreover, to the components proposed by (Bishop, 2003), we can encompass the mechanism for protecting access to facilities by means of the following systems.

Biometry

Biometry can be defined as "*the statistical analysis of biological observations and phenomena*" (Merrian-Webster, n.d.). This concept covers the main topics studied in this chapter: facial and fingerprint recognition.

Fingerprint recognition

The fingerprint recognition process is a popular biometric method composed by enrollment and authentication. The former is when a human places a finger (generally the index finger), to a fingerprint sensor which is capable of capturing the image and, by means of a digital processor running Digital Image Processing (DIP), obtains a template. This template is subsequently stored into an internal memory to perform an authentication (Patel & Ramalingam, 2018). In accordance with (Maltoni, Maio, Jain, & Prabhakar, 2009), the fingerprint matching can be divided into three principal groups.

1) *Correlation - based matching*, where two fingerprint images are overlaid with reason of estimating the correlation between them, using diverse orientations. The *eq. 1* shows that the similarity *S* between the template (*T*) and the image (*I*) achieved from the sensor is given by the maximum cross-correlation (*CC*) of *T* and the rotation of *I* by an angle θ, shifted by Δx and Δy in direction x and y.

$$S(T, I) = \max_{\Delta x, \Delta y, \theta} CC(T, I^{\Delta x, \Delta y, \theta}) \tag{1}$$

2) *Minutiae - based matching*, the most commonly used method, consists of identifying the alignment between a template and the minutiae obtained from the acquired image. For this technique, it is necessary to find the maximum number of minutiae pairings and to calculate a feature vector (of variable length)—whose elements represent the fingerprint minutiae. The minutiae are represented normally as a triplet $m = \{x, y, \theta\}$ where *x*, *y* denote the minutiae position coordinates and θ represent the minutiae angle:

$$T = \{m_1, m_2, ..., m_m\}, \quad m_i = \{x_i, y_i, \theta_i\}, \quad i = 1...m$$

$$I = \{m'_1, m'_2, ..., m'_n\}, \quad m'_j = \{x'_j, y'_j, \theta'_j\}, \quad j = 1...n$$

Where the number of minutiae is represented by *m* in *T* and *n* in *I*. Nevertheless, to ensure a concordance between the T and I minutiae, a distance (*sd*) with minimum tolerance r_o must be presented (*eq.* 2) and in the same way there must be a minimum angular tolerance θ_o (*eq.* 3).

$$sd(m'_j, m_i) = \sqrt{(x'_j - x_i)^2 + (y'_j - y_i)^2} \leq r_0, and \tag{2}$$

$$dd(m'_j, m_i) = min(\mid \theta_j - \theta_i \mid, 360° - \mid \theta'_j - \theta'_i \mid) \leq \theta_0 \tag{3}$$

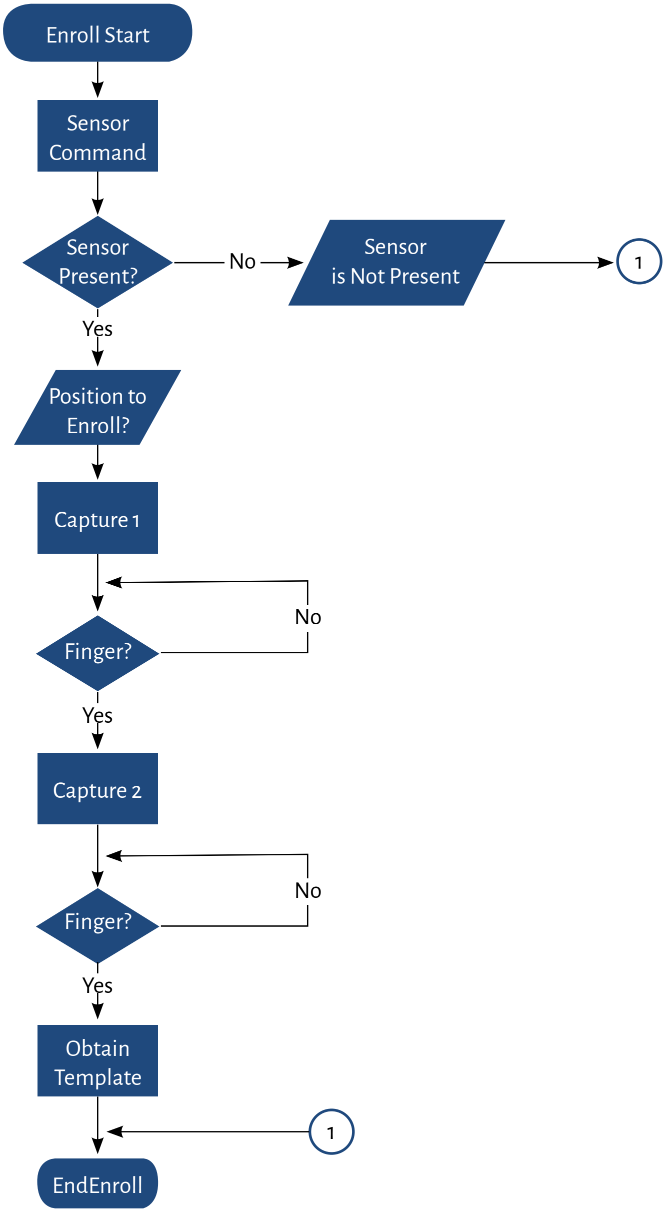
3) *Non Minutiae featured - based matching*. In this group, fingerprints are compared in accordance with features obtained from the ridge pattern. This technique is used with low-quality fingerprints images where the minutiae is almost impossible to detect, with fingerprints with small area and it also helps increase the system accuracy and robustness. *Non minute featured* has various match methods: geometrical attributes and spatial relationship of the ridge lines; number, type, and position of singularities; global and local texture information, etc. (Maltoni et al) indicates that "*the technique most popular to match fingerprint based on texture information remains the FingerCode approach by* (Jain, Prabhakar, Hong, & Pankanti, 2000)", represented by *eq. 4*.

$$V_{ij} = \frac{1}{n_i}\left(\sum_{C_i} \mid g(x, y : \theta_j, 1/10) \mid - \overline{g_l}\right) \quad (4)$$

Where C_i is the *ith* cell of the tessellation, n_i is the number of pixels in C_i, the Gabor filter is represented by *g()* and $\overline{g_l}$ is the mean value of *g* over the cell C_i.

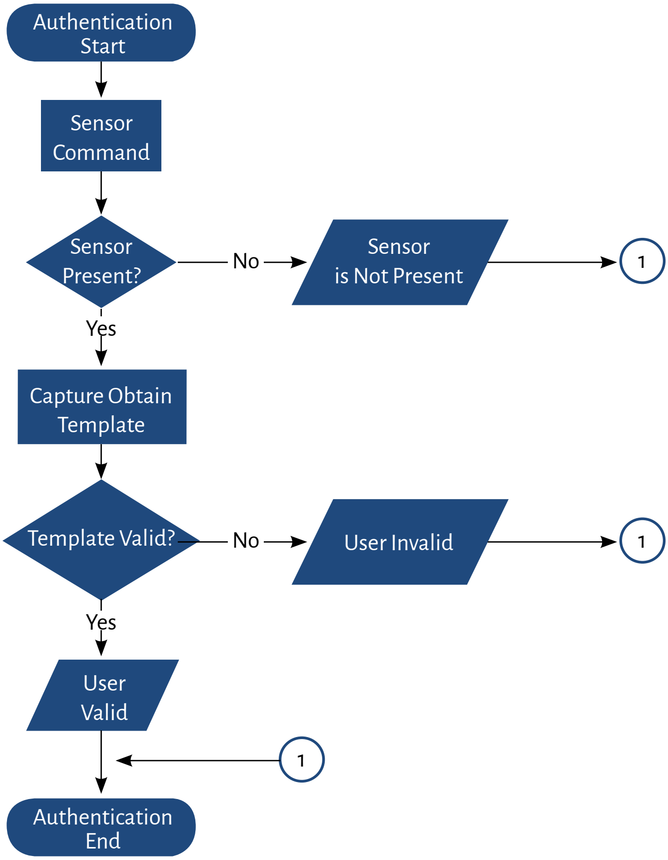
The flow charts for the enrolling and authentication in this work are showed in Figures 1 and 2 respectively. In Figure 1, you can see that it is necessary to acquire two images to obtain the user template to enroll. The sensor is a system that needs to receive messages via serial port and it is capable of making the process when it is indicated through a command.

Figure 1. *Data Flows for Enroll.*



Source: *Own elaboration.*

Figure 2. Data Flows for Authentication.



Source: Own elaboration.

Face recognition

Facial recognition is a technique used for identifying and verifying the identity of a person using DIP and interaction with the end user is not required. This procedure has been used in different situations, many authors have carried out the implementation of the Eigenface algorithm for face recognition in attendance system using Android and web technologies with geolocation extraction feature (Kurniawan, Wicaksana, & Prasetiyowati, 2017). The development of a facial recognition system with a mechanism for transmitting identification messages by e-mail was carried out by Okokpujie, Osaghae & Oputa in 2017. The attendance fraud is set to be reduced through the Fisherfaces algorithm. In previous research, the facial recognition technology along with a physical access card, and a PIN were used to improve security in Automatic Teller Machines (ATM) (Eze, Gozie, & Aru, 2013).

OpenCV

Open Source Computer Vision Library (OpenCV) is a software library for computer vision and machine learning created by Intel®. OpenCV can be used for quick software development since the code can be modified and adapted to the user's needs (OpenCV, n.d.). With this tool you can implement computer vision algorithms like object detection, tracking, movement analysis, segmentation, 3D reconstruction, etc. (Yin & Yang, 2017). OpenCV main algorithms of facial recognition are: Eigenface, FisherFace and LBPFace.

These algorithms use characteristics or features extractions to search the coincidence between a patron image and an acquired image. The OpenCV libraries are distributed to Windows operating systems like Dynamic Link Library files (Shen, Yang, Wei, Chou, & Hu, 2017).

Eigenfaces

Eigenface is a facial recognition method that projects the space of an image linearly. Its algorithm needs eigenvalue and eigenvector estimate of a matrix, considering that a face image can be represented as a two-dimensional array of numbers (Turk & Pentland, 1991). To find the eigenfaces it can be done as follows (Kurniawan, Wicaksana, & Prasetiyowati, 2017):

Given X = $\{x_1, x_2, \ldots, x_n\}$ a random set of vectors with observations $x_i \in \Re^d$, where *n* is the number of images trained.

1) Take facial image $I_1, I_2, \ldots, I_M$ (training images). The facial image must be in the middle of the frame and has the same size.
2) Change each image matrix I_i in a vector Γ_i.
3) Estimate the average face vector Ψ *eq. 5*.

$$\Psi = \frac{1}{M}\sum_{i=1}^{M}\Gamma_i \tag{5}$$

4) Search the difference (ø) between the t rained image x_i and the mean μ, *eq. 6*.

$$\phi = \Gamma_i - \mu \tag{6}$$

5) Estimate the Covariant Matrix *S*, *eq*.7.

$$C = \frac{1}{M}\sum_{i=n}^{M}\phi_n\phi_n^T = AA^T(N^2 \times N^2 matrix) \quad (7)$$

where $A = [\phi_1, \phi_2, \phi_3 ... \phi_M](N^2 \times M\ matrix)$.

6) Estimate the eigenvalue λ and the eigenvectors Av_i from *C* (*eq*. 8).

$$A^T Av_i = \mu_i v_i \Rightarrow AA^T Av_i = \mu_i Av_i \Rightarrow$$
$$CAv_i = \mu_i Av_i\ or\ C\mu_i u_i\ where\ u_i = Av_i \quad (8)$$

7) Later the eigenvector *v* is achieved, the next step is estimating the eigenface µ.

$$\widehat{\phi_l} - mean = \sum_{j=1}^{k} w_j u_j, (w_j = u_j^T \phi_i) \quad (9)$$

After finishing the eigenface training, it is possible to perform the facial recognition process. This procedure is done by calculating the Euclidian distance between the face training images and the face images acquired. Here, it is required to find the shortest distance and compare it against a threshold to know if the face is recognizable. Stages of face recognition are performed as follows:

i. An Eigenface is calculated from new face image Γ_{new}.

$$\mu_{new} = v(\Gamma_{new} - \psi) \quad (10)$$
$$\Omega = [\mu_1, \mu_2, ..., \mu_M] \quad (11)$$

ii. Estimation of the Euclidian distance between the new facial image with the facial images database.

$$e_d = \| \phi - \widehat{\phi} \| \quad (12)$$

iii. Search for the minimum distance, resulting from the calculations above, and compare it against the threshold, if it is lower, then the face is recognized.

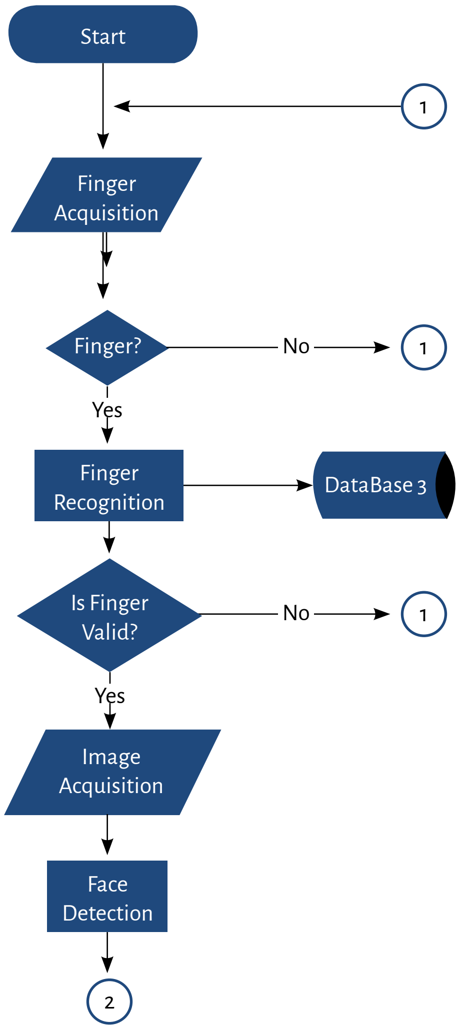
$$e_d < T_d \quad (13)$$

Case studies

The two requirements for the two study cases are to limit the use of facilities and equipment to people without authorization and to make a registry of the users who access the insured environment. The way to achieve these measure is by using a set of hardware and software, integrating the user validation procedures that can be performed by means of the dual biometrics presented in next section. The policy is to employ a dual biometrics system to find out if the person requesting entry is authorized. A record of any opening attempt will be made, informing if the entry was granted or denied.

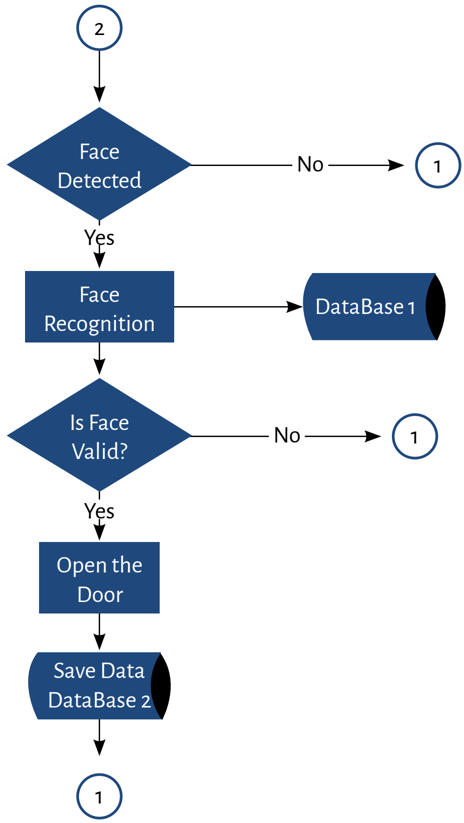
The Figures 3-a (first part) and 3-b (second part) show the data flow of the systems proposed, it indicates that the door opening is based on the sequential recognition of the fingerprint and the correct identification of the face. Even though the system could recognize the fingerprint of a user, it needs to recognize their face too. This configuration adds more security to grant the access to the computers room. It is not necessary to use an expensive camera to ensure that the picture is a real human. Additionally, the system takes a picture of the recognized face and sends it to the DataBase2, where the administrator could inspect it.

Figure 3-a. Data flow of the system based in Lattepanda (first part of two).



Source: Own elaboration.

Figure 3-b. *Data flow of the system based in Lattepanda (second part of two).*

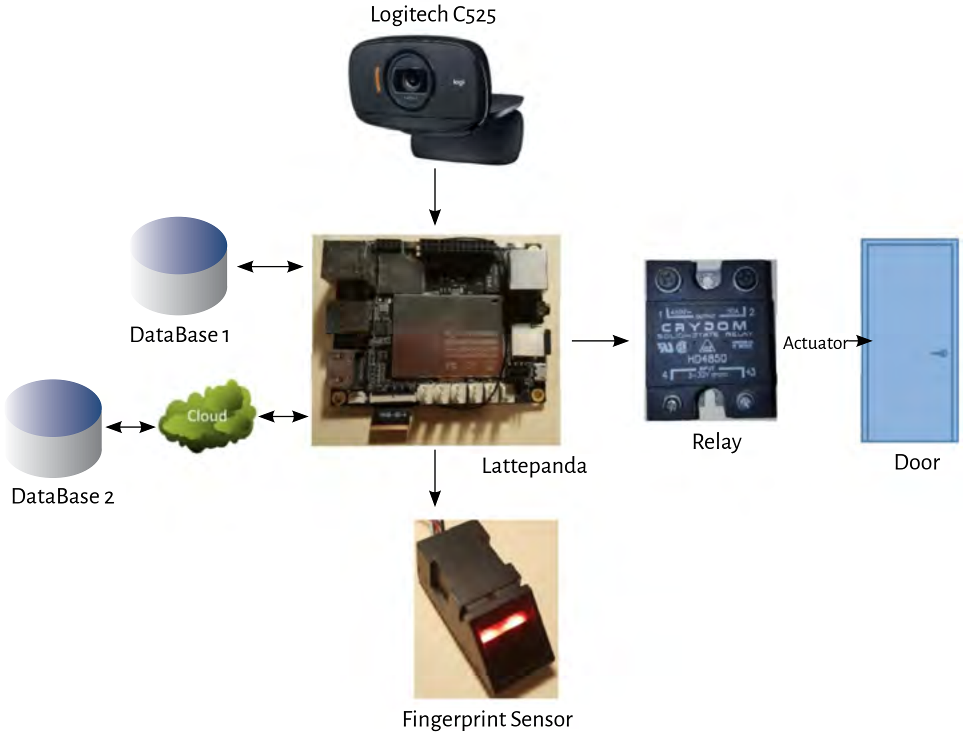


Source: *Own elaboration.*

Case 1 based in Lattepanda

In Figure 4 the case 1 is presented, the costs are obtained from www.amazon.com and the prices are in United States Dollar (USD).

Figure 4. *System architecture based in Lattepanda.*



Source: *Own elaboration.*

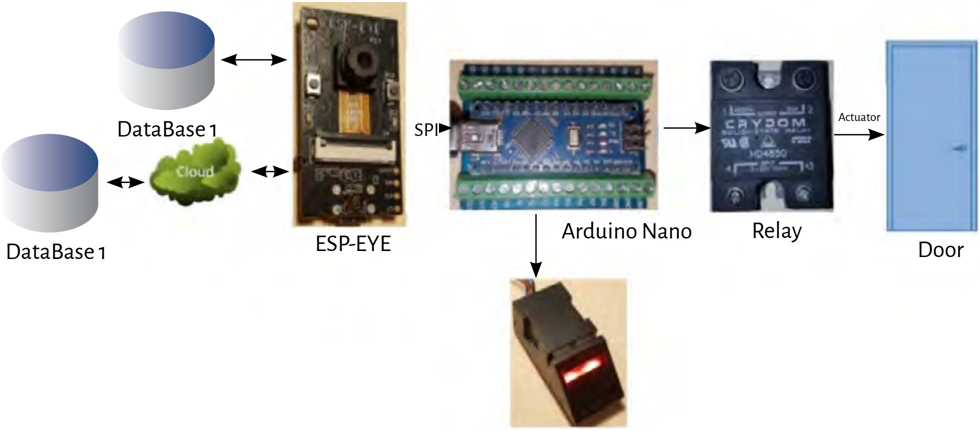
- Lattepanda 4GB/64GB. The first solution proposed is based in Lattepanda Board. It can connect to a USB camera, such as a Logitech C525, to acquire images, since it is run by Windows 10, it can execute programs made with C++. The program used in this board was coded in Visual Studio 2015, it uses OpenCV libraries to process the facial recognition with the help of the eigen-faces algorithm. It is equipped with an Intel Cherry Trail Z8350 Quad Core processor with three USB ports (two USB 2.0 and one USB 3.0) withintegrated Wi-Fi and Bluetooth 4.0. This device also includes an Arduino co-processor, which provides hardware acceleration for performing specific tasks, such as: control process, data acquisition, etc. and it costs $209.00 (Lattepanda, n.d.), It is possible to connect an USB camera with Lattepanda to execute facial recognition in Windows 10. To do this one needs to connect the fingerprint sensor through the Arduino, control the relay to energize the actuator that allows door access and transfer data over a wireless and/or wired network, (Manoharan, 2019).

- Webcam Logitech C525. The webcam C525 is a foldable USB HD 720p video camera. This camera works at 30 frames per second but the most important feature is that it has autofocus, which allows to carry out facial recognition processing It costs $59.99 (Logitech, n.d.), (Bulpin, n.d.).
- ELP-USB0230X2-KV90. ELP Face Recognition & Biological Detection Dual Lens USB camera RGB has a 2 megapixels WDR AR0230 sensor with wide dynamic range up to 105dB. This camera can be used instead of the Logitech C525 since it has an IR sensor. Post-processing can be added to ensure that the image obtained is from a person who is physically at the location where the image was taken and not from a photograph. It is equipped with dual lens of two different output, one RGB (Red, Green and Blue) mode and another is IR (Infrared) mode. The camera is used in applications like face recognition, (Ailipu Techology Co., n.d.).
- DataBase1. The DataBase1 is used to store the user face images that have authorization to enter at computer room, this information is stored in Lattepanda´s memory.
- DataBase2.In DataBase2 information is stored in the Cloud, name, date, hour of the person that enter to the protected space and a picture of the user who gained access to the room, this data is accessible to authorized users.
- Fingerprint Sensor. With the optical Fingerprint Sensor, the image of fingerprint is acquired, processed and the verification (if the user is authorized to enter the computer room) by a Digital Signal Processor (DSP). The system can enroll and store up to 162 fingerprints in the onboard FLASH memory called DataBase3 This sensor costs $24.88 (Geralde et al., 2017), (Patent No. US 6,750,955 B1, 2004).
- Relay. The Solid State Relay (SSR) HD4850 is used to control with low voltage (5V from Microcontroller (µC) embedded in Lattepanda) the actuator that is responsible for door access and the activation of a buzzer. It has Silicon Controlled rectifier (SCR) output, zero voltage or instantaneous turn-on output, AC or DC control and only 7mA of maximum input current. It costs $72.45 (ready to use directly with µC) (CRYDOM, 2016), (Patent No. US 2020/0014379 A1, 2020).

Case 2 based in ESP-EYE

The second case study is based in ES-EYE board and is showed in the Figure 5, although this proposal is cheaper than case 1, it is also slower in terms of time for the facial recognition. Nevertheless, the time required is enough to make a facial recognition in a second approximately. The component that changes for this system are described below.

Figure 5. *System architecture based in ESP-EYE.*



Source: *Own elaboration.*

- ESP-EYE is a development board that combines the ESP32 chip with an artificial intelligence (AI) development framework. This board can be used for image recognition an audio processing in different applications. It has the capability of using ESP-WHO development framework, which was planned for Artificial Intelligence of Things (AIoT) applications. "It also supports image transmission via Wi-Fi and debugging through a Micro-USB port". It costs around $31.24 (ESPRESSIF, n.d.). This board replaces the Logitech C525 and the Lattepanda.
- Arduino Nano with terminal expansion adapter. The Arduino Nano is a small development board based in the UC ATmega328, which has 22 Digital input/output (I/O) pins, 8 Analog I/O pins, 1 serial port, etc. This board is capable of interconnecting with the fingerprint through the serial port, the SSR via the digital pin and with the ESP-EYE by means of a Serial Peripheral Interface (SPI) communication protocol. The Terminal expansion adapter is used to

connect wires easily using the pin screw terminal blocks, (Badamasi, 2014). This board is required because the ESP-EYE does not have serial port, neither digital pins (only a SPI port), which are required for connecting to the fingerprint and the relay. It cost around $14.19.

Conclusions

This chapter discusses the importance of using biometric data in the cybersecurity implemented for Industry 4.0 through the security of a company's physical infrastructure. From the proposed works Case 1, it is noted that the Lattepanda microcomputer has the advantage of being able to update the facial recognition algorithm, make use of another camera such as the ELP-USB0230X2-KV90 which it can confirm that a real person is in the acquisition of the image and that the size is relatively small. For Case 2, which is based on ESP-EYE, it is a better option in terms of cost and size. Furthermore, the algorithm that employs artificial intelligence is good for what is required, however, the camera and algorithm cannot be updated as easy as in Case 1.

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CHAPTER 3

Critical Psychosocial Factors in Workplace Design

Gabriela Jacobo Galicia[1, *], Aurora Irma Máynez Guaderrama[2], Vianey Torres Argüelles [2]

[1]*Universidad Autonoma de Baja California.*

[2]*Universidad Autonoma de Ciudad Juarez*

* *Corresponding Author: gabriela.jacobo@uabc.edu.mx*

Abstract. This chapter shows the results of a literature review on effects of work conditions on the health and well-being of workers. The investigation was conducted to identify how psychosocial factors influence their professional experience. Thirty-five articles published in refereed academic sources during the period of 2013 - 2018 in the area of Occupational Health were reviewed. Some of the most common health disorders were: musculoskeletal conditions, depression, burnout and well-being disorders among other health problems. Moreover, we identified that workload/work rhythm, social support / interpersonal relationships and situations of power imbalance are psychosocial factors with high relevance. The findings highlight the importance of providing methodologies for the evaluation and design of workplaces that consider, in a comprehensive way, the risks that employees may face by working in increasingly automated areas, such as those associated with Industry 4.0.

Keywords: Occupational health, occupational risk, psychosocial risk factors

Introduction

Workers are the biggest contributors to economic and social development. Nonetheless, workers are at risk of facing health problems, not only because of workplace hazards, but also because of social and individual factors. It is necessary to improve the evaluation and management of health risks in the workplace by defining essential interventions to prevent and control mechanical, physical, chemical, biological and psychosocial hazards in the workplace (WHO, 2007). Globally, the impact of health in the workplace is relevant because, on average, 2.3 million annual deaths are related to occupational diseases or are attributable to the work environment. Cardiovascular and circulation diseases [35%] and cancer [29%] are responsible for almost 70% of work-related deaths, followed by occupational injuries [15%] and infectious diseases [10%] (Nenonen et al., 2014). In Mexico, a worker is absent from work up to 25 days a year due to depression, 20 due to panic attacks, 14 due to post-traumatic stress and 20 if they suffer from anxiety; this generates productive losses of approximately 16 billion pesos per year, estimated conservatively (STPS, 2015).

As seen in the charts above, researchers in occupational health have shown in recent years a growing concern for psychological conditions and social factors in workplaces (Persson et al., 2012). In this regard, in 2013 the International Labor Organization [ILO] noted that, although some of the traditional risks have diminished thanks to safety, technical advances and regulations, their negative effect on workers' health continues. At the same time, new types of occupational diseases are beginning to appear and increase without adequate protection and control measures being implemented (STPS, 2018). It has also been found that the new profile of work-related illnesses and accidents has transitioned into a psychosocial risk and its consequences, which have gained prominence due to the frequency increase with which they appear and that have a direct effect on work absences caused by work-related health problems or accidents (Gil-Monte, 2012).

Figure 1: Taxonomy of psychosocial risk factors

Work Context

Organizational function and culture
• Poor comunication, low support for problem resolution and personal development, lack of definition of organizational goals.

Function in the organization
• Ambiguity and conflict of functions, responsibility for other people.

Professional development
• Professional stagnation and insecurity, excesive or insufficient promotion, low salary, job insecurity, low social value of work.

Autonomy in decision making
• Low participation in decision making, lack of control (latitude of decision)/ Control over work.

Interpersonal relationships at work
· Social and physical isolation, poor relationship with superiors, interpersonal conflict, lack of social support.

Work Content

Work envioronment and work team
· Problems related to reliability, availability, adequacy and maintenance or repair of equipment and facilities.

Task design
• Lack of variety and and short work eyeles, fragmented work or lack of meaning, underutilization of qualifications, high uncertainty.

Workload/Work Rhythm
· Excess of defect in workload, lack of control over rhythm, high levels of pressure in relation to time.

Work Shedule
• Work in shifts, non-flexible hours, unpredictable hours, long shifts or that don't allow having a social life.

Source: *Cox, T., Griffiths, A., & Rial-González, E. (2005). Investigación sobre el estrés relacionado con el trabajo. Agencia Europea para la Seguridad y la Salud en Trabajo.*

In Mexico, the Secretaría del Trabajo y Previsión Social [STPS, Secretary of Labor and Social Security] defines psychosocial risks as those that can cause anxiety, non-organic sleep [circadian cycle] disorders and severe stress, as well as adaptation, derived from the nature of the job functions, working hours and exposure to severe traumatic events or acts of workplace violence to employees, based on the work performed (STPS, 2018). Factors that can generate these risks, eg Cox, Griffiths and Rial-González (Cox et al., 2005), can be categorized according to the conditions defining the hazard [see Figure 1].

This taxonomy shows that factors associated with technical issues can be identified, such as workload or pace of work [to give an example], which can be solved if both business interests and design considerations are incorporated in the work station layout design (Gil-Monte, 2012). It is important to emphasize that there is currently a very extensive theoretical and practical basis on how to improve performance of a process through the use of already established techniques. Nonetheless, this is not the case when it comes to achieving satisfaction and well-being in the workplace, since not only physical but also psychological factors are involved (Hollnagel, 2014). Manufacturing processes are constantly evolving. The most recent phase is the Industry 4.0 that involves the high technification of manufacturing processes through automatization, internet and artificial intelligence (Peralta & Soltero, 2020; Pinzone, et al., 2020). Despite the high degree of technological sophistication that these systems can achieve, the human factor remains a key component. The effects that these changes will have on the way that people will interact within the new production processes, as well as the risks emerging from these systems, are yet to be determined (Brocal et al., 2019; Gualtieri, Rauch & Vidoni, 2020).

Since this new phase in the manufacturing evolution continues to develop, factors that can create psychosocial risks are unknown. Current analysis of manufacturing processes will be used to identify how risk can be prevented within organizations as the level of technification increases (Gualtieri, Rauch & Vidoni, 2020). Furthermore, recent research indicates that implementation of safety principles to the process design is a good technique that generates a safer, more sustainable and economically viable production plant (Rathnayaka et al., 2014). While taking into account that success or effectiveness of organizational measures for the prevention of psychosocial risks depends both on the level of involvement of companies, their values, needs and the competitive context of their environment, occupational health must be part of the business strategy of any organization (Grote, 2014).

Given the importance of organizational health, there are several studies linking work conditions to occupational health problems (Bernal et al., 2015; García et al., 2016; Kozak et al., 2015; Kraatz et al., 2013; Lang et al., 2012; Rosário et al., 2016; Santos et al., 2016; Simpriniet al., 2017; Stenfors et al., 2013; Vieco et al., 2014), occupational accidents (Chiasson et al., 2012; Giraudo et a., 2017; Johannessen et al., 2015; Rommel et al., 2016) and the associated costs (Bhattacharya, 2014; Lebeau et al., 2014; Riaño-Casallas & Palencia -Sánchez, 2016; Sultan-Taïeb et a., 2013; Takala et al., 2014; Thepaksorn & Pongpanich, 2014). However, it is important to be familiar with the current trend in research with respect to work conditions and their effect on workers' health in order to identify if among these are psychosocial factors that critically impact the well-being of workers. Then, at a later stage, we can identify the best way to include them in the process of workplace design, to reduce the effects of psychosocial factors and increase the quality of their professional life.

Methodology

We used two search tools for this review: Google Scholar and Metasearch from the Library at Universidad Autónoma de Baja California. For both cases, key words used were *job risk, work risk, psychosocial factor / risk, psychological factor / risk, social factor / risk, human factor, occupational risk, manufacturing environment, process design*. In the case of Google

Scholar, the keywords were concatenated into more or less coherent phrases, for example: *psychological factors in manufacturing*. In the case of Metasearch, logical search connectors were used, which allowed joining several terms by conjunction [AND], disjunction [OR] and exclusion [NOT]. The articles were limited to the period from 2013 to 2018 and gave preference to articles from peer-reviewed academic publications. Articles were pre-selected through their title and abstract. In the first instance, articles of a medical nature related to symptomatology and palliative or corrective treatment were discarded; those related to health conditions not associated with the work environment such as HIV / AIDS; and those that dealt with psychosocial risk factors in environments other than work environments such as those focused on adolescents or infants.

From the first selection, 155 articles were obtained. We did a more detailed review of this group of studies, looking into the content of the introduction of each article and the results reported by the authors. Articles that showed links between work conditions and effects on workers' health were selected. Within this group of studies, those who made gender differentiations were not considered, given that the approach is of general interest, not specific. Health problems related to smoking, obesity or alcoholism, when identified as causes, were also excluded because the links that are interesting to analyze are those that may be resolved at the process design level. Once the selection process was concluded, a total of 35 studies remained—with specific information on health and working conditions—to be categorized.

Results

Any type of company, regardless of its industrial, commercial or service, has a psychosocial work environment resulting from the interaction of the elements associated with the tasks and the personnel that carries them out. This interaction is complex, and is influenced by multiple factors (Hansen et al., 2015). As a result of the literature review, it was possible to identify different factors that affect not only workers' health, but also have an effect on their impression of well-being in the workplace and that can also have consequences on the quality of work life of the employees. Figure 2 shows the relationship per each factor.

Figure 2: Psychosocial factors and their effects.

Workload / Rhythm	**Musculoskeletal problems:** Bernal et al. (2015), Gerr et al. (2014), Govindu & Babski-Reeves (2014), Kraatz et al. (2013), Pereira Fernandes, Santos Pataro, Brasileiro de Carvalho, & Burdorf (2016), Silva, Barros, Cunha, Carnide, & Santos (2016), Widanarko, Legg, Devereux, & Stevenson (2014) and Zamri, Moy, & Hoe (2017) **Depression:** Niedhammer & Chastang (2015) **Cardiovascular problems:** Garcia-Rojas, Choi, & Krause (2015) **Absenteeism due to work injury or illness:** Johannessen et al. (2015) Lu, Nakata, Park, & Swanson (2014) and Slany et al. (2014) **Fatigue:** Tang, Li, & Huang (2016) and Stenfors et al. (2013) **Sleep problems:** Chazelle, Chastang, & Niedhammer (2016) and Magnusson Hanson, Chungkham, Åkerstedt, & Westerlund (2014) **Work burnout:** Barrios León & Illada (2013) and Liu & Cheng (2018) **Well-being:** García et al. (2016), Liu & Cheng (2018) and Schütte et al. (2014) **Stress:** Javaid, Isha, Sabir, Ghazali, & Nübling (2018) **Attending sick or distracted at work:** Janssens et al. (2016)
Empowerment	**Musculoskeletal problems:** Bernal et al. (2015), Gerr et al. (2014), Govindu & Babski-Reeves (2014), Kraatz et al. (2013), Pereira Fernandes et al. (2016) and Silva et al. (2016) **Depression:** Vander Elst et al. (2014) **Fatigue:** Tang et al. (2016) **Work burnout:** Pinto, Dawood, & Pinto (2014)
Social support / Interpersonal relationships	**Musculoskeletal problems:** Bernal et al. (2015), Govindu & Babski-Reeves (2014), Kraatz et al. (2013) and Pereira Fernandes et al. (2016) **Depression:** Magnusson Hanson et al. (2014) and Niedhammer & Chastang (2015) **Absenteeism due to work injury or illness:** Slany et al. (2014) **Sleep problems:** Chazelle et al. (2016) **Work** burnout**:** Carrion-Garcia, Lopez-Baron, & Gutierrez Strauss (2015) and Pinto et al. (2014) **Fatigue:** Stenfors et al. (2013) **Well-being:** García et al. (2016) and Schütte et al. (2014) **Stress:** Etefa, Teklu, & Teshome (2018) **Attending sick or distracted at work:** Janssens et al. (2016)
Labor insecurity	**Musculoskeletal problems:** Yang, Haldeman, Lu, & Baker (2016) **Cardiovascular problems:** Garcia-Rojas et al. (2015) and Kaur, Luckhaupt, Li, Alterman, & Calvert (2014) **Well-being:** García et al. (2016) and Schütte et al. (2014) **Stress:** Inoue, Kawakami, Eguchi, & Tsutsumi (2018) and Javaid et al. (2018)
Hostile environment / Violence	**Musculoskeletal problems:** Yang et al. (2016) **Cardiovascular problems:** Kaur et al. (2014) **Absenteeism due to work injury or illness:** Lu et al. (2014) and Slany et al. (2014) **Work burnout:** Liu & Cheng (2018) **Wellness:** Liu & Cheng (2018)

Poor leader-ship/ Supervi-sor support	**Musculoskeletal problems:** Zamri et al. (2017) **Absenteeism due to work injury or illness:** Slany et al. (2014) **Well-being:** Schütte et al. (2014)
Reward	**Musculoskeletal problems:** Bernal et al. (2015), Matsudaira et al. (2015) and Sekkay et al. (2018) **Absenteeism due to work injury or illness:** Slany et al. (2014) **Sleep problems:** Chazelle et al. (2016) **Desire to resign:** Li et al. (2013) **Well-being:** Herr et al. (2017) **Attending work sick or distracted:** Janssens et al. (2016)
Effort	**Musculoskeletal problems:** Bernal et al. (2015) and Sekkay et al. (2018) **Desire to resign:** Li et al. (2013) **Well-being:** Herr et al. (2017) **Attending work sick or distracted:** Janssens et al. (2016)
Professional Development	**Absenteeism due to work injury or illness:** Slany et al. (2014) **Well-being:** Schütte et al. (2014)
Night work/ Overtime/ Night shift	**Musculoskeletal problems:** Silva et al. (2016) **Absenteeism due to work injury or illness:** Slany et al. (2014) **Sleep problems:** Chazelle et al. (2016) **Stress:** Etefa et al. (2018
Balance life – job	**Musculoskeletal problems:** Oakman, Macdonald, & Wells (2014) Yang et al. (2016) **Sleep problems:** Chazelle et al. (2016) **Well-being:** Schütte et al. (2014) **Stress:** Javaid et al. (2018)
Role conflict/ Meaning of work	**Absenteeism due to work injury or illness:** Johannessen et al. (2015) **Work burnout:** Carrion-Garcia et al. (2015) **Well-being:** Schütte et al. (2014) **Stress:** Inoue et al. (2018)

Source: *Prepared by the Authors, based on the literature review.*

Discussion

Psychosocial risk factors are aspects related to conception, organization and management of work, as well as its social and environmental context, which can cause physical, social or psychological damage to employees (Cox et al., 2005). Consequences of these risks include non-organic anxiety disorders of the sleep-wake cycle [circadian cycle] and severe stress and adaptation problems (STPS, 2014).

The result of the literature review shows a wide spectrum of effects that psychosocial factors have on the work conditions of an employee. These range from musculoskeletal problems to depression, where musculoskeletal disorders stand out with the highest number of mentions in 13 studies that identify them as a consequence of deficient psychosocial factors. Depression, work burnout and negative effects to the feeling of well-being followed with 4 studies each. Psychosocial factors that appear with greater frequency are workload/rhythm in 24 articles, social support/deficient interpersonal relationships in 14 and empowerment problems with 9 papers each. On the other hand, the factor with the greatest number of effects is workload / rhythm, with 10 different associated affectations. Followed by social support/interpersonal relationships with 8, and reward with 6 studies.

Analysis of these findings in the context of Industry 4.0 highlight the importance of providing methodologies for the evaluation and design of workplaces that consider the risks that employees may face by working in increasingly automated areas. The aim should be to identify and manage potential sources of psychosocial risk that have an impact not only on the health of the individual but also on the achievements of the objectives of the Organization.

Limitations

This examination of the most recent works on the subject is the starting point for a deeper investigation which should be based both on the results of subsequent literature reviews, as well as on field investigation, The present work shall serve as a basic guide on the effects of specific work conditions. It is important to distinguish that conditions that impact quality of life at a more general level were not considered: age, obesity, lack of exercise, alcoholism, smoking, nutrition; or pre-existing health situations such as: disabilities, diabetes and high blood pressure, among others. Such conditions were excluded since they cannot be resolved through a better workplace design.

Conclusions and recommendations

Work is a key factor for social inclusion, since it has positive effects on the mental health of workers by providing social status, income security, a structure for managing time, a sense of identity and achievement, as well as self-esteem, while favoring social interaction (OECD, 2012). According to this literature review, research in recent years has allowed a better understanding of the psychological, social and cultural influences to which both human behavior and decision-making are subject. By demonstrating that these influences have a significant impact on the results in terms of socioeconomic development, these investigations also reveal that it is possible to take advantage of these influences to achieve the objectives of such development (World Bank, 2015). Nevertheless, it is important to remember that humans are not a technical element within a system, human behavior cannot be adjusted to technical processes and although people have the ability to self-recover, they may also resist change. This characteristic makes the human factor different from the rest of the elements of the manufacturing system (Laidoune & Gharbi, 2016).

The exploratory analysis carried out in this study showed that health problems caused by work conditions are varied and can have a high impact not only in the work environment, but it may also affect society in general. Although we were able to get an overview from this study, it is also true that a more exhaustive analysis must be carried out based on the information generated as manufacturing systems evolve.

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CHAPTER 4

Reliability Engineering in Industry 4.0

Manuel Baro-Tijerina*[1], Manuel R. Piña-Monarrez[1],
Rey David Molina Arredondo[1]

[1] *Universidad Autónoma de Ciudad Juárez*
* *Corresponding Author: al164467@alumnos.uacj.mx*

Abstract. In the digitalization era, organizations are investing in tools that allow their processes, human resources, machines, supply chains, and products, to be integrated into a global network. This helps the company's improvement and development to increase in a more efficient way. The industry 4.0 (also known as "the fourth industrial revolution") considers the Internet of Things (IT) and how the improvement in technology allows devices or products interconnect to obtain data, analyze and intercommunicate the data to other devices in real-time. Industry 4.0 is based on mechanization, electricity and the internet. Therefore, the fourth industrial revolution, via the IT becoming integrated with the manufacturing environment. Because Industry 4.0 considers the connection of the physical world and virtual world by an internet protocol, the physical-virtual systems will take shape of smarts facilities, smart storage, smart factories, and smart supply chains. This lets us bring improvements in manufacturing through the whole value chain. The source for improvement comes from the process, engineering, material usage, product management and product reliability. Thus, the object of this research is to present a practical reliability methodology that can be integrated into the implementation of the industry 4.0 paradigm.
Keywords: Future Development for the Internet of Things, Industry 4.0, Factors Affecting Industry 4.0.

Introduction

The development of new technologies is currently advancing at higher rates but one of the greatest technological advances thus far is the internet. According to various authors, like (Cascio & Montealegre, 2016), the internet has adjusted the way of communication all over the world. Because of this, all kinds of products and devices are now connected to a network protocol called the internet. The integer is beginning to have more control of products, processes, human resources, supply chain, transportation, including the final disposition of products in industries and companies. This is possible due to the Internet of Things (Oztemel & Gursev, 2018). The IT not only does it allow a connection between different devices (such as computers, cars, refrigerators, smartphones, industrial machines, tools, etc.), it also permits the sharing of information, data analysis and decision making in real-time (Alcácer & Cruz-Machado, 2019). Nonetheless, the development of an infrastructure with physical systems and models to manage in a more efficient way the facilities of Industry 4.0 is yet to be improved. Time span is a mayor element to consider within Industry 4.0, since the emergence of new industrial areas are clearly inescapable (Nagy, Oláh, Erdei, Máté, & Popp, 2018). This has caused organizations to learn, understand and implement the internet and to be prepared for its progressive development and process transformation. In this chapter, the industrial Internet of Things, big data analysis, horizontal system integration, autonomous robots and cybersecurity (OECD, 2017) are explored to demonstrate how reliability analysis can be used in Industry 4.0. Notwithstanding, it is important to keep in mind that the connectivity devices depend on the reliability index level.

The Internet of Things

IT became relevant in the world because of the advances in technology and mobile devices. Fundamentally, the Internet of Things concerns billions of products or objects that can sense, communicate and share data while interconnected by internet protocol network. The objective of the interconnection of objects is the capacity of planning, management and decision making. Having that in mind, the Internet of Things can be defined as a physical object communicated by a network (Patel & Patel, 2016). It is important to remember that IT is not only about computers networks, it is also about all type of devices (see fig.1) (INCIPY, 2015).

Figure 1: Internet of things

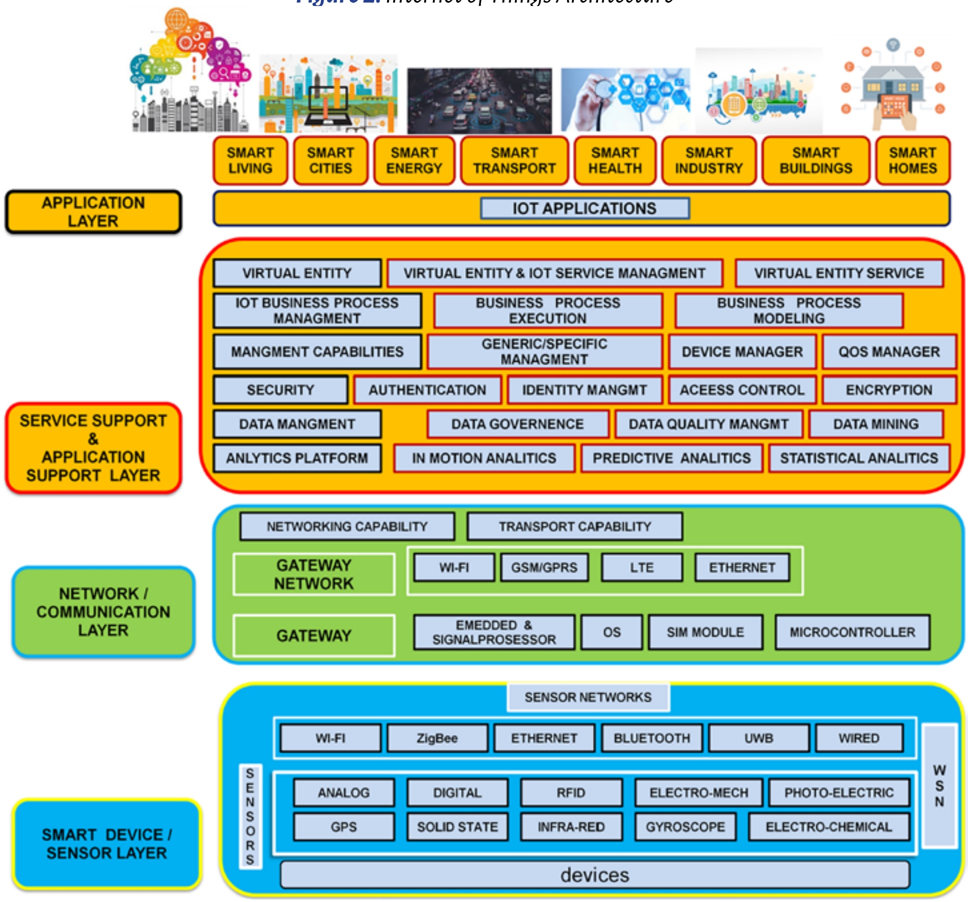
Source: *(Regis, 2014)*

The Internet of Things will continues to increase its impact in all activities. Considering that we can already notice an effect the internet has had on education, communication, industry, science, government, etc. Because of this, one can say that it is one of the most important human advances. Moreover, IT represents the next evolution of the internet, which will involve the interchange and analyzation of data and its distribution (GSMA Association, 2014). IT can be summarized into three main categories: people to people, people to machines and things machine to things machine, all of them interacting through the internet.

Future Development for the Internet of Things

The development of technologies such as sensors, smartphones, information systems, cloud network, and software, will be necessary in order to allow the physical evolution of devices to operate in a dynamic environment. Moreover, development is necessary also to permit connection between them anytime and anywhere (Cheruvu, Kumar, Smith, & Wheeler, 2020). An affiliation between the physical and the virtual using internet protocol as communication and the interchange of date is what IT seeks to achieve. However, increasing to a world scale the devices integrations to interoperability information generated by the IT resources is still a challenge. Nonetheless, the Internet of Things is based on an architecture that consists of several layers, from the data acquisition at the bottom to the application at the top. As seen in fig.2 (Bandyopadhyay & Sen, 2011).

Figure 2: Internet of Things Architecture



Source: *(Patel & Patel, 2016)*

Industry 4.0

Industry 4.0 can be defined as a new organization and control level over all the value chain if the lifecycle of devices or products is geared to the individualization of customer requirements. This control in an organization begins with the raw material and ends with the recycling of the product, including customer service during the lifetime of the product. The significance of Industry 4.0 relies on the availability of information in real-time by connecting the instances of the value chain, which is vital for industries to optimize each link of the product in the value chain. Moreover, the connection of systems, things, and people create a dynamic value-added with organizations. For example. the costumers are closer to the industries and the information is dual between the company and client (Tjahjono, Esplugues, Ares, & Pelaez, 2017). Industry 4.0 allows the organization to become digitalized with sensing devices virtually in all components, products, machines, and tools (Schwab, 2016). Table 1 presents some definitions of Industry 4.0.

Table 1: *Industry 4.0 Definition*

Autor and year	Definition
Kagermann, Wahlster & Johannes (2013).	Industry 4.0 utilizing the power of communications technology and innovative inventions to boost the development of the manufacturing industry.
Qin, Liu & Grosvence (2016)	Industry 4.0 encourages manufacturing efficiency by collecting data smartly, making correct decisions and executing decisions without any doubts. By using the most advanced technologies, the procedures of collecting and interpreting data will be easier. The interoperability operating ability acts as a "connecting bridge"to provide a reliable manufacturing enviroment in Industry 4.0. This overall consciousness gives Industry 4.0 the most importante aspect of artificial intelligent functions.
Schumacher, Erol & Sihn (2016).	Industry 4.0 is surrounded by a huge network of advanced technologies across the value-chain. Service, Automation, Artificial Intelligence Robotics, Internet of Things and Additive Manufacturing are bringing in a brand new era of manufacturing processes. The boundaries between the real world and virtual reality is getting blurrier and causing a phenomenon known as Cyber-Physical Production Systems (CPPS),
Schwab (2016)	Industry 4.0 differentiated by a few characteristics of new technologies, for example: physical, digital, and biological worlds. The improvement in thecnologies is bringing sifnificant effects on industries, economics and goverments development plans. Schwab pointed out that Industry 4.0 is one of the most important concept in the development of global industry and the world economy.
Wang et all, (2016)	Industry 4.0 makes full use of emerging technologies and rapid development of machines and tools to cope with global chalenges in order to improve industry levels. The main concept of Industry 4.0 is to utilize the advances information technology to deploy IoT services. Productiono can run faster and smoothly with minimum downtime by integration engineering knowledge. Therefore, the product built will be of better quality, production system are more efficient, easeier to maintain and achieve cost savings.
Mrugalska & Magdalena (2017)	The modern and more sophisticated machines and tools with advanced software and networked sensors can be used to plan, predict, adjust and control the societal outcome and business models to create another phase of value chain organization and it can be managed throughout the whole cycle of a product. Thus, Industry 4.0 is an advantage to stay competitive in any industry. To create a more dynamic flow of production, optimization of value chain has to be autonomously controlled.

Source: (Tay, Lee, Hamid, & Ahmad, 2018).

The changes by Industry 4.0 Application

Generally, organizations are focused on the production process. Nonetheless, the changes with the implementation of the Industry 4.0 are the focus in a lifetime of a product and the decision-making in the agreement of information (Cotteleer & Sniderman, 2017).

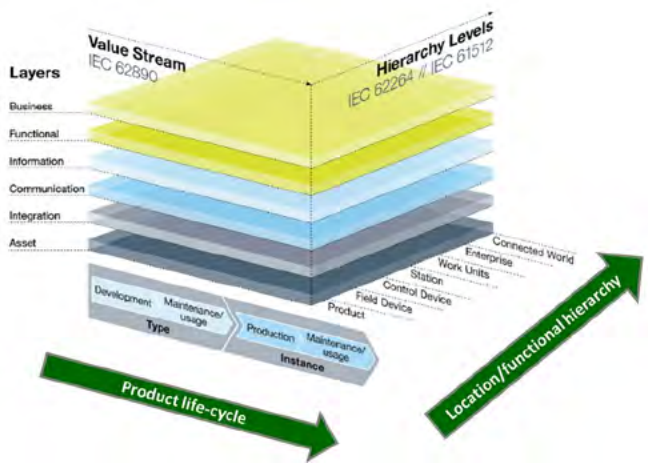
Figure 3: *Changes in production operations industry 4.0*

Source: *(Crnjac, Veža, & Banduka, 2017)*

Factors Affecting Industry 4.0

The implementation of Industry 4.0 in organizations represents an important challenge due to all the hardware requirements needed. In order for the hardware to support all data, processes, and interconnectivity, it must provide the necessities of Industry 4.0. The correct hardware is not only what industries need, it is also important how long the hardware installed will perform efficiently in order to support the communication and data in the industry (J.-S. Chen & Tsou, 2012).

Figure 4: *Architecture Model for Industry 4.0*



Source: *(Rojko, 2017)*

The software used during connection and data processing is another key element to consider throughout the implementation of Industry 4.0. Although some corporations provide software during the application of Enterprise Resources Planning (ERP) like SAP and Oracle, Industry 4.0 encompasses more than communication with all branches integrated within the complete enterprise, the suppliers and the customer. This new software needs to support a considerable amount of data. For now, the data represents quantities like terabytes and even petabytes to support data interchange. Moreover, the industries not only must deal with the correct software, but also with the duration witch that software will perform in an efficient way (Breeding & Smith, 2013). Another relevant factor that can be part of the success or failure in a company is the connection. Transmission of big data (see figure 4) between every node in the internet protocol is a very important problem. i.e., Industry 4.0 makes that industries have to evolve in a virtual global company. The necessary connection in Industry 4.0 include multiple countries to interchange data with companies, suppliers, clients, transport and customers while each one is interconnected (Koch & Kuge, 2015). It is also important to consider the connection time and the speed of data interchange(Biggs, 2019). Notwithstanding, reliability is also a vital tool for optimal performance in industry 4.0.

Reliability Engineering in Industry 4.0

The efficiency of the interconnection, the hardware performance in optimal conditions and software support over time, depends on the reliability of the user's device to perform the interconnection. Moreover, wireless transmission of big data depends on a frequency. The used signal to connect devices like smartphones, computers, smart buildings, etc., is possible through the use of stochastic processes (Govindan, Zeng, & Mohapatra, 2011), which means, that connections in devices and the wireless technology are representing by a probability density function (Raptis, Passarella, & Conti, 2019). The Weibull distribution is widely used in internet connections because this distribution provides better goodness-of-fit to real-world data and as it is known. The Weibull distribution is also widely used in reliability estimation. A methodology to determine the reliability of devices presented in the framework of the industry 4.0 approach (Liu, White, & Dumais, 2010). Reliability predicts analysis and optimizes products, elements or systems. This represents an opportunity in Industry 4.0 to be efficient all over the value chain. This is because reliability methods respond to the optimal work of devices like hardware, software, and connectivity, without this, all the framework cannot be performed. As a consequence, Industry 4.0 could be implemented in any company or organization but all the changes, challenges and invest to implementation will be irrelevant if the time of performance is unknown. For example, if the company doesn't know reliability of devices and connectivity, the uncertainty of Industry 4.0 it will be significant (Farsi & Zio, 2019). Uncertainty is one of the main challenges in both virtual and physical applications. The uncertainty can be managed using reliability methodology (Andrzej, 2016). The implementation of reliability methods in Industry 4.0 are imperative to deal with uncertainty and it possess an efficient physical and virtual fabric in a global network of communication and data interchange, based on internet protocol. In the next section, reliability concepts and generalization are presented. Moreover, for an electronic device or product to be qualified as safe and reliable, it is necessary to identify significant factors and conditions that affect de device performance and find the failure mode. Using this failure mode, the lifetime of the device can be estimated with a high-reliability level (Phister, 2019). Thus, it is important to understand the mechanisms that cause the failure and identify what factors accelerate or decelerate the failure mechanism to accurately estimate and predict the life and mitigate the unexpected failures (Varde, 2010).

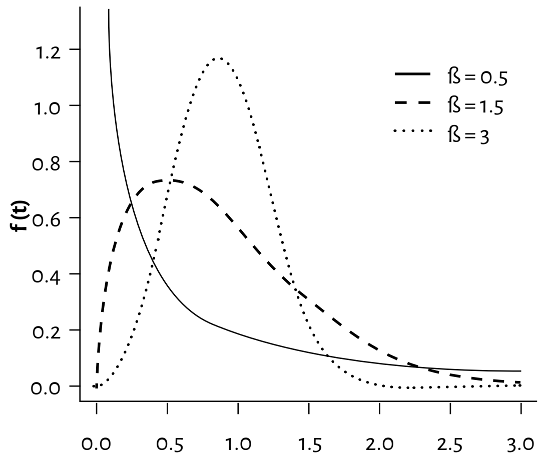
Reliability Engineering Concepts

Reliability is the best quantitative measure of products, elements or systems design, it is quality over the time of parts, elements, systems, etc. that performed this function without failure, in a specific environment for a time period (Rinne, 2009). In other words, the function for which it was created, under the conditions and operational environment established for a given period of time (Sorenson, 2011). It is necessary to remember that reliability only applies once the process is in control, that is, stable and predictable over time, highlighting that it is met only for the given conditions and environment (Ebeling, 1997). Nonetheless, one of the most used distributions in reliability engineering to model the life of any product whose deterioration is due to physical phenomena is the Weibull Distribution. As it was illustrated above, Weibull distribution is widely used to determine electronic devices and internet wireless connectivity reliability. Reliability in Industry 4.0 mainly relied on Weibull distribution to get a trustworthy design over a period of time (Tortorella, 2005).

Weibull Distribution Generalities

The Weibull distribution is widely used in reliability and lifetime analysis due to its flexibility, the design, production, and wear-out or aging phases of a product (see figure 5). Moreover, all products are subjected to a random environment (Piña-Monarrez, Ramos-Lopez, Alvarado-Iniesta, & Molina-Arredondo, 2016).

Figure 5: Cumulative Density Function Weibull Distribution



(Ortiz-Yañez & Piña-Monarrez, 2018) The Weibull distribution (Weibull, 1939) given by:

$$f(t) = \frac{\beta}{\eta}\left(\frac{t}{\eta}\right)^{\beta-1} e^{-\left(\frac{t}{\eta}\right)^{\beta}} \tag{1}$$

With cumulative failure function and reliability function given by

$$F(t) = 1 - e^{-\left(\frac{t}{\eta}\right)^{\beta}} \tag{2}$$

$$R(t) = e^{-\left(\frac{t}{\eta}\right)^{\beta}} \tag{3}$$

Where the estimation of the β and η parameters is performed by using the linear form of Eq. (2) as

$$Y_i = \ln\left(-\ln\left(1 - F(t_i)\right)\right) = -\beta \ln \eta + \beta \ln t_i \tag{4}$$

The linear model is given by

$$Y_i = b_0 + \beta X_i \tag{5}$$

With $Y_i = \ln\left(-\ln\left(1 - F(t_i)\right), b_0 = -\beta \ln(\eta)\right.$, and $x_i = \ln(t_i)$.

$F(t_i)$ in Eq. (2) is estimated by median rank approach (Mischke, 1979) given by

$$F(t_i) = \frac{1-0.3}{n+0.4} \tag{6}$$

From (Piña-Monarrez et al., 2016), the sample size n is determined as

$$n = \frac{-1}{\ln(R(t))} \tag{7}$$

And the mean μ and the standard deviation σ are given as

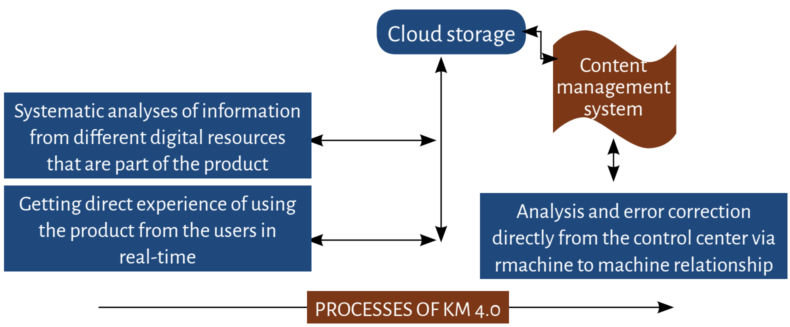
$$T_1 = \eta * \Gamma_1\left(\frac{1}{\beta} + 1\right) \tag{8}$$

$$\sigma_T = \eta\left(\Gamma\left(\frac{2}{\beta} + 1\right) - \Gamma\left(\frac{1}{\beta} + 1\right)^2\right)^{\frac{1}{2}} \tag{9}$$

Weibull Distribution and Industry 4.0

The information on the mean values of signals in telecommunications like cellphones, internet protocol, computers, radios, printers and all devices that used a frequency to communicated is not sufficient to characterize the performance of communication systems, time variation, space and frequency, must also be taken into account (Guimaraes, 2009). The dynamic behavior of the desired and interfering signals plays a decisive role in the analysis of system reliability and in the choice of system parameters, the signals must be considered as a random variable and to model this variable a probability density function is necessary (Aggarwal, 2013). On the other hand, electronic devices are used physical and virtually everywhere, thus, Industry 4.0's success is based on the accuracy of these electronic devices and the communication between all of them. In this manner, the electronic communication needs to be able to reach the entire world (Lampropoulos, Siakas, & Anastasiadis, 2019).

Figure 6: *knowledge Management Industry 4.0*



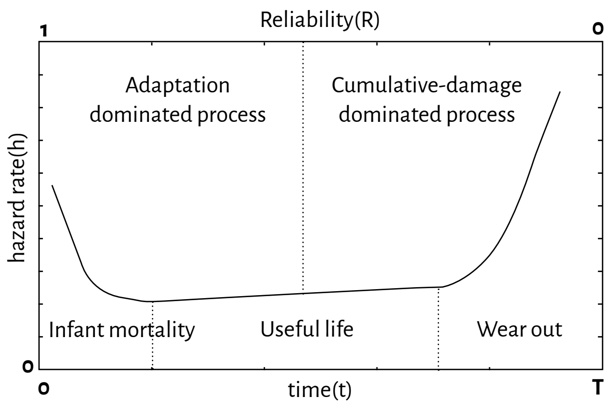
Source: *(Roblek et al., 2016)*

Description of the life of a product or element known as the bathtub curve (see figure 7). The bathtub curve consists of three periods: an infant mortality period with a decreasing failure rate followed by a normal life period with a low rate, relatively constant failure rate, concluding with a wear-out period.

The bathtub describes the relative failure rate of an entire population of products over time (Wang, Hsu, & Liu, 2002). The success factor is the choice of the reliability model that captures lifetime variables for parameters estimation and defined adequately the distribution. In that way, the most adequate distribution to fit the failure mode in electronic devices and connectivity protocol is the Weibull distribution, since it is based in the weakest link, allowing electronic and virtual devices identify the failure mode and accurately calculate the reliability of components being physical or virtual (Bernstein et al., 2006).

Nonetheless, Weibull distribution is very useful in the modeling of Internet traffic data sessions, flows and packets at different internet network connection levels. The scale parameter of the Weibull distribution can also be used to characterize the internet traffic and flow (Arfeen, Pawlikowski, McNickle, & Willig, 2013).

Figure 7: *Bathtub Curve*



Source: *(Wang et al., 2002)*

Stress-Strength Models in industry 4.0

As mentioned above, there exists factors that affect the efficiency in the components in Industry 4.0. For example, the device that received the information and processes it to increase the making of decision easier. Devices include all kinds of diapositives like personal computers, cellphones, smart factories, etc. The connection between devices using internet protocol is another significant element. Connectivity on devices across wireless internet is possible due to the signals that send and receive hypertext at the same time. These signals are transferred like a wave frequency, thus, these signals are also random variables. The overlap of two signals represents a failure either in received or transmitted hypertext. In this case, the reliability estimation can be performed using stress-strength analysis. The generalities of stress-strength are presented in the next section as well as the stress-strength Weibull-Weibull to estimate reliability.

Stress-Strength Generalities

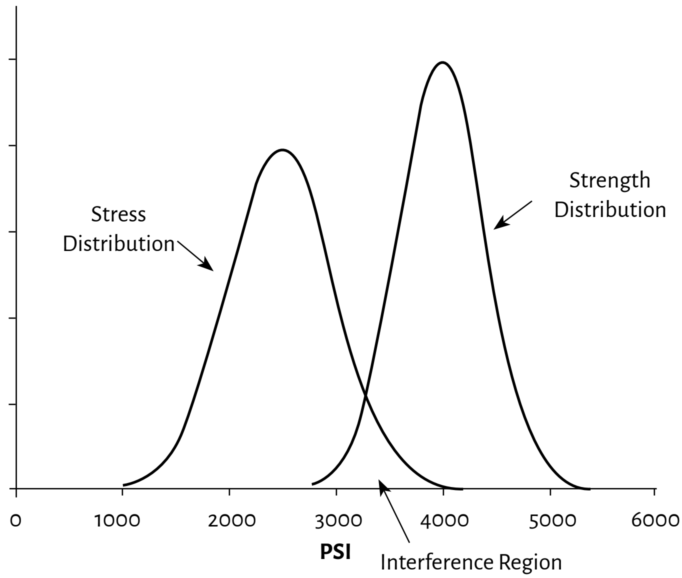
There are some applications where product reliability depends on their physical inherent strength (Weiqiang, Azarian, & Pecht, 2008). Thus, if a stress level higher than the stress is applied then they break down (Levitin & Finkelstein, 2017).

Therefore, if the random variable X represents the 'stress' and the random variable Y represents the 'strength', the stress-strength reliability is denoted by the probability that Y>X (Eryilmaz, 2010). In the stress-strength analysis, the term "stress" is referred to the load that produces the failure and the "strength" is referred to as the ability component to sustain the load (Quanterion Solutions Incorporated, 2014). On the other hand, in the stress-strength model, the interference between the stress and strength variables results in a statistical distribution (Mohammad Modarres, Mark P. Kaminskiy, 2009). Thus, a natural scatter occurs in these variables when the two distributions interfere with each other (Borradaile, 2003). When the stress becomes higher than the strength, a failure occurs (Elishakoff, 2004). That is to say, when the probability density functions of both stress and strength are known, the component reliability may be analytically determined by its interference (see Figure 8) (J. Chen, 2004). Seeing this, let Y and X be two random variables such that Y represents "strength" and X represents "stress" and let Y, X follow a joint probability density function pdf (Shayib & Haghighi, 2013). Then based on the , the reliability of the component is estimated as

$$R = P(X < Y) = \iint_{-\infty}^{x} f(y,x)dxdy \tag{10}$$

Where is the probability that the strength exceeds the stress and is the joint pdf of Y and X (Basu, 2008).

Figure 8: Stress-Strength



Source: Authors

Stress-Strength Weibull-Weibull Reliability Formulation

Considering the problem of finding the strength reliability of an item functioning until the first failure, when both strength (Y) and stress (X), i.e. (Huang, Mi, & Wang, 2012), follow a Weibull distribution with pdf form:

$$f(x) = \beta\eta t^{\beta-1} e^{\eta t^{\beta}} \tag{11}$$

Therefore, the inference region represents the corresponding cumulative failure function (Huang et al., 2012). Thus, based on the Weibull distribution defined in Eq. (1), the Weibull/Weibull stress/strength formulation for $\beta s = \beta S$ is as follows.

Stress-Strength Weibull for ($\beta_1 = \beta_2$)

When parameters are the same, it can be observed that the Weibull-Weibull stress-resistance model is the same as the exponential-exponential model, as long as β_1 and β_2 remain constant (Babula & Sadananda, 2015). The methodology to determine the reliability in the Weibull-Weibull in the ($\beta s = \beta s$) case is defined as

$$R = P(Y > X)$$

$$R(t) = \int_0^{\infty} f(x)\left[\int_t^{\infty} f(y)dy\right]dx \tag{12}$$

$$R(t) = \frac{\eta_y^{\beta}}{\eta_y^{\beta}+\eta_x^{\beta}} \tag{13}$$

Unfortunately, because the stress behavior is determined by the environment on which the device and the device strength depends on connection time, the stress and strength variables are independent of each other, as a consequence, the probability that $\beta s = \beta s$ is very low.

Numerical Application for $\beta_S = \beta_S$

Table 2: *Stress and strength Frequency*

Stress (Hertz)	Strength (Hertz)
10096	13507
10469	13793
10955	13943
11183	14017
11391	14147
11486	14351
11534	14376
11919	14595
12105	14746
12141	14810
12405	14940
12527	14951
12536	15104
12595	15218
12657	15303
13777	15311
13862	15480
13971	15496
14032	15522
14138	15547

Source: *Authors Self-made*

From this data the Weibull stress parameters are βs=12.2171, and ηs = 12791 and the Weibull strength distribution parameters are βs=12.2171 and and ηs = 15041. From eq.(13)

the reliability index is *R (w)* = *0.878643*. This means that the probability of non-overlap signals is 87.86%.

Stress-Strength Weibull Formulation for *(β1 ≠ β2)*

For stress variable *X1=X* and the strength variable *X2=*Y holds only for *βS* = *βs*. Therefore, the fact that the stress-strength Weibull-Weibull reliability function, for *βS≠βs* is given as

$$R(t) = P(Y > X)$$

$$R(t) = \int_0^{\infty} f(x)\left[\int_x^{\infty} f(y)dy\right] = \int_0^{\infty} f(y)\left[\int_x^{\infty} f(x)dx\right]dy \quad (15)$$

$$R(t) = 1 - \int_0^{\infty} e^{-\left[W + \left(\frac{\eta_y W^{\frac{1}{\beta_y}}}{\eta_x}\right)\right]} dW \quad (16)$$

Numerical Application for (*β1 ≠ β2*)

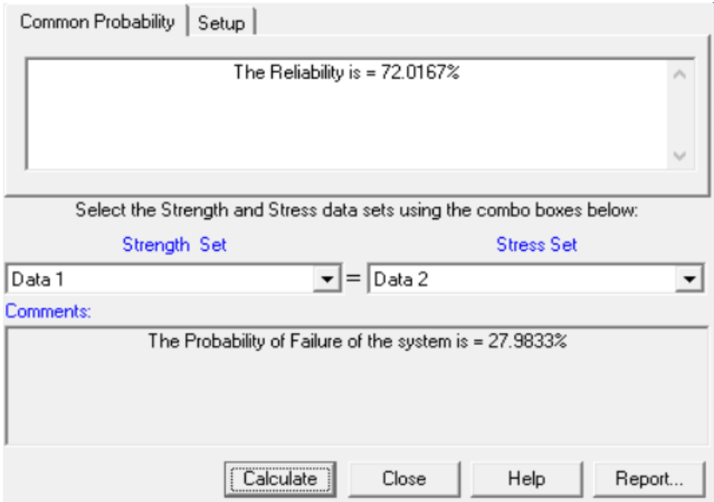
The first set of values is the number of cycles per second before the failure of 23 signals measured in an accelerated life test and the second set of values represents the distribution of the stress to which the signals were subjected as presented below.

Table 3: *Cycles to Failure kHz*

Strength	Stress	Strength	Stress
17.88	100	68.44	40
28.92	95	68.64	35
33	90	68.88	30
41.52	85	84.12	25
42.12	80	93.12	20
45.6	75	98.64	15
48.8	70	105.12	10
51.84	65	105.84	10
51.96	60	127.92	10
54.12	55	128.04	10
55.56	50	173.4	10
67.8	45		

Source: *Authors*

Figure 9: Stress-Strength Weibull-Weibull



Source: Authors

As it can be assured by using the reliability software, the reliability for the stress-strength analysis is 72.0167, with beta and eta of the strength of 2.25 and 80.75 respectively. Moreover, the stress parameters are equal to 1.48 for the parameter form β and 51.44 for the η scale. The shape parameters of both stress and resistance are different, thus, the infinite integral presented in Eq. (16) is performed.

Capability Index as an Efficient Measure in Industry 4.0

An important efficient method in reliability estimation is the capabilities index. This measure guarantees the efficient performance of devices and connectivity in Industry 4.0. This capability index is based in the Weibull distribution, this distribution is highly effective in electronic reliability devices and in internet signal connections. Since the proposed PCIs are based on the logarithm of the lifetime data, which is asymptotically normal, then they are analogous to those of the normal distribution defined. The only difference is that the Weibull PCIs are measured in the logarithm scale.

$$CP_w = \frac{USL_x - LSL_x}{6\sigma_x} \tag{17}$$

$$CPK_w = \left[\frac{USL - \mu_x}{3\sigma_x}; \frac{\mu_x - LSL}{3\sigma_x}\right] \tag{18}$$

For more information see (Piña, Baro-Tijerina, & Ortiz-Yañez, 2017).

Conclusion

Industry 4.0 is considered the fourth industrial revolution. The concept of Industry 4.0 can be defined as a new organization control level over all the value chain. The control begins with raw materials and ends with the product being recycled including the customer in each supply-chain step of the process. The concept of Industry 4.0 is similar to tat of the Internet of Things, however, the application of the latter is in companies, factories, organization, etc. Moreover, Industry 4.0 permits an interchange of electronic data in real-time and serves as a commercial advantage in the decision-making process. If the information is extensive, then the decision possesses a minor uncertainty, this is possible because of technological advances. This chapter showed how the use of reliability engineering improved Industry 4.0 and it illustrates the importance of reliability in the integration of all levels in Industry 4.0 in order to ensure that necessary factors performed in a correct way for an expected time. Moreover, the reliability application in Industry 4.0 allowed modeling of variables that are involved over the value chain. The application of reliability methods is vital to ensure optimal performance in devices and connectivity for the purpose of proper exchange of electronic information around the world for a given period of time.

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CHAPTER 5

Weibull Reliability Methodology for Ball Bearing Design Based on Hertz Stress With Focus on Industry 4.0

Baldomero Villa-Covarrubias*[1], Manuel R. Piña-Monarrez[1], Lázaro Rico-Pérez[1]

[1] *Doctorado en Tecnología, UACJ.*

**Corresponding Author: baldomero.villa@uacj.mx*

Abstract. The fourth industrial revolution, also known as Industry 4.0, is characterized by the digitalization of processes and use of technologies for manufacturing along with the combination of production processes and machines using internet, software and sensors is common. Since many of the mechanical elements of machines like bearings, screws, springs, gears, and pulleys are prone to failures or requiere constant maintenance, Industry 4.0 allows an analysis and provides instant feedbacks of the problems. Thus, when the process machines are interconnected and available, fewer failures will surface due to instantaneous feedback. Consequently, maintenance programs need to be rigorously designed, implemented and monitored. Moreover, there exist various types of maintenance such as preventive, corrective and predictive. The latter is the maintenance that is more commonly used in Industry

4.0. Nonetheless, one of its major issues is that there are machines in which it is difficult to adapt sensors to monitor it when maintenance is required. In this case, the alternative option is schedule its preventive maintenance based on the useful life of their components. In some industries, such as aeronautics and wind power, it is necessary to know the failure time of the mechanical components to replace them and to avoid machines shutdowns, this is done based on its reliability. Although manufacturers of mechanical elements (such as bearings) offer their products with a reliability of 90%, because they were produced in different environments than the ones they are used on. Nonetheless, designers, maintenance engineers and machinery users need to know their reliability percentage under the actual conditions. Therefore, in this chapter, a methodology to obtain the reliability of a ball bearing that corresponds to the actual conditions is presented. The bearing reliability is determined based on the Weibull distribution. The Weibull parameters are determined from the generated contact Hertz stresses that occur below the surface of the outer race of the bearing. Finally, from the real reliability index, the corresponding lifetime of the component is determined and then it is used to formulate the corresponding maintenance plan. This methodology can be applied in cases where the adaptation of sensors is difficult and when it is required to know the life of the components to avoid failures.

Keywords: Weibull reliability methodology, Hertz stress, Industry 4.0.

Introduction

Industry 4.0 consists of the union of physical and digital technologies to generate intelligent production systems that integrate all the stages of development of a product and process which has therefore a positive impact on efficiency and increased productivity. Generally, Industry 4.0 focuses primarily on increasing production and quality so that it can increase revenues and competitiveness (Oláh et al. 2020). This brings together machines and production processes by using internet, software and sensors. Therefore, when machines are connected with each other, it is required for all of them to be in operation and not present any failures. The above task can be achieved through proper maintenance, and predictive maintenance. Predictive maintenance is commonly used in Industry 4.0 because at this stage we use sensors and other equipment to monitor the machine components. However, because there are machines that contain elements on which it is difficult to adapt sensors, or it is expensive to use predictive maintenance, reliability index is used to schedule its maintenance. In particular, since ball bearings are the components that allow movement in a machine—as it is the case of vehicles, machines, airplanes, appliances, and precision equipment (Yu et al., 2018)(Panda et al., 2015)—analysis under the Industry 4.0 framework is necessary. Ball bearings are the main cause of failure in the rotating machine (Upadhyay & Kankar, 2018). A ball bearing failure can cause the machine to breakdown, which causes a communication loss with other machines and economic downturns (Cui et al., 2019). Thus, fatigue life prediction for bearing has significant and practical value for machines that are used in industry 4.0 (Guo et al., 2015).

Bearing manufacturing companies offer their products with a reliability based on an L10 life. Unfortunately, because it is obtained through testing bearings based only on static loads and specific rotation speed (Budynas et al., 2015), it does not represent the actual environment on which the ball bearings are performing. Therefore, in this article, a new methodology to determine the real reliability of a ball bearing is presented. The methodology is based on the Hertz's contact stresses values generated under the surface of the fixed ring race (the outer ring in this case). The methodology will be useful as an example in the aerospace industry where bearings are critical and require high performance (Yakout et al., 2019).

The approach is based on the traditional method to select a ball bearing, and based on the Hertz's theory, the contact stresses values are determined. Then, they are used to estimate the shape parameter beta (β) and the scale parameter eta (η) of the Weibull distribution. Finally, based on the Weibull theory, the real reliability of the ball bearing is determined. It is highlighted that by applying this methodology the real reliability for any application that uses single-row deep groove ball bearing can be determined.

This chapter is organized as follows: Generalities of of Industry 4.0 and the Internet of the Things are presented in Section 2. In Section 3 the maintenance generalities are presented. The reliability and Weibull distribution concepts are given in Section 4. Section 5 presents the ball bearings generalities. Section 6 describes the steps to get the real reliability of a ball bearing. Section 7 shows the application of the new methodology. Conclusions are presented in Section 8.

Industry 4.0

Manufacturing industry has undergone a rapid evolution, commonly known as Industry 4.0 (Kagermann et al., 2011). The numeration 4.0 is assigned because it is the fourth industrial revolution. The first industrial revolution was during the eighteenth century with the rise of steam engines. The second industrial revolution refers to mass production driven by electricity. The third industrial revolution originated in the second half of the twentieth century with the automation of machines and the rise of computers. Three previous industrial revolutions caused great advances in productivity and changed the lives of people around the world (Evans, 2011).

In the last decade, the manufacturing industry is undergoing changes due to the incorporation of digital and information technologies. These changes have brought great improvements in manufacturing processes achieving improvements in products and services. The concept of Industry 4.0 is relatively new and was established in Germany in 2011 due to an governmental economic policy based on high-tech strategies (Ynzunza et al., 2017)(Sommer, 2015). It is characterized by the digitalization of processes and the use of technologies such as electronics and information in manufacturing (Cooper et al., 2009). In addition, manufacturing and information technologies have been integrated to create innovative manufacturing systems, management and ways of doing business, which allow to optimize manufacturing processes, achieve greater flexibility, efficiency and generate a value proposition for its customers.

Another component of Industry 4.0 is based on intelligent production systems consisting of the union of physical and digital technologies, in addition to the integration of all stages of development of a product or process. This brings an important positive impact on efficiency and increased productivity (Ynzunza et al., 2017). In Industry 4.0, machines and production processes are united using internet, software and sensors. There are several technologies that support Industry 4.0 such as the Internet of Things (IoT), the internet of people and services, the development of systems (Cooper et al., 2009) (Lasi et al., 2014) (Ning et al., 2016); in addition, additive manufacturing, 3D printing, reverse engineering (Sommer, 2015), artificial intelligence, big data analysis, augmented reality, etc., (Tao et al., 2014) (Chen et al., 2015)(Qiu & Sha, 2007) (Wang et al., 2014) (Wang et al., 2016). IoT is a technology that is connected directly with Industry 4.0, one cannot talk about 4.0 Industry without mentioning the Internet of Things.

Internet of things

The Internet of things is made up of two parts, the first one is the Internet network which allows computers and phones to be connected worldwide and to share information. The second part is the things or objects that we have in homes or machines and equipment in factories which have been adapted with sensors, circuits, software and are connected to each other through the network. In addition, these objects can collect data and exchange information with each other or with the internet network. These objects are also known as IoT nodes or smart devices and they must fulfill the following functions:

- Monitoring. As the object has several sensors it can collect information like speeds, temperatures, heights, weight, pressures, etc.
- Control. Once the information is collected, the control allows actions such as turning off a device, like opening a valve or a gate, etc.
- Optimization. Know how to use resources when required.
- Automation. Facilitate and reschedule routine activities.

Intelligent devices are objects that have sensors and integrated circuits to collect information that can be exchanged with other intelligent devices or computers that have the function of analyzing data and making decisions that optimize processes.finally, IoT has integrated information, communications technologies, standardization agreements, and a way of seeing society interacting with a Person-Machine or M2M (Machine-to-Machine). Thus, its communications infrastructure will provide a new generation of services in the Internet of the future that will allow the interconnection of wireless sensing devices in wireless sensor networks (WSN Wireless Sensor Network) through the use of an IP (Ishaq et al., 2013).

Maintenance

Even though machines are now integrated with sensors, circuits and are intercommunicated by the internet, they requiere constant maintenance and ignoring it can cause failures. Since Industry 4.0 requires machines that are always available, that have fewer failures and shutdowns, maintenance programs must be stricter in preventing failures. Moreover, with the advance of Industry 4.0, many of the mechanical elements of the machines will not change radically, such as the bearings, screws, springs, gears, cams, pulleys, which will remain the same and operate on the same principles. In some industries, like aeronautics and wind fields, it is necessary to know the failure time of the mechanical components to change them in time and avoid stoppages. Thus, it is necessary to know the real lifetime and reliability, which can be integrated into a maintenance program of several types.

Preventive Maintenance

The purpose of preventive maintenance is to avert machines, machine elements and equipment from failing. Preventive maintenance programs are most often provided by the machine manufacturer. The failures that are predicted with preventive maintenance avoid stoppages in the machinery, thus, avoiding economic losses caused by downtime of production. In addition to guaranteeing the continuous flow of production and the flow of the economy (Schmid et al., 2014). Preventive maintenance is scheduled for a certain period in which a machine has to receive adjustments, cleaning or some changes of filters or fluids.

Corrective Maintenance

Corrective maintenance is carried out to repair the damage when a machine fails. Here, damaged parts must be changed and adjustments made so that the machine returns to work efficiently. A failure involves economic losses since certain elements must be changed and/or the machine repaired, in addition to losses due to production downtimes.

Predictive Maintenance

Predictive maintenance is a product that has been widely disseminated in the industry. Predictive maintenance is based on the existence of functional parameters. The first parameter is the indicator of the status of the equipment and the second is the continuous monitoring parameter of the equipment. Both are intended to detect the failure before it occurs to ensure proper operation, observe its evolution and predict the residual life of its components (Gomez de Leon, 1998). The predictive maintenance evaluates the state of the machinery and with the result it makes the decision to intervene (or not), to make the necessary adjustments or to change a piece before failure, which produces great savings. The objective of this type of maintenance is to optimize the reliability and availability of critical machinery and equipment at minimum cost (Paper, 2018). The most common predictive techniques in industrial facilities are the following:

- Vibration analysis, considered by many to be one of the most important techniques in predictive maintenance.
- Thermographs.
- Borescopic.
- Analysis of oils.
- Ultrasound analysis.
- Analysis of combustion fumes.
- Thickness control in static equipment.

Predictive maintenance is linked to Industry 4.0 and the IoT because a machine can be monitored with sensors and take large amount of data to predict failures and make decisions. Currently, there are factories where it is difficult or expensive to adopt sensors and software machinery, so it is necessary to know the real lifetime of the components they use in some other way.

If the life of the components is known, failure, closures and corrective maintenance can be avoided. In the aeronautical and the wind power industry, it is necessary to know precisely the life of its components, like the bearings used in its mechanisms. This chapter focuses on the bearing industry, where companies offer lifetimes based on reliability determined in their laboratories under constant forces. Thus, it is necessary to know the reliability and actual lifetime caused by real forces to the that the bearing is subject.

Reliability

Reliability is defined as the probability that a product, component or equipment will function properly over a period of time in specified environments at a given level of confidence. Another way to define reliabilityis "quality over time". Today, the concept of reliability is applied in all product design areas. An example, in the design of ball bearings, where you want to know your lifetime. Mechanical designers use safety factors that compare the effort generated in the component against the strength of the material. Nonetheless, most of the time they do not consider the concept of reliability, which goes beyond a safety factor. Reliability analyzes the life of a product which can be measured in cycles, revolutions, hours, or years depending on the type of product. In the analyzed period, the product is expected to operate satisfactorily without failures. In this analysis, the distribution function used is the Weibull distribution.

Weibull Distribution

Weibull distribution was developed in the middle of the 20th century by mechanical engineer Waloddi Weibull. In 1951, Weibull published an article called "A statistical distribution function of wide applicability" from which the Weibull distribution arose (E. Y. Zaretsky, 1986) (B, D 2006). In this analysis the two-parameter Weibull distribution is used and is defined by the parameter (β) that determines the shape or profile of the distribution and the parameter teta (η) that indicates the scale of the distribution, showing how sharp or flat is the distribution. The probability density function of the Weibull distribution of two parameters is given by:

$$f(t) = \left(\frac{\beta}{\eta}\right)\left(\frac{t}{\eta}\right)^{\beta-1} e^{-\left(\frac{t}{\eta}\right)^{\beta}} \tag{1}$$

Therefore, its reliability function is:

$$R(t) = e^{-\left(\frac{t}{\eta}\right)^{\beta}} \qquad (2)$$

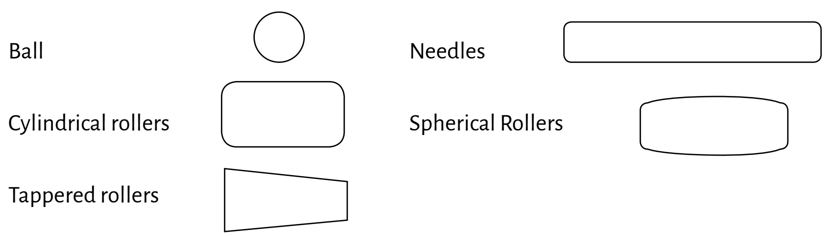
Bearings

The bearings are mechanical components that allow the rotational movement of a shaft and at the same time allow the shaft to be attached to a machine frame. The purpose of the bearing is to reduce friction by allowing the free rotation movement of the shaft (Arakere et al., 2010). Moreover, bearings are high precision components that let machines move easily and efficiently (Anoopnath et al., 2018). The bearing are one of the most important elements in the industry presently. They are also key components in rotating machinery such as turbines, engines, gearboxes, (Yu et al., 2018) (Dias et al., 2016) (Fengtao et al., 2017) and are used in systems such as engine rotors, machine tools and train wheels (Guo et al., 2015).

Bearing Types

Although there currently exists a wide variety of bearings, they can be divided into the rolling element that they contain, which can be a ball, a roller, a tapered roller, a needle and spherical rollers (Nisbet, 1976). Nevertheless, in each type of rolling element there are subdivisions based on the accommodation of these elements. This research focuses on the analysis of single-row deep groove ball bearings.

Figure 1. *Types of rolling elements in a bearing.*



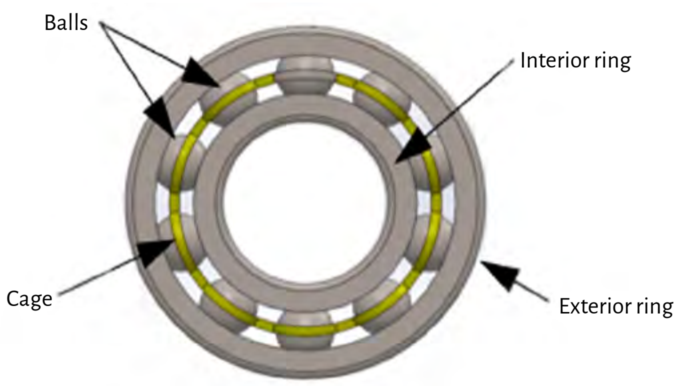
Source: *Own elaboration.*

Single Row Deep Groove Ball Bearings and their Components

The single-row deep groove ball bearing is the most commonly used in field applications. Their components are as follows (Nisbet, 1976) (see Figure 2) are the following:

- Inner race. This race is the one that is in contact with the shaft, most of the time this race moves along with the shaft, on the contrary, rarely remains static.
- Outer race. This race is the one that has contact with the structure or frame, most of the time this race remains static.
- Balls. Balls are one of the most important components in the bearings and serve to transmit the reaction force from the inner race to the outer race, they allow the rotation of the shaft by reducing friction.
- Cage. The cage permits an equidistant separation distance between all the balls that the bearing contains so that there is no contact between them.
- Seal. The operation of the seal allows the lubricant that contains the bearing not to go out of it and preventing dirt from outside to enter the bearing and contaminating it, causing a reduction in the useful life.

Figure 2. *Components of a single row ball bearing.*



Source: *Own elaboration.*

Materials Used for Bearings

Currently, bearings are made of different materials, like steels, ceramic materials, to plastic materials. Ball bearings are made of different materials depending on the parts that compose them. The material used in the manufacture of bearing components affects reliability and performance and it depends on the operating conditions, such as the magnitude of the load, friction, deformation and inertial forces. It can also be affected by other parameters such as temperatures, oxidation and humidity.

Materials for the ball and the races

The materials most used in the races and balls are stainless steels because they are more resistant to surface corrosion and can withstand large loads. The SKF bearing manufacturer uses steels with a high chromium content, according to ISO 683-17. The most used steel is the AISI 52100 is one of the oldest and most researched steels, due to the requirements regarding the durability of the bearings that are increasingly greater.

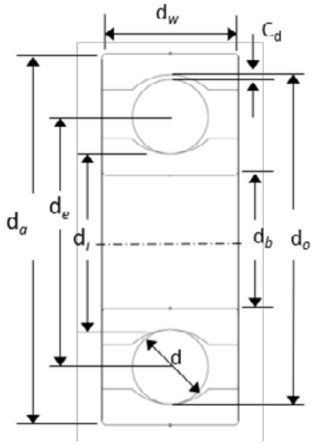
Cage Materials

The most commonly used materials in cages of the bearings are structural steel and brass. Moreover,, polymers can be used being the most common nylon and molded acetate. Other plastics used are phenol formaldehyde and polyamide 66.

Ball Bearing Geometry

The geometry of its components is of great importance for the effective operation in any type of bearing. There are many geometric variables in a single-row, deep groove, ball bearing. In this section, the main geometry in a ball bearing (the pitch and clearance diameter, longitudinal diameter, shoulder height, diameter of the ball, the width of the bearing) is shown (see Figure 3). There are also other geometric characteristics that are related with the characteristics mentioned in the previous statement, such as the sum and difference of the curvature, track conformity, which are analyzed in the proposed methodology section.

Figure 3. Main geometry of a ball bearing.



Source: Own elaboration.

Types of Ball Bearing Failures

The proper functioning of the rotating machinery mainly depends on the dynamic characteristics of the rotating components like ball bearings (Yakout et al., 2019). Ball bearings can fail for various reasons. Nonetheless, failures not only affect the bearing, but they also affect the entire chain of mechanical elements of which a machine is composed. This is because its operating state directly and significantly impacts the accuracy, reliability and useful life of all the machine (Guo et al., 2015). Bearing failure can also cause accidents (Guo et al., 2015) and it can lead to the final failure of a mechanical equipment which brings economic losses for companies (Cui et al., 2019).

Therefore, the study and monitoring of the condition of the bearings and the intelligent diagnosis of failures have an important theoretical and practical value in engineering (Cui et al., 2019) (Song et al., 2018). The failures that can occur to ball bearings are the following:

- Inadequate manufacturing and assembly of ball bearings, these errors have a great impact on the life of the bearings (Yakout et al., 2018) (Weiss, 2005) (Behzad & Bastami, 2011) (Sales & Gmbh, n.d.).
- Selection of an inappropriate bearing or a bearing that does not meet the characteristics required in the application.

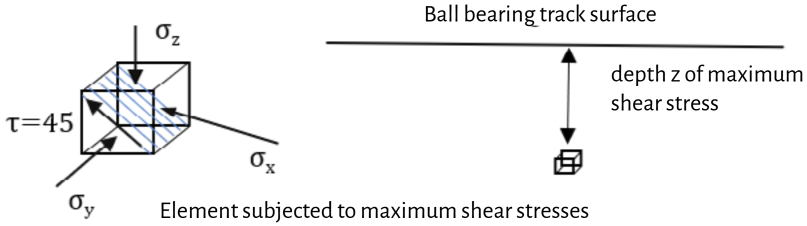
- Excess load. When a bearing with a load greater than the one designed is loaded (Sales & Gmbh, n.d.).
- Inadequate lubrication. When an inappropriate lubricant is used that does not meet the manufacturer's specifications.
- Failure due to lack of lubrication. This type of failure occurs in some types of bearings that require lubrication every certain period of time. When the bearing is not lubricated due to lack of maintenance, high temperatures are caused by friction, which causes the bearing to wear out more quickly (Sales & Gmbh, n.d.) (Insight & Europe, n.d.).
- Corrosion failures occur when the bearing is in corrosive environments and corrosion agents manage to penetrate the bearing causing damage to the races and the ball (Sales & Gmbh, n.d.).
- Electric shock. If the bearing receives an electric shock that causes damage to its components (Sales & Gmbh, n.d.).
- Fatigue failures are caused because the materials have reached their fatigue limits. The problem is that some materials such as AISI 52100 steel do not have a specified fatigue limit.
- Failures due to contact or Hertz efforts. This failure is generated due to the loads applied to the bearing causing contact stresses and a shear stress which is maximum at a certain depth, such efforts with the passage of time generate cracks under the surface of the races, which with the passage of time progress to the surface, causing holes in the race tracks. These types of failures are the dominant ones in the bearings (Arakere et al., 2010) (Pandiyarajan et al., 2012) (Asada et al., 1992) (Bower, 1988).

The focus of this investigation is on failures generated below the surface caused by Hertz's contact efforts.

Ball bearing failures caused by Hertz's contact stress

In a bearing, the loads are transmitted from the shaft where the bearings are mounted to the inner race. Afterwards, they pass to the balls and finally the loads are transmitted to the outer fixed race. Contact forces are generated in the transmission of force from the inner race to the balls and from the balls to the outer race. The contact forces generated are large and fall within the range of 2000 MPa, in this manner, a maximum shear stress is presented. The value of the maximum shear stress is presented below the surface (see Figure 4), where cracks also occur over time, which are moving towards the surface generating small holes (Arakere et al., 2010) (Sales & Gmbh, n.d.) (Erwin V Zaretsky, 2013). When holes are generated in one of the two races, the passage of the balls causes the holes to grow (see Figure 5), which then causes vibrations in the bearing, affecting its operation and causing the failure. In addition, cracks that are generated below the surface act as stress concentrators making the problem bigger (Bower, 1988).

Figure 4. *Contact efforts under the Surface.*



Source: *Own elaboration.*

It is difficult to predict the time when this type of failure will occur. Moreover, this problem arises when the races are made of a material like AISI 52100 steel, which does not have its fatigue limit well defined.

Figure 5. *Race damage.*

a. Damage at the time for recognition

b. Damage after 900 hours of service.

c. Damage after 1300 hours of service.

Source: *Own elaboration.*

Hertz Contact Generalities

In 1879, Heinrich Hertz found that the determination of the stresses on the surface of rolling bodies were only an approximation with empirical assumptions. Two years later, Hertz proposed the "contact stress theory" or "Hertz theory", which is a mathematical analysis of the relationship between the shape of the geometry and the size of the contact area and the distribution of stresses in two bodies with curved surfaces. Subsequently, some researchers added to the existing theory the fact that the maximum stresses that cause the ball bearings to break are below the contact surface. Contact stresses occur when two bodies transmit loads across their surfaces, generating a contact point or line (Anoopnath et al., 2018). There are three ways in which contact forces can occur: when a sphere or a roller is pressed on a flat surface, when two spheres or two rollers are pressed against each other and when a roller or a sphere it is pressed against a concave curved surface. The surface that is in contact flattens out and takes an elliptical, circular or rectangular shape, depending on the shape of the bodies that are in contact, when applying a force on two bodies. In the case analyzed in this article, the contact between a ball and the outer race, an elliptical contact surface will be generated that meets the conditions to apply Hertz's theory (Schmltz et al., 1992) (Herák et al., 2018), which are:

- The materials of both bodies must be homogeneous and isotropic.
- The contact areas are relatively small compared to the radios of curvature.
- The contact surfaces have an elastic behavior.
- Loads are normal to contact surfaces.

In the Weibull analysis developed to determine the life of the bearing, the contact stresses generated in the Ball bearing are used when a ball is pressed against a concave race to determine the Weibull parameters. The main stresses are the most important, σ_x, σ_y, σ_z, and $\tau_{max,}$ which are created below the bearing surface where the shear stress τ_{max} is maximum (Schmltz, F; Seherr-Toss, Count, 1992). Nonetheless, when τ_{max} is maximum is when cracking occurs in the outer race, which generates the failure. Thus, the analysis is made on the outer race and the ball bearing.

Ball Bearing Life

Throughout this investigation, the concept of a bearing's useful life is taken as a fatigue failure. Failures due to electric shock, poor maintenance, lack of lubrication, overload, misalignment, corrosion, etc., are ruled out. The service life is taken on a bearing that is well installed, well lubricated, clean, and sealed to avoid dirt from dust and foreign particles. The life of a bearing can be defined as the number of revolutions or the number of hours of operation at a given constant speed which a bearing is able to resist before starting to present the first symptoms of fatigue in one of its elements (balls, in the interior or exterior race, or other) (Erwin V Zaretsky, 2013). The standard that the association of manufacturers of anti-friction bearings (AFBMA) mentions that the failure criterion is the first evidence of fatigue. For example, the Timken company uses a failure criterion which consists of shelling or stinging in an area of 0.01 in^2 (Budynas Richard G. and Nisbett Keith., 2015). Nonetheless, a bearing can still work even when the first evidence of fatigue appears.

Nominal Duration or L10 Life of a Bearing

Manufacturers test hundreds of bearings until failure. Tests are carried out with constant loads at constant speeds to obtain the nominal duration or life L_{10}. However, tests performed in laboratories show that identical bearings that operate in apparently identical conditions have different lifespans (Budynas Richard G. and Nisbett Keith., 2015). For this reason, the calculations are based on the nominal duration, that is, the nominal life L_{10} that suggest that 90% of the bearings will work correctly and 10% will have premature failures.

The duration specified by the manufacturer relies on hypothetical data based on the load and speed supplied by the same manufacturer. The term L_{10} introduces a concept in which there is a load limit that represents the maximum load that the component can support, under which the bearing failure will not occur under ideal conditions.

$$L_{10} = L_1 \left(\frac{C}{P_d}\right)^K \quad (3)$$

L_{10} = Revolutions for which 10% of designed bearings fail.
$L_1 = 10^6$ revolutions.
C = Dynamic load specified by the manufacturer
P_d = Design load
K = Exponent relationship load life.

The L_{10} formula was proposed by the SKF, Lundberg and Palmgren researchers in the early 1950s (Arakere et al., 2010). Currently the formula was adopted by ISO 281 and continues in use.

Proposed Methodology

Proposed methodology used for the selection of a bearing has been applied for several decades. The current methodology is shown in the catalogs of bearing manufacturers and in some mechanical design books. The methodology is a simple process that is based on concepts of materials mechanics, encompassing the selection of the bearing to the calculation of life L_{10}.

Steps to determine the contact stresses and the L_{10} life of a ball bearing

- Step 0. Determine the loads that are acting on the ball bearings.
- Step 1. From the Static Shaft Analysis determine the design P_d load at which the ball bearing will be subjected. By using the radial (F_r) and axial (F_a) forces determined in the shaft's static analysis, with the X radial and Y axial ball bearing coefficients given in the selected ball bearings' catalogues, from Eq. (4) determine the equivalent radial load P value as:

$$P = XF_r + YF_a \tag{4}$$

then by using the P radial force with the rotation factor V determine the design load value as

$$P_d = VP \tag{5}$$

Notice from equation 2 that if the interior race is the one that is rotating then *V=1*, and in contrast, if the exterior ring is the one that is rotating, then *V = 1.2*, (see Figure 2).

Note 1: The P_d value in Eq. (3) is determined in the static phase analysis, and it is done based on the applied loads that corresponds to the point where the ball bearing is going to be mounted.

- Step 2. Select the ball bearing. It can be selected from a catalogue. Doing this, first the type of ball bearing which corresponds to the application is determined. In this paper a deep groove ball bearing is used. To select it from the catalogues, the diameter of the catalogues must be the diameter of the shaft value where the ball bearing is going to be mounted. And the designed load P_d addressed in step 1, must be lower than the dynamic load (C) of the catalogues. If C is lower than P_d, other type of ball bearing must be selected. Similarly, the rotation speed at which the ball bearing is going to be mounted, must be lower than the one given in the catalogues. Additionally, the P_d value has to be lower than the basic static load (C_o) of the catalogue.

- Step 3. Determine the designed L_{10} Life of the ball bearing. By using C from step 2, and P_d from step 1, determine the ball bearing L_{10} life as (Panda et al., 2015) (Tong & Hong, 2017) (E. V. Zaretsky, 2010)

$$L_{10} = 10^6 \left(\frac{C}{P_d}\right)^3 \tag{6}$$

Where L_{10} represents the expected number of cycles at which 90% of the ball bearings will survive. The following is the analysis to determine the contact area which causes the failure in a ball bearing.

Steps to Determine the Contact Area of the Ball Bearing

- Step 4. Determine the total curvature R of the contact area. In this case, the curvature analysis is performed between the outer race and the ball. From it, the total curvature R is determined based on the ball bearing dimensions, the inner race radio and on the radio of the ball bearing (Adeshara & Darji, 2015) (Hamrock & Dowson, 1981). Since in a ball bearing the curvature is generated in the x and y directions, then the total curvature is given as:

$$\frac{1}{R} = \frac{1}{R_x} + \frac{1}{R_y} \tag{7}$$

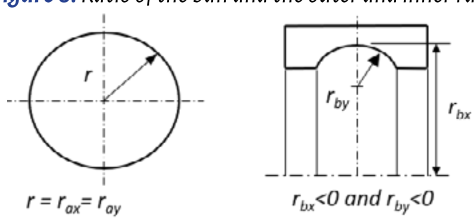
Where

$$\frac{1}{R_x} = \frac{1}{r_{ax}} + \frac{1}{r_{bx}} \tag{8}$$

$$\frac{1}{R_y} = \frac{1}{r_{ay}} + \frac{1}{r_{by}} \tag{9}$$

And since r_{ax} and r_{ay} are the ratio of the ball in the ***x*** and ***y*** direction respectively, then $r_{ax} = r_{ay}$. Thus, r_{bx} is the curvature radio from the center of the ball bearing to the inner race and r_{by} is the curvature radio of the outer race (see Fig.6). This analysis focuses on the outer race because load distributions between outer race and balls are much larger than those between inner race and balls (Li et al.,2018).

Figure 6. *Ratio of the ball and the outer and inner race.*



Source: *Own elaboration.*

Nevertheless, because most of catalogues do not contain the inner race, then it is determined as in Eq.(10) where R_r is the conformity of the inner race with standardized value of 0.52, and *d* is the ball diameter (Li et al., 2018). Therefore, the inner race r_{by} radio is given as

$$R_r = \frac{r_{by}}{d} \tag{10}$$

- Step 5. Determine the curvature's index α_r as

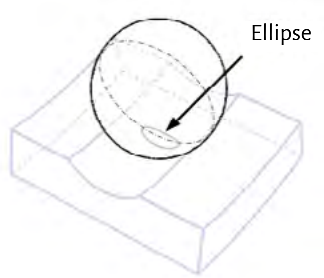
$$\alpha_r = \frac{R_y}{R_x} \tag{11}$$

- Step 6. Determine the elliptical parameter k_e as

$$k_e = (\alpha_r)^{2/\pi} \tag{12}$$

- Step 7. Select the elliptical equations to be used to determine the axes a and b of the contact ellipse. The contact ellipse is generated when a force pressures the ball against the exterior inner (Figure 7).

Figure 7. *Ellipse generated between the ball and the exterior inner.*



Source: *Own elaboration.*

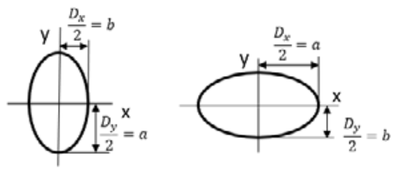
The elliptical equations to evaluate the elliptical integers of first order ($\mathcal{F}$) and the second order ($\mathcal{E}$) are determinate as follows: If the curvature's index α_r determined in step 5, is between 1 and 100, we select the elliptical equations given in the left size of Table 1. In contrast, if α_r is between 0.01 and 1, then we select the elliptical equations given in the right size of Table 1 (Hamrock & Dowson, 1981). Depending on the α_r value, the axes *x* and *y* of the generated contact ellipse take their direction as it is shown in Figure 8.

Table 1. Simplified Equations of the Ellipticals Integrals

	Range of the curvature's radio	
Property	**Left size (1 α_r 100)**	**Right size (0.01 α_r 1)**
Elliptical ratio	$k_e = \alpha_r{}^{2/\pi}$	$k_e = \alpha_r{}^{2/\pi}$
Elliptical integer of first order	$F = \frac{\pi}{2} + \left(\frac{\pi}{2} - 1\right)\ln\alpha_r$	$\mathcal{F} = \frac{\pi}{2} - \left(\frac{\pi}{2} - 1\right)\ln\alpha_r$
Elliptical integer of second order	$\mathcal{E} = 1 + \frac{\pi - 2}{2\alpha_r}$	$\mathcal{E} = 1 + \left(\frac{\pi}{2} - 1\right)\alpha_r$

Source: *Own elaboration.*

Figure 8. *Sense of the ellipse depending on the curvature index ar.*



Left size $(1 \le \alpha_r \le 100)$ Right size $(0.01 \le \alpha_r \le 1)$

Source: *Own elaboration.*

- Step 7.1. Determine the value of the simplified ellipticals integrals $\mathcal{F}$ and $\mathcal{E}$. By using the curvature's index α_r and the elliptical parameter k_e, obtain the value of the elliptical integer of first order $\mathcal{F}$ and the elliptical integer of second order $\mathcal{E}$.

$$\mathcal{F} = \frac{\pi}{2} + q_a ln\alpha_r \quad (13)$$

$$\mathcal{E} = 1 + \frac{q_a}{\alpha_r} \quad (14)$$

$$\mathcal{E} = 1 + q_a\alpha_r \quad (15)$$

Depending on the value of the radius ratio α_r, select the correct equations from Table 2 (Schmid et al., 2014).

- Step 8. Determine the effective elasticity module (E'). Base on the Poisson coefficients (υ) and on the elasticity modules (E) of the used materials, the effective elasticity module is given as

$$E' = \frac{2}{\frac{(1-v_a{}^2)}{E_a} + \frac{(1-v_b{}^2)}{E_b}} \quad (16)$$

In equation 10, υ_a is the Poisson coefficient of the ball and υ_b is the Poisson coefficient of the outer ring. Similarly, E_a is the elasticity module of the ball, and E_b is the elasticity module of the outer ring.

- Step 9. Determine the a and b dimensions of the axes of the ellipse that is formed in the contact point between the ball and the race of the exterior ring (see Table 1). The a and b values are determined as one half of the dimensions of the (D_y) and (D_x) diameters of the ellipse given as

$$D_y = 2\left(\frac{6k_e{}^2 \mathcal{E} P_d R}{\pi E'}\right)^{1/3} \tag{17}$$

$$D_x = 2\left(\frac{6\mathcal{E} P_d R}{\pi k_e E'}\right)^{1/3} \tag{18}$$

Note 2. Notice in the ellipse "*a*" always represents the higher semi axis. For example, if $D_y > D_x$, then

$a=D_y/2$ and $b=D_x/2$, in contrast if $D_x>D_y$, then *$a=D_x/2$ and $b=D_y/2$*.

Based on the above dimensions, the following is the equation to determine the contact principal stresses values based on which of the Weibull parameters are determined to know the ball bearing life.

Steps to Determine the Contact Principal Stresses Values

- Step 10. Determine the maximum stress P_{max} value. It occurs in the contact point between the ball and the race of the exterior ring, and it is given as

$$P_{máx} = \frac{6P_d}{\pi D_x D_y} \tag{19}$$

- Step 11. Determine the contact principal stresses s_x, s_y, s_z, and τ_{max} values. They are given as

$$\sigma_x = \left[M\left(\Omega_x + \upsilon\Omega'_x\right)\right]\frac{b}{\Delta} \tag{20}$$

$$\sigma_y = \left[M\left(\Omega_y + \upsilon\Omega'_y\right)\right]\frac{b}{\Delta} \tag{21}$$

$$\sigma_z = -\left[\frac{M}{2}\left(\frac{1}{n} - n\right)\right]\frac{b}{\Delta} \tag{22}$$

From Eq. (20 to 22) the maximum and minimum principal stresses values are selected according to the stress's values determined in step 11. For example, if σ_x, σ_y and σ_z, then σ_x is taken as the maximum principal stress value σ_1. Similarly, the lower value σ_z is taken as the minimum principal stress σ_3 value. Therefore, based on the σ_1 and σ_3 values, the shear stress that causes the failure in the ball bearing is given as

$$\tau_{máx} = \frac{(\sigma_1 - \sigma_3)}{2} \quad (23)$$

In the following sub-steps, the parameters to determine the σ_x, σ_y *and* σ_z values are given.

- Step 11.1. Determine the k, k' and z value. The functional relation between the a and b values of the contact ellipse is given by

$$k = \frac{b}{a} \quad (24)$$

$$k' = \sqrt{1 - k^2} \quad (25)$$

And the depth z value at which the maximum shear stress is generated, is given [19] as

$$z = 0.78b \quad (26)$$

- Step 11.2. Determine the n, M, W_x, W_y, W'_x, W'_y and D parameters. They are given as:

$$n = \sqrt{\frac{k^2 + k^2\left(\frac{z}{b}\right)^2}{1 + k^2\left(\frac{z}{b}\right)^2}} \quad (27)$$

$$M = \frac{2k}{k'^2 \mathcal{E}} \quad (28)$$

$$\Omega_x = -\frac{1-n}{2} + k\frac{z}{b}[\mathcal{F} - \mathcal{E}] \quad (29)$$

$$\Omega'_x = -\frac{n}{k^2} + 1 + k\frac{z}{b}\left[\left(\frac{1}{k^2}\right)\mathcal{E} - \mathcal{F}\right] \quad (30)$$

$$\Omega_y = \frac{1}{2n} + \frac{1}{2} - \frac{n}{k^2} + k\frac{z}{b}\left[\left(\frac{1}{k^2}\right)\mathcal{E} - \mathcal{F}\right] \quad (31)$$

$$\Omega'_y = -1 + n + k\frac{z}{b}(\mathcal{F} - \mathcal{E}) \quad (32)$$

$$\Delta = \frac{1}{A+B}\left(\frac{1-\nu_a{}^2}{E_a} + \frac{1-\nu_b{}^2}{E_b}\right) \quad (33)$$

In Eq.(27) the ν_a, ν_b, E_a and E_b values are the Poison and elasticity modules values used in step 8. And *A* and *B* are constants that depend on the curvature ratio of the ball and inner race.

- Step 11.3. Determine the A and B values. The functional relation is

$$A = \frac{1}{2}\left(\frac{1}{r_{ay}} + \frac{1}{r_{by}}\right) \quad (34)$$

$$B = \frac{1}{2}\left(\frac{1}{r_{ax}} + \frac{1}{r_{bx}}\right) \quad (35)$$

Where the ratios r_{ax},r_{ay},r_{bx} and r_{by} were determined in step 4. The Weibull parameters are determined as follows:

Steps to determine the Weibull Shape and Scale Parameters

Based on the maximum σ_1 and minimum σ_3 stresses values, these Weibull scale η and shape β parameters are determined.

- Step 12. Determine the Weibull η and β parameters. From, the scale parameter is given as

$$\eta_{use} = \sqrt{\sigma_1 \sigma_3} \tag{36}$$

and the shape parameter is given as

$$\beta_{use} = -\frac{4\mu_y}{0.995 * ln(\sigma_1/\sigma_3)} \tag{37}$$

The β_{use} and η_{use} parameters are the Weibull parameters that completely represent the addressed principal stresses σ_1 and σ_3 values (Piña-Monarrez 2018).

Steps to determine the Real Reliability of the Selected Ball Bearing

The real reliability of the ball bearing is determined by using the L_{10} life of step 3, with the addressed Weibull β_{use} and η_{use} parameters as well as with the supplier η_{cat} parameter.

- Step 13a. Determine the reliability that corresponds to the L_{10} life and the η_{use} parameter. By using the L_{10} life of step 3 and the β_{use} and η_{use} parameters of step 12, determine the reliability of the ball bearing as

$$R(t) = \exp - \left\{\frac{L_{10}}{\eta_{use}}\right\}^{\beta_{use}} \tag{38}$$

- Step 13b. Determine the real L_{use} life for which R(t) = 0.90. By using the η_{use} and β_{use} parameters estimated in step 12, with R(t)=0.9 in Eq. (38), the L_{use} life is given as

$$L_{use} = \eta_{use} \sqrt[\beta]{-\ln(0.90)} \tag{39}$$

- Step 13c. Determine the catalogue η_{cat} value that corresponds to the L_{10} life. By using the β_{use} value of step 12 with the L_{10} life from step 3, and R(t)=0.90 in Eq.(39), the catalogue scale parameter is given as

$$\eta_{cat} = \frac{L_{10}}{\sqrt[\beta]{-\ln(0.90)}} \tag{40}$$

- Step 13d. Determine the real reliability of the selected ball bearing. It is given as

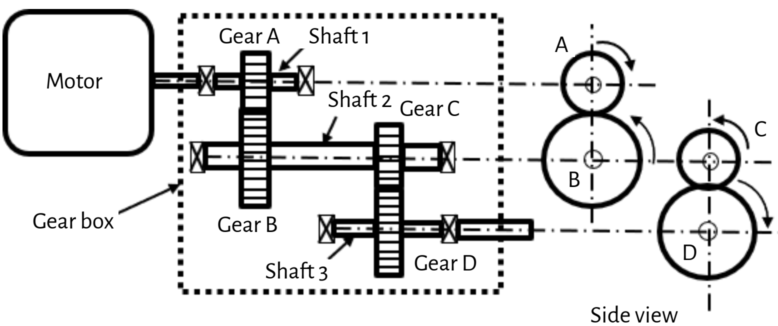
$$R(t) = \exp - \left\{\frac{L_{use}}{\eta_{cat}}\right\}^{\beta} \tag{41}$$

From Eq.(41) observe the given R(t) value represents the real reliability that the ball bearing presents under the actual conditions because in Eq.(39) L_{use} serves as the expected life under the actual conditions and η_{cat} represents the actual strength that the selected ball bearing presents to overcome the applied stress. Now lets present the numerical application.

Application of the Proposed Methodology

The application of the proposed methodology is based on the traditional static design methodology. Therefore, the application is as shown in Figure 9. As an application, the intermediate shaft of the speed reducer shown in Figure 9 is used to determine the principal stresses values that are acting on the ball bearing. In the application, the speed is reduced from the initial 1800 rpm to a final speed of 450 rpm. Initially, the motor transmits a constant power of 12hp. And in the intermediate shaft the objective consists on reducing the initial speed of 1800 rpm to 900 rpm while the power of 12 hp remain constant. The intermediate shaft is shown in Figure 10. This shaft is made of AISI 1020 steel with a shaft's diameter of 1.7716 in (45mm). The designed shaft will rotate with an angular speed of 900 rpm. While the pass diameter of gear B is of 5 in, for gear C it is of 3 in. And the pressure of the angle between these gears is of 20°.

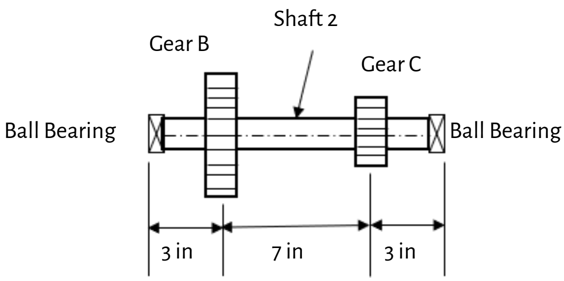
Figure 9. *Speed reducer design connected to a motor.*



Source: *Own elaboration.*

With the dimensions of the selected bearing, the application of the Hertz theory is carried out to obtain the main stresses that act in the outer race of the bearing. These principal stresses are used to determine the Weibull distribution parameters that allow us to finally estimate the real reliability of the ball bearing.

Figure 10. Top view of shaft 2.



Source: Own elaboration.

The step by step analysis as given in section 6 is as follows

- Step 0. The loads that are acting in the shaft 2 are determined as follows:

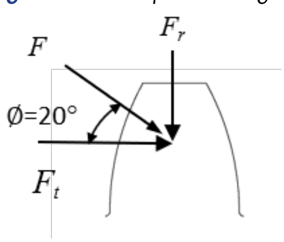
Since the torque generated on shaft 2 depends on the angular speed (ω) of rotation and on the power (P) that the shaft transmits, then the constant torque generated on shaft 2 is of

$$T = \frac{63000P}{\omega}$$

$$T_B = \frac{63000P}{\omega} = \frac{63000(12hp)}{(900rpm)} = 840lbin \qquad (42)$$

And because shaft 2 is in equilibrium, then the generated torque in gear B and C is equal but in opposite direction. It is to say the torque in C is T_c = -840 lb in. On the other hand, as shown in Figure 11 the radial and tangential forces that are acting on the gears depend on the pressure angle of Φ=20°.

Figure 11. Gear´s pressure angle.



Source: Own elaboration.

Therefore, because in function of the torque and convergence ratio, the tangential force is given by

$$F_t = \frac{T}{r} \tag{43}$$

Then the corresponding radial force is given by

$$F_r = F_t\,(\tan \emptyset) \tag{44}$$

And since for gears B and C, $\Phi = 20°$, and r_B=2.5 in and r_C=1.5 in, then numerically

$F_{tB} = \frac{T}{r_B} = \frac{840lbin}{2.5in} = 336lb$, $F_{rB} = F_{tB}tan\emptyset = (336lb)\tan 20° = 122.29lb$. And

$F_{tC} = \frac{T}{r_C} = \frac{840lbin}{1.5in} = 560lb$ with $F_{rC} = F_{rC}tan\emptyset = (560lb)\tan 20° = 203.82lb$.

The radial and tangential forces, as well as the corresponding reaction that are acting in the x-y and in the x-z plane, are shown in Fig.12 and in Fig.13.

Figure 12. *Forces and reactions in the x-y plane.*

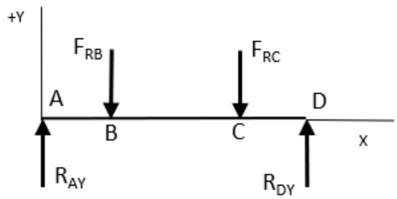
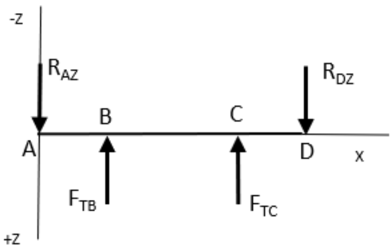


Figure 13. *Forces and reactions in the x-z plane.*



Source: *Own elaboration.*

As shown in Fig. 12, the forces and reactions that are acting in the x-y plane are:

$$+\circlearrowleft \sum M_D = 0 = (122.29lb)(10in) + (203.82lb)(3in) - (13in)(R_{Ay});\ R_{Ay} = 141.10lb$$
$$\sum F_y = 0 = 141.10lb - 122.29lb - 203.82 + R_{Dy};\ R_{Dy} = 185.01lb$$

Similarly, as shown in Fig. 13, the forces and reactions that are acting in the x-z plane are:

$$+\circlearrowleft \sum M_D = 0 = (R_{Az})(13in) - (336lb)(10in) - (560lb)(3in);\ R_{Az} = 387.69lb$$
$$\sum F_z = 0 = -387.69lb + 6lb + 560 - R_{Dz};\ R_{Dz} = 508.31lb$$

$$R_A = \sqrt{R_{Ay}^2 + R_{AZ}^2}$$ d D are:

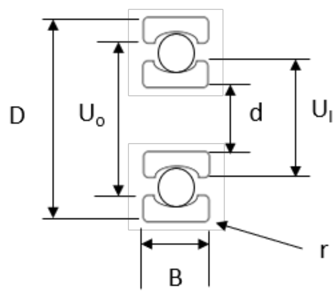
$$R_A = \sqrt{(141.10lbin)^2 + (387.69lbin)^2} = 412.56lbin \tag{45}$$

$$R_D = \sqrt{R_{Dy}^2 + R_{DZ}^2}$$
$$R_D = \sqrt{(185.01lbin)^2 + (508.31lbin)^2} = 540.92lbin \tag{46}$$

And since $R_D > R_A$, then R_D represents the reaction force value base on which the ball bearing is selected.

- Step 1. Since for shaft 2 we do not have axial force, then the design load is directly given by the radial force represented by R_D from Eq.(4). Thus, P = R_D=540.92 lb in. Moreover, since the inner race is rotating, then V=1, and therefore, from Eq.(5). The designed load is:
$$P_d = VP = (1)(540.92lb); P_d = 540.92lb = 2406.13N$$
- Step 2. From the design shaft phase, the diameter of shaft 2 is 1.65 in (41.91 mm), and from step 1 P_d=540.92 lb (2406.13 N), then from the SKF catalogue the selected ball bearing is the 6009 SKF type ball bearing with diameter of 45 mm. The related ball bearing characteristics are given in Figure 14 and in Table 2.

Figure 14. *Ball bearing dimensions.*



Source: *Own elaboration.*

Table 2. *Ball bearing specifications.*

Bearing Type	Capped single row deep groove ball bearings
Bore Diameter (d)	45 mm
Outer Diameter (D)	75 mm
Width (B)	16 mm
Dynamic Load Rating (C)	22100 N
Static Load Rating (Co)	14600 N

Max Speed	10000 rpm
Max. Shaft Shoulder Dia. Inner (Ui)	67.8 mm
Min. Housing Shoulder Dia., Outer (Uo)	54.7 mm
Chamfer radius (r)	1 mm
Ball Quantity	13
Ball Diameter (db)	8.731 mm
Material	52100 Chrome Steel

Source: *Own elaboration.*

- Step 3. According to the catalogues the designed L_{10} Life of the ball bearing is

$$L_{10} = 10^6 \left(\frac{22100N}{2406.13N}\right)^3 = 774.85 \times 10^6 rev$$

Considering this data, the contact area generated in the ball bearing mentioned in section 6.2 is determined as follows:

- Step 4. Since the curvature generated in the x direction is

$$r_{ax} = r_{ay} = 4.365 \times 10^{-3} m \ and \ r_{bx} = 35.003125mm = 35.003125 \times 10^{-3} m$$

then from Eq. (8)

$$\frac{1}{R_x} = \frac{1}{4.365\times10^{-3}m} - \frac{1}{35.003125\times10^{-3}m} = 200.52m,$$

and therefore $R_x = 4.986 \times 10^{-3} m$

And because the outer ratio r_{by} is unknown, then from Eq.(10) by using the compliance value of 0.52 the r_{bv} value is

$$r_{by} = dR_r = (0.52)(8.731mm) = 4.54mm = 4.54x10^{-3} m,$$

Therefore from Eq.(9)

$$\frac{1}{R_y} = \frac{1}{4.365\times10^{-3}m} - \frac{1}{4.54\times10^{-3}m} = 8.83m \text{ implying } R_y = 0.1132m.$$

From Eq. (7)

$$\frac{1}{R} = 200.52m + 8.83m = 209.35m$$

then the total curvature is $R = 4.77 \times 10^{-3}\ m$

- Step 5. From Eq.(11) the curvature's index α_r is $\alpha_r = \frac{0.1132m}{4.986\times10^{-3}m} = 22.70$
- Step 6. From Eq.(12) the elliptical parameter k_e is $k_e = (22.70)^{2/\pi} = 7.299$
- Step 7. Since k_e<100, the equations of the left size of Table 1 are selected.
- Step 7.1. The simplified values of the first and second order elliptical equations $\mathcal{F}$ y $\mathcal{E}$ are:

$$\mathcal{F} = \frac{\pi}{2} + \left(\frac{\pi}{2} - 1\right)\ln(22.70) = 3.353$$

$$\mathcal{E} = 1 + \frac{\left(\frac{\pi}{2} - 1\right)}{22.70} = 1.025$$

- Step 8. From Eq.(16) by using the Poisson ratio of the AISI 52100 $v_a = v_b = 0.30$ and its elasticity modules $E_a = E_b = 200$ GPa of the material, the effective elasticity module is

$$E' = \frac{2}{\frac{[1-(0.30)^2]}{200 \times 10^9 Pa} + \frac{[1-(0.30)^2]}{200 \times 10^9 Pa}} = 219780219780 Pa$$

- Step 9. Based on the diameter D_y and D_x of the ellipse formed in the contact area between the ball and the outer ring given in Eqs.(17 and 18), the a y b values of the axis are

$$D_y = 2\left[\frac{6(7.299)^2(1.025)(2406.13N)(4.77 \times 10^{-3}m)}{\pi(219780219780\, N/m^2)}\right]^{1/3} = 3.518 \times 10^{-3}m$$

$$a = \frac{3.518 \times 10^{-3}}{2} = 1.759 \times 10^{-3}m = 1.759mm$$

$$D_x = 2\left[\frac{6(1.025)(2406.13N)(4.77 \times 10^{-3}m)}{\pi(7.299)(219780219780N/m^2)}\right]^{1/3} = 4.820 \times 10^{-4}m$$

$$b = \frac{4.182 \times 10^{-4}}{2} = 2.410 \times 10^{-4}m = 0.2410mm$$

Based on the analysis above, the contact principal stresses values mentioned in section 6.3 are determined as follows.

- Step 10. From Eq.(19) the maximum stress $P_{máx}$ value is

$$P_{máx} = \frac{6(2406.13N)}{\pi(3.518 \times 10^{-3}m)(4.820 \times 10^{-4}m)} = 2710045464.29Pa$$

- Step 11. From Eqs.(20 to 23) the principal contact stresses s_x, s_y, s_z, values and the maximum shear τ_{max} value, as well as the depth at which τ_{max} occurs are as follows.
- Step 11.1. From Eqs.(24 and 25) the k, k' values are

$$k = \frac{b}{a} = \frac{0.2410mm}{1.759mm} = 0.137$$

$$k' = \sqrt{1 - k^2} = \sqrt{1 - (0.137)^2} = 0.9905$$

And from Eq.(26) the corresponding depth value is

$$z = 0.78b = 0.78(0.2410mm) = 0.18798mm = 0.18798x10^{-3}m$$

-

- Step 11.2. From Eqs.(27 to 33) the n, M, W_x, W_y, W'_x, W'_y and D parameters used to determine the corresponding s_x, s_y y s_z values are

$$n = \sqrt{\frac{k^2 + k^2\left(\frac{z}{b}\right)^2}{1 + k^2\left(\frac{z}{b}\right)^2}} = \sqrt{\frac{(0.137)^2 + (0.137)^2\left(\frac{0.18789}{0.241}\right)^2}{1 + (0.137)^2\left(\frac{0.18789}{0.241}\right)^2}} = 0.1727$$

$$M = \frac{2k}{k'^2\mathcal{E}} = \frac{2(0.137)}{(0.9905)^2(1.025)} = 0.2724$$

$$\Omega_x = -\frac{1-n}{2} + k\frac{z}{b}[\mathcal{F} - \mathcal{E}]$$

$$\Omega_x = -\left(\frac{1 - 0.1727}{2}\right) + (0.137)\left(\frac{0.18798}{0.2410}\right)(3.353 - 1.025)$$

$$\Omega_x = -0.1648$$

$$\Omega'_x = -\frac{n}{k^2} + 1 + k\frac{z}{b}\left[\left(\frac{1}{k^2}\right)\mathcal{E} - \mathcal{F}\right]$$

$$\Omega'_x = -\left[\frac{0.1727}{(0.137)^2}\right] + 1 + 0.137\left(\frac{0.18798}{0.2410}\right)\left[\left[\frac{1}{(0.137)^2}\right](1.025) - 3.353\right]$$

$$\Omega'_x = -2.7238$$

$$\Omega_y = \frac{1}{2n} + \frac{1}{2} - \frac{n}{k^2} + k\frac{z}{b}\left[\left(\frac{1}{k^2}\right)\mathcal{E} - \mathcal{F}\right]$$

$$\Omega_y = \frac{1}{2(0.1727)} + \frac{1}{2} - \frac{0.1727}{(0.137)^2} + 0.137\left(\frac{0.18798}{0.2410}\right)\left[\left[\frac{1}{(0.137)^2}\right](1.025) - 3.353\right]$$

$$\Omega_y = -0.3286$$

$$\Omega'_y = -1 + n + k\frac{z}{b}(\mathcal{F} - \mathcal{E})$$

$$\Omega'_y = -1 + 0.1727 + 0.137\left(\frac{0.18798}{0.2410}\right)(3.353 - 1.025)$$

$$\Omega'_y = -0.5785$$

- Step 11.3. From Eqs.(34 and 35) the A and B values to determine Δ are

$$A = \frac{1}{2}\left(\frac{1}{4.365 \times 10^{-3}m} + \frac{1}{-4.54 \times 10^{-3}m}\right) = 4.415m^{-1}$$

$$B = \frac{1}{2}\left(\frac{1}{4.365 \times 10^{-3}m} + \frac{1}{-35.003125 \times 10^{-3}m}\right) = 100.26m^{-1}$$

Therefore from Eq.(30)

$$\Delta = \frac{1}{4.415m^{-1} + 100.26m^{-1}}\left[\frac{1-(0.30)^2}{200 \times 10^9 \frac{N}{m^2}} + \frac{1-(0.30)^2}{200 \times 10^9 \frac{N}{m^2}}\right] = 8.6933 \times 10^{-14}\, m^3/N$$

Then from Eqs.(20 to 22) the principal contact stresses values are

$$\sigma_x = \left[[0.2724(-0.1648 + (0.30)(-2.7238)] \left(\frac{0.000241}{8.6933 \times 10^{-14}}\right) \right]$$

$$\sigma_x = -741522665.686$$

$$\sigma_y = \left[[0.2764(-0.3286 + (0.30)(-0.5785)] \left(\frac{0.000241}{8.6933 \times 10^{-14}}\right) \right]$$

$$\sigma_y = -384772372.51$$

$$\sigma_z = \left[-\left[\frac{0.2764}{2}\left(\frac{1}{0.1727} - 0.1727\right)\right] \left(\frac{0.000241}{8.6933 \times 10^{-14}}\right) \right]$$

$$\sigma_z = -2152276334.65Pa$$

And from Eq.(23) the maximum shear stress value is

$$\tau_{máx} = \frac{(2152276334.65 - 384772372.51)}{2} = 883751981.07Pa$$

Based on the above stress values, the Weibull parameters used to determine the real life and reliability of the ball bearing are determined as mentioned in section 6.4.

- Step 12. Determine the parameters Weibull η y β.

By using the maximum contact stress value σ_1 and minimum contact stress value in Eq.(36), the use Weibull scale parameter is

$$\eta_{use} = \sqrt{\sigma_1 \sigma_3} = \sqrt{(2152276334.65)(384772372.51)} = 910020039.109$$

And from Eq.(37) the Weibull shape parameter is

$$\beta = -\frac{4\mu_y}{0.995 ln\left(\frac{\sigma_1}{\sigma_3}\right)} = -\frac{4(-0.54562412)}{0.995 \ln\left(\frac{2152276334.65}{384772372.51}\right)} = 1.274062 \cong 1.28$$

Therefore, the Weibull parameters used to determine the life of the ball bearing are W(1.28, 910020039.109rev). With these parameters, the real reliability of the ball bearing as mentioned in section 6.5 is *Step 13a*. From Eq.(38) By using the catalogues L_{10} life of 774.85 ´ 10^6 rev and the use Weibull scale parameter, the reliability of the ball bearing is estimated to be

$$R(t) = \exp\left\{-\left(\frac{L_{10}}{\eta_{use}}\right)^{\beta}\right\} = \exp\left\{-\left(\frac{774.85x10^6}{910020039.109}\right)^{1.28}\right\} = 0.4431$$

Notwithstanding, it is important to distinguish that because the L_{10} value was used, it does not represent the applied stress, instead, it represents the expected life at the conditions at which the ball bearing was designed. The η_{use} value does not represent the strength and the conditions at which the ball bearing was designed, thus, the estimated reliability of R(t)=0.4431 does not represent the life that the ball bearing will have under the stress environment at which the shaft 2 is operating. Therefore, to determine the real reliability we must proceed with the next steps.

Step 13b. By setting Eq.(38) at R(t) = 0.90, the real $L_{(use)}$ life that represents the actual conditions at which shaft 2 is operating, is given from Eq.(39) as

$$L_{10(use)} = \eta_{use} * \sqrt[\beta]{-\ln(0.90)} = 156862111.04rev.$$

Now that the $L_{(use)}$ value represents the actual stress environmental, it is necessary to determine the Weibull scale parameter that represents the strength of the selected ball bearing. It is determined as follows:

Step 13c. The strength η_{cat} value that represent the strength of the ball bearing is determined from Eq.(39) by using the catalogue L_{10} life.

$$\eta_{cat} = \frac{L_{10}}{\sqrt[\beta]{-\ln(0.90)}} = 495215719.28rev$$

Finally, by using the $L_{(use)}$ value and the η_{cat} value the real reliability of the ball bearing is

- Step 13d. From Eq.(41) the real reliability of the selected ball bearing is

$$R(t) = \exp - \left(\frac{L_{(use)}}{\eta cat}\right)^{\beta} = \exp - \left(\frac{15686211.04}{4495215719.28}\right)^{1.28} = 0.9864$$

Ultimately, we can notice from step 13d that the real reliability of the ball bearing is higher than the designed reliability of R(t)=0.90. This occurs mainly because the estimated life is lower than the catalogues life ($L_{use} < L_{10}$). This implies that the ball bearing's lifetime in this application is higher than it was designed.

Conclusions

The proposed methodology allows practitioners to determine the real reliability of mechanical components. The use of the Weibull distribution lets us predict the failure occurrence. Consequently, the derived reliability index can be used to determine the time to schedule the corresponding maintenance program. Since the reliability index can be determined at any desired time, then it can be implemented in the Industry 4.0 framework to manage and give instantaneous feedback to the process. In the ball bearing case, the given methodology permits practitioners to determine the Weibull parameters directly from the generated contact Hertz stresses values. Once the value of the applied (generated) stresses is known, the Weibull parameters can be determined. Then, the proposed methodology can be used to obtain the real reliability in different bearing applications. As a result, the real reliability of machine component can always be determined and in the Industry 4.0 framework, a computer algorithm can easily be implemented.

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CHAPTER 6

Critical Factors on Sustainable Management in Smart Manufacturing Plants of Ciudad Juárez

Cristina Zapien-Guerrero*[1], Vianey Torres-Argüelles[1], Salvador Noriega[1], Andrés Hernández-Gómez[1], Roberto Romero[1]

[1] *Department of Industrial and Manufacturing Engineering, Institute of Engineering and Technology, Autonomous University of Ciudad Juárez, Ciudad Juárez, Chihuahua, México*

* *Corresponding Author: vianey.torres@uacj.mx*

Abstract. This research reports the determination of the factors that influence the creation and implementation of sustainability practices in international manufacturing plants located in Ciudad Juarez, Mexico. The factors are determined through an exhaustive literary review used by the factories. These elements are segregated by a Confirmatory Factorial Analysis (CFA) by means of structural equations modeling, using AMOS®, v. 22. The findings allowed us to conclude that the deployment of sustainability strategies must be classified into four categories: environmental, economic, social and technological. All classifications include 9 critical success factors that must be managed to ensure that organizations carry out efficiently the sustainability practices.

Keywords: Smart manufacturing, Sustainable Manufacturing, Sustainable Strategies, Confirmatory Factorial Analysis.

Introduction

Globally, pollution is the central focus of environmental awareness. The Intergovernmental Panel on Climate Change reports that industrial processes are one of the main sources of pollution (IPCC, 2018). This threat configures a demanding and somehow conflicting paradox, since while it seeks environmental protection by insisting in a legislation that assures a more sustainable industrial production, the global markets also demands better products from companies and constant improvements of their manufacturing technologies. Therefore, the technology used for the industrial development not only must it focus on the products improvement, but it should also be considered as an essential axis for sustainability. Production technology is evolving, Intelligent Manufacturing is relatively new in the Industry 4.0 system. This includes diverse technological components (Kusiak, 2017) such as smart equipment, robots, simulation, big data, (Heck & Rogers, 2014), agile and flexible processes capable of high quality and low cost production (Ruessmann, 2015) to increase quality, efficiency and competitiveness in the long run (Lu et al., 2016). Nonetheless, current environmental awareness requires that manufacturing industries employ strategies that execute sustainable actions and practices for environmental management. (GACCFM, 2014). Environmental management is a set of strategies focused on the reduction of environmental impacts (Latan et al., 2018) deployed by diverse actions aimed at protecting ecosystems, their conservation, defense and improvement (Graves et al., 2013), under a policy of optimal management of resources and costs reductions by means of efficient waste management, use of raw materials, energy and water (Hull et al., 2017). Manufacturing companies lean towards sustainable management by adopting strategies such as: green supply chain (Chaabane et al., 2012), reverse logistics (Guarnieri et al., 2016), and clean production (Govindan & Soleimani, 2017), which can lead to the integration of the smart industry with the green industry (Meng & Chi, 2018), a transition to Green Intelligent Manufacturing.

The border of Ciudad Juarez with El Paso, Texas, has a world-class manufacturing industry. International companies operate more than 200 industrial plants, employing more than 200,000 workers and utilizing innovative technologies. Nonetheless, some of the production processes such as electrochemical, soldering, washing, painting, equipment lubrication or packaging materials—which are widely used by industrial factories—impose environmental threats. Given that these threats, their compliance, related costs and efficiency are closely linked, sustainable practices are of great relevance. Companies seek greener processes to avoid pollution, lower cleanup costs and meet international social and environmental standards (Abdul-Rashid et al., 2017; Mani et al., 2016). To achieve this, companies must identify the essential factors of the implementation of sustainable practices, improve the processes, and efficiently reduce waste generation (Cai et al., 2018) and pollution (Velázquez et al., 2014); and thus, obtaining a sustainable development.

To accomplish the objective of this study, a literature review was first carried out to identify the factors that influence sustainability in the manufacturing industry. These factors are presented in section 2 of this chapter. This review was based on four dimensions of sustainability: environmental, economic, social and technological. Section 3 reports the methodology. Section 4 presents the results, factors of sustainability adoption are identified by structural equations modeling. Finally, section 5 presents the conclusions of this study and the factors required to integrate sustainable management into the intelligent industry.

Literature Review

The optimization of resources can be carried out in the different industrial processes. Table 1 lists the critical factors to adopt practices in each sustainable dimension that were extracted from the reviewed literature.

Table 1. *Dimensions and factors of sustainability*

Sustainable Dimension	Factor	Reference
Environmental: Demands that the development of the company be compatible with the maintenance of ecological processes and natural resources.	Energy	Hashmi et al., 2015; Marconi et al., 2018; Yang et al., 2006
	Water	Hörisch et al., 2015; Renukappa et al., 2013
	Waste	Buratti et al., 2016; Carrillo-Hermosilla et al., 2010; Mativenga et al., 2017
Economic: Demands an economically efficient and equitable development with environmental actions.	Inversion	Demirel & Kesidou, 2011; Ghisellini et al.,2016;
	Recuperation	Lett, 2014; Pinjing et al., 2013
Social: Seeks to strengthen the commitment of its staff and that the company transmits to society a commitment to the environment	Internal: practices that companies deploy	Hesselbarth & Schaltegger, 2014; Winroth et al., 2016
	External: social, suppliers and consumers	Abdul-Rashid et al., 2017; Vieira et al., 2016; Wiesen et al., 2014

Sustainable Dimension	Factor	Reference
Technological: Aims to develop cleaner processes from science and technology	Technological inventory	Despeisse et al., 2012; Ghisellini et al., 2016
	Eco-innovations	Carrillo-Hermosilla et al., 2010, Cheng et al., 2014, Triguero et al., 2013 Esmaeilian, Behdad & Wang, 2016. Ranson et al., 2015; Razali et al., 2015;

Source: *Self-made.*

This review shows nine critical success factors. Their management as sustainable practices leads to the reduction of the environmental threats of industrial processes, agreeing with Hörisch, et al., (2015), including social and industrial economics effects. The factors focus is on the efficient use of energy, water and materials by means of policies, practices, discipline, reuse and recycling (Mativenga et al., 2017). Investments in the deployment of policies, practices and reuse-reducing of the product unit cost because policies reduce energy prices (Singh et al., 2013). Recycling reduces raw materials costs, which also reduces scrap costs, enhancing employees morale (Winroth et al., 2016), policies and practices are also deployed through agreements between the companies and their customers, seeking increases in the level of service under a sustainable and green approach. (Abdul-Rashid et al., 2017). Equipment, product technologies, manufacturing and transformation processes have to focus on the production of eco-innovation goods, greener production technologies and investments on more efficient industrial production with a sustainable focus on materials (Navarrete, 2015).

Methodology

A measuring instrument was developed from the factors identified in the literature review and it is presented in this document to show the relationship with the model developed in this work. The 35 indicators are part of the 9 sustainable factors of the 4 sustainability dimensions studied. The selected factors have a significant effect on production processes and are proposed as activities that can be carried out as part of sustainable management. Tables 2 a, b, c, and d, show the environmental, economic, technological and social dimensions of sustainability respectively along with their particular factors and indicators; the table corresponds to sections b, c, d, and e, of the measurement instrument. The complete instrument can be seen in Zapién-Guerrero, Torres-Argüelles, & Romero (2018).

The reliability validation of this instrument is also reported by Zapién-Guerrero et al., (2018) where it shows that the obtained Cronbach's Alpha, in the validation process was equal to 0,968; This means that the items measured on a Likert scale measure the same construct and they have a highly correlated (Cortina, 1993).

The sample of manufacturing industries of Ciudad Juárez is constructed by factories using all sorts of technologies, excluding the food, beverage, textile, clothes printing, furniture and leather industries. Considering the importance of size, factories are selected by the staff workforce size, selecting from eleven to two hundred and fifty employees.

To prove the validity of empirical data, a useful tool, according to Hernández et al., (2017), is the confirmatory factor analysis (AFC), which allows to assess the contribution of each indicator (Escalera-Chávez et al., 2014).

Table 2a. *Indicators of the environmental dimension of Sustainability*

Electricity / Gas	1	Monitored through a report electricity usage.
	2	Monitored through a report using gas.
	3	Develop energy and gas efficiency practices.
	4	Make a report of greenhouse gas emissions CO_2.
Water	5	Monitored through a report the use of drinking water.
	6	Know the destination of your residual loads (drainage / causes).
	7	Develop water use practices.
	8	It makes use of treated water.
Waste	9	Identify the sources of waste generation.
	10	Maintains segregation procedures for organic and inorganic waste.
	11	Maintains programs for the reuse of generated internal waste.
	12	Maintains a solid waste management plan.
	13	It monitors, through a report, the quantities and type of waste generated.
	14	It monitors that part of the scrap is recoverable.
	15	Is aware if the process / service generates toxic waste.
	16	Identify from the total of your shipments that percentage uses returnable packaging.

Source: *Self-made.*

Table 2b. Indicators of the economic dimension of Sustainability

Investment	17	Perform a SWOT analysis to carry out sustainable practices (efficient use of energy and non-renewable resources, recycling, among others).
	18	Performs the review of a budget for investment in sustainable technologies or innovations.
	19	Realizes a control of return of investment of each of the technologies and sustainable practices implemented.
Recovery	20	Make a collection and analysis of the savings produced by the use of recycled materials, green energy, and recycled water among other practices.
	21	Realizes a control of the economic entrances by concept of recovery or transformation of scrap or waste.

Source: *Self-made.*

Table 2c. Indicators of the technological dimension of Sustainability

Sustainable technology inventory	22	It carries out a review of the technologies, to ensure the control of emissions (Automatic equipment shutdown, after a prolonged period of non-use.)
	23	Performs a review of the technologies, to reduce the amount of waste they generate.
	24	Performs a review of administrative processes that use sheets, and may be replaced by an electronic database.
Eco-innovations	25	Make eco-innovation projects in your products.
	26	Make eco-innovation projects in their processes.
	27	Make eco-innovation projects in your organization.

Source: *Self-made.*

Table 2d. Indicators of the social dimension of Sustainability

Internal	28	Carries out training for the company's personnel, on the care of the environment, recycling, toxic waste, environmental accidents, among others.
	29	Make a communication of the environmental behavior of the company to its employees.
	30	Knows what percentage of their suppliers have a sustainable certification (clean industry / ISO 14000).
	31	Know what percentage of your total products are recycled or reused at the end of their life cycle.
	32	It has IDs for being a green product (eco labels) if applicable.

External	33	Know what percentage of your customers are interested in having a sustainable certification (clean industry / ISO 14000)
	34	Make environmental actions in the environment of your company (reforestation, cleaning parks or vacant lots, among others).
	35	Coordinate with your client to take the product to collection sites, when it reaches its useful life.

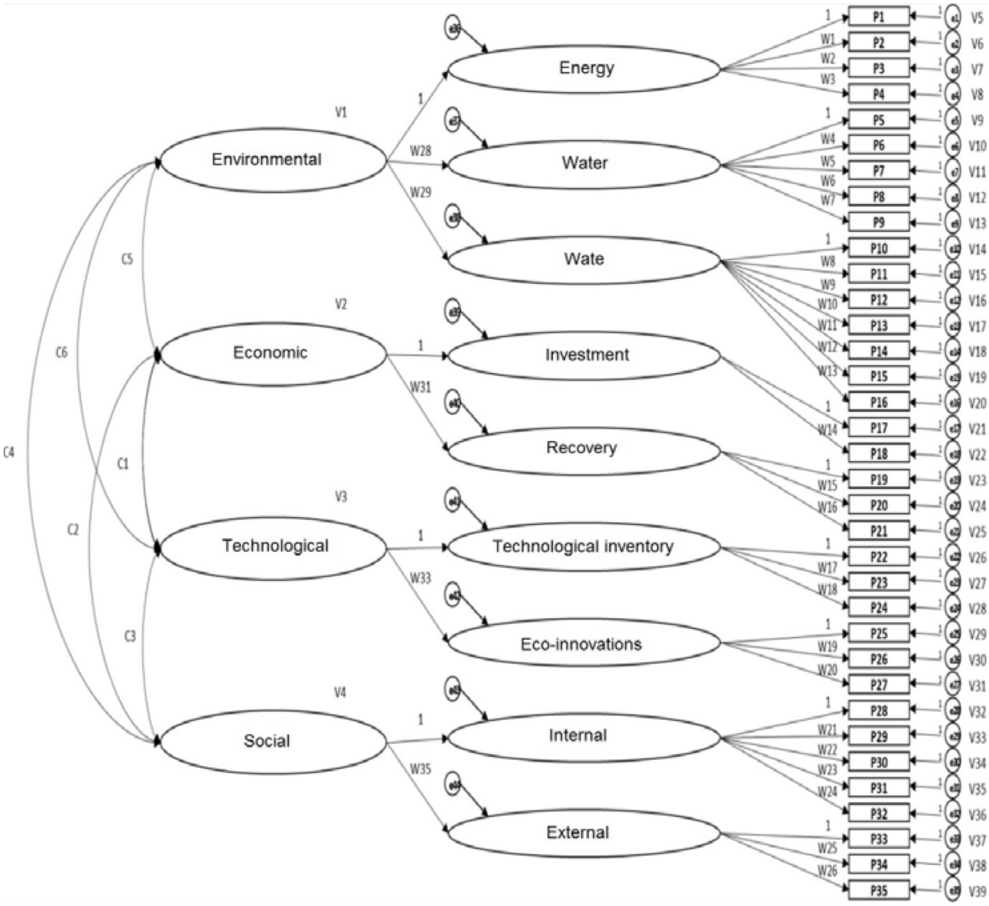
Source: *Self-made.*

Results and Discussion

The application of the measuring instrument resulted in 85 valid surveys. The graphic representation of the measuring instrument was obtained by AMOS modeling software. Figure 1 presents the model, it gives the relationships between the 4 dimensions of sustainability, its 9 factors and the 35 indicators, which were encoded from P1 to P35.

Table 3 presents the usual goodness-of-fit measures used to assess model fit. The Chi-square statistic (χ2) is conceptually the most used as an adjustment index, but it is very sensitive to the sample size. Nonetheless, it is not acceptable in this case n this case. For this reason, Chi-square / degrees of freedom (df) are usually used where values in the range 1 to 3 and with limits of up to 5 are accepted (Hair et al., 1999; 2014), which indicates that the model has an acceptable fit because it gives a result of 2,021, the rest of the adjustment indices are shown in Table 2, also demonstrating that the fit of the model is adequate. Statistics indicate an acceptable fit. The statistics indicate an acceptable fit. Table 3 presents the unstandardized parameters and their standard errors of estimation (SE) indicating whether the parameters are significantly different from zero. The first column describes the values of the regression weights between the components and the indicators, the numbers that appear on the model chart on the arrows that link the latent variables or component with their indicators. The next column of Table 3 is the estimation errors. Because they depend on the unit of measurement in the observed and latent variables, as well as on the magnitude of the estimated parameter, there is no definitive criterion established for them to state whether they are small or large. The third column is used to know the statistical significance of the parameters through the Critical Ratio (CR) statistical test, which represents the quotient between the estimated parameter and its standard error. The fourth column is the p-value and finally the same weights appear for the standardized solution. These are the factorial weights; values that relate a dimension to the corresponding observed variable and thus, each dimension can be characterized. In this case, all weights are statistically significant, considering a confidence level of 95%, the Critical Ratios are greater than 1.96 and their p-values are lesser than 0.05 level. In the fifth column, the default label of the variable given by AMOS appears. Finally, the values next to the arrows linking the sustainable dimensions with the factors and indicators from P1 to P35 indicate the standardized factorial weights of the indicator variables, which are shown in Table 3 in the standardized factorial weights column.

Figure 1. AMOS Structural Relationships Model. Source: self-made.



Source: *Self-made.*

Based on the analysis of the results, it was determined that the proposed factors to management of sustainable practices have a significant and positive effect on the sample companies. The relationships between the study dimensions and their categories or factors show an acceptable fit, so it was not necessary to modify the model.

Table 3. Goodness of FIT Statistics. Source: self-made

Adjustment index	Code	Criteria	Result	Decision
Chi Square	X^2	$p \geq 0.05$	0	Non acceptable
Ratio Chi-Square/ Freedom Degrees	X^2/ gl	De 1 a 5	2.021	Acceptable
Square Root of the Media of the Waste	RMR	Close to 0	0.268	Acceptable
Parsimonious Adjustment				
NFI Corrected by Parsimonia	PNFI	Close to 1	0.616	Moderately accept-able
Parsimonia Adjustment Goodness Index	PGFI	Range 0.5 a 1	0.501	Acceptable
Adjustment Goodness Index	GFI	Close to 0.9	0.58	Moderately accept-able
Corrected Adjustment Goodness Index	AGFI	Close to 0.9	0.514	Moderately accept-able
Root of the Approximate Average Quadrate Residue	RMSEA	$p \leq 0.05$	0	Acceptable

Source: *Self-made.*

Table 4. Non-standardized and Standardized Results for sustainability dimensions. Source: self-made.

	Factorial Weight (Non-standarized factor load)	S.E.	C.R.	P	Label	Factorial Weight (Standarized factor load)
Energy <-Environmental	1.00					0.90
Water<-Environmental	1.13	0.134	8.39	***	W28	0.95
Waste<-Environmental	0.76	0.139	5.464	***	W29	0.87
Investment<-Economic	1.00					1.00
Recovery <-Economic	1.03	0.106	9.643	***	W31	0.96
Internal<-Social	1.00					0.93
External<-Social	0.82	0.152	5.401	***	W33	0.97
Technological invento-ry<-Technologic	1.00					0.97
Eco-innovation<-Tech-nologic	1.28	0.213	6.025	***	W35	0.82

Source: *Self-made.*

Conclusions

The objective of this study was to identify the factors that have a significant effect on the implementation of sustainability. According to the research, there are nine factors (shown in Table 4), which in turn are composed of various indicators, distributed in the four dimensions of sustainability of the industry. Being: 1) Environmental: Energy, Water, and Waste; 2) Economic: Investment and Recovery; 3) Social: Internal and External; and 4) Technological: Technological inventory and Eco-innovations. As reported by our analysis, there are two activities that, although they required an implementation of sustainability, they have a marginal contribution. They are represented by indicators 24 and 25 shown in Table 1c and correspond to the administrative processes that generate waste and to the projects focused on eco-innovation, respectively. The dimensions described above have an important implication for organizations that seek to adopt strategies to promote sustainability, and in turn, represent the essential aspects to be developed during the application of sustainable activities. That is, any action that is planned to be initiated must be aligned to each of the dimensions determined in this study. On the other hand, given the nature of the research method used, the findings should be interpreted with caution. Therefore, it is recommended to replicate research in different contexts to increase the explanatory power of the model of the dimensions of sustainability and the factors whose effect is significant. It is necessary to develop a complementary study that allows establishing the relative weight of each of the identified dimensions, and thus, establishing structural hypothesis that deepen the exploration of the phenomenon of applying sustainability strategies in manufacturing companies.

Table 5. *Non-standardized and Standardized Results for factors. Source: self-made.*

	Factorial Weight (Non-standarized factor load)	S.E.	C.R.	P	Label	Factorial Weight (Standarized factor load)
P1 <- Energy	1					0.86
P2 <- Energy	1.06	0.107	9.945	***	W1	0.85
P3 <- Energy	1.04	0.098	10.613	***	W2	0.88
P4 <- Energía	0.88	0.125	7.092	***	W3	0.68
P5 <- Water	1					0.88
P6 <- Water	0.98	0.101	9.66	***	W4	0.82
P7 <- Water	1.02	0.1	10.237	***	W5	0.84

	Factorial Weight (Non-standarized factor load)	S.E.	C.R.	P	Label	Factorial Weight (Standarized factor load)
P8 <- Water	0.67	0.144	4.627	***	W6	0.48
P9 <- Waste	1.35	0.212	6.349	***	W7	0.87
P10 <- Waste	1					0.62
P11 <- Waste	1.04	0.195	5.353	***	W8	0.69
P12 <- Waste	1.19	0.195	6.121	***	W9	0.82
P13 <- Waste	1.33	0.213	6.214	***	W10	0.84
P14 <- Waste	0.79	0.181	4.381	***	W11	0.54
P15 <- Waste	1.25	0.229	5.454	***	W12	0.7
P16 <- Waste	1.16	0.219	5.304	***	W13	0.68
P17 <- Investment	1					0.84
P18 <- Investment	1.13	0.096	11.823	***	W14	0.94
P19 <- Recovery	1					0.88
P20 <- Recovery	1.01	0.098	10.365	***	W15	0.84
P21 <- Recovery	0.87	0.098	8.822	***	W16	0.77
P22 <- Internal	1					0.93
P23 <- Internal	1.02	0.061	16.78	***	W17	0.96
P24 <- Internal	0.76	0.111	6.84	***	W18	0.63
P25 <- Internal	0.54	0.129	4.142	***	W19	0.43
P26 <- Internal	0.67	0.123	5.434	***	W20	0.53
P27 <- External	1					0.59
P28 <- External	1.02	0.204	4.976	***	W21	0.72
P29 <- External	0.96	0.215	4.478	***	W22	0.61

	Factorial Weight (Non-standarized factor load)	S.E.	C.R.	P	Label	Factorial Weight (Standarized factor load)
P30 <- Technological inventory	1					0.65
P31 <- Technological inventory	1.28	0.195	6.551	***	W23	0.85
P32 <- Technological inventory	1.29	0.2	6.438	***	W24	0.83
P33 <- Eco-innovation	1					0.94
P34 <- Eco-innovation	1.12	0.052	21.489	***	W25	0.99
P35 <- Eco-innovation	1.01	0.059	17.139	***	W26	0.94

Source: *Self-made.*

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CHAPTER 7

Model of Logistics Factors and their Impact on the Competitiveness of Small and Medium Enterprises within the Industry 4.0 Paradigm

Idalí Bailón[1], Roberto Romero[1], Favela Marie*[1]

[1] *Department of Industrial and Manufacturing Engineering, Institute of Engineering and Technology, Autonomous University of Ciudad Juárez, Ciudad Juárez, Chih., México*

* *Corresponding Author: marie.favela@uacj.mx*

Abstract. The creation of new actions that promote the competitiveness of Small and Medium sized Enterprises (SME) is due to SME expansion. In Mexico, according to data provided by the National Institute of Geography and Statistics (INEGI), there are about 4 million 15 thousand business units, of which the 99.8% are SME that generate 52% of the Gross Domestic Product (GDP) and 72% of the jobs in the country. This means that choosing a right logistics and supply chain strategy requires using a creative process to develop an appropriate corporate strategy, using logistical factors that help to increase the SMEs competitiveness within the Industry 4.0 paradigm. The purpose of this research is to assess the impact of every logistical factor on the SME competitiveness in the plastics injection field. The methodology applied in

this research consists of first carrying out a literature review of many databases in order to identify the logistical factors, then, each one of these factors will be operationalized and thus, an instrument with 33 items will be produced. This instrument was validated according to content and criterion. To conclude, a first order factor model will be used to know the effect of each one of the logistical factors. The results of the theory review were 7 factors: transportation, distribution, inventory management, production, customer service, storage and supplying and purchases. In the validation stage, the Kendall Index and Cronbach's alfa were 0.366 and 0.907 respectively, which are acceptable ratings. Likewise, the factorial model presents acceptable adjustment indexes, being the customer service factor the most meaningful with a standardized weight of 0.906.
Keywords: Competitiveness, logistical factors, Multivariate Analysis

Introduction

Competitiveness is the result of the transformation of competencies, which offer a difference with respect to others and, in turn, turn them into attributes valued by demand (Bilancio, 1999). At present, the high competitiveness among companies has led various experts to propose models to raise it, but these models are particularly aimed at large companies because of their economic importance (Contreras, 2003), forgetting the small and medium-sized enterprises (SMEs) and their specific needs. In Mexico, according to data from the National Institute of Statistics and Geography, there are approximately 4.15 million business units, of which 99.8% are SMEs that generate 52% of the Gross Domestic Product (GDP) and 72% of employment in the country (PROMEXICO, 2014; Saavedra & Tapia, 2012; Soto, 2009), in this way, it is appropriate to support SMEs to raise their competitiveness levels that are in decline (Lopez, Ahumada, Perusquia and Zarate, 2010). Therefore, it is necessary to create actions that promote the competitiveness between SMEs. According to Ballou (2004), the creation of strategies begins with a clear understanding of the objectives that the company intends to achieve such as profit, survival, social, return on investment and market share or growth. This implies that the selection of an adequate logistics and supply chain strategy requires the use of a creative process, which allows the development of an adequate corporate strategy (David, 2003), which according to Ballou (2004); Zevallos (2006); Christopher (2003), innovative approaches in logistics and supply chain strategy can represent a competitive advantage by increasing flexibility, quality standards and efficiency (Tjahjono, Esplugues, Ares and Pelaez, 2017). Furthermore, it should not be forgotten that a competitive advantage is the consequence of having identified and exploited what another could not (Bilancio, 1999). An innovative process of logistics which have been in used since remote times, such as in the military, to be later adopted by companies as an efficient measure of competitiveness and to increase the profitability of the business (López et al, 2010).

Description of the problem.

Markets have become highly competitive and due to their rapid growth, they are constantly changing, going from simple to complex, from stable to dynamic (Gebauer, Gustafsson, & Witell, 2011). According to the importance that SMEs represent in the growth of a country (Ochoa, Jacobo, Leyva, & López, 2014), it is necessary to adopt strategies to contrast the demands of survival in the market (López-Mielgo, Montes-Peón, & Vázquez-Ordás, 2012). One strategy to follow when there are short product life cycles, or development of new product lines, or changing supply chains and new technologies, is logistics, which has become an essential instrument for the competitive success of companies (Christopher, 2003).

The application of logistics increases the need for coordination and conjunction of processes and systems, which in turn allows the emergence of a final product or service perfected to market segments with constantly changing needs (Carranza et al, 2003). In order to position a company in such a way that it can be distinguished from its rivals, it is necessary to take full advantage of the value of its capabilities, as well as to implement strategies that make them competitive (Porter, 1982). Therefore, it is clear that the design and implementation of these growth and innovation strategies are what allow companies to achieve a better position (O & S, 2010; Rozmahel, Grochová, & Litzman, 2014) Nonetheless, the strategies adopted by SMEs are still not known with certainty because they are not documented (Ojeda, 2009), nor are the factors used for a better management of the company known, allowing it to take advantage of its resources in the best way and compete successfully in the market, overcoming the difficulties that currently arise and contributing to its growth (Bonitto, 2010).

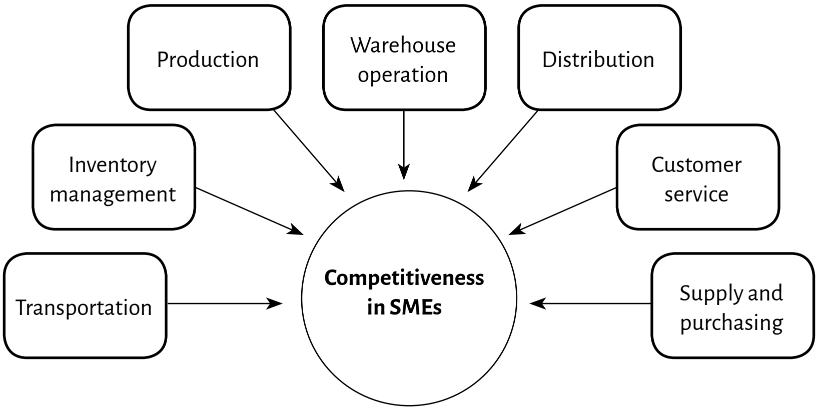
Competitiveness

Competitiveness is conceived as a business phenomenon or organizational pattern of society, related to its behavior in the market in which it operates (Orozco-Rosas, Ahumada-Tello, & Zárate, 2010; Sanchez & Fajardo, 2008), maintaining and increasing its participation based on new strategies (Mora-riapira & Vera-colina, 2015). In most cases, competitiveness depends on productivity, profitability, competitive position, and participation in the domestic and foreign markets (Saavedra & Tapia, 2012). For Porter (1990), competitiveness is "...the production of goods and services of higher quality and lower price than domestic and international competitors, which translate into increasing benefits for the inhabitants of a nation by maintaining and increasing real incomes".

Proposed ModelModel

According to the literature review, a logistics model is proposed for SMEs so that they can increase their competitiveness within the market (see Figure 2.1).

Figure 2.1 *Proposed model for increasing competitiveness in SMEs Each of these factors will explain the positive effects it has on increasing competitiveness in SMEs.*



Source: *Own elaboration.*

Generation of instrument as a survey

Survey designed is also of great importance since the way a question is written influences the answers obtained to the extent that the respondent may feel pressured to answer in a certain way (Alaminos & Castejon, 2015). The competitiveness of an organization linked to the management of Transportation for inventories associated with the distribution and storage of production is a decisive task of utmost importance (along with the proper characterization of a correct Customer Service Supply) to make the purchasing experience more efficient.

Formulation of the questions

The wording of the question should be carefully chosen as it may influence the responses of the interviewees. The more flexible the question is, the answers become more vague. Therefore, questions should not mislead the interviewee, should not be ambiguous, should not ask for information that the interviewee does not have or cannot recall with certainty, or be too sensitive and cause the interviewee to avoid them or answer them in a misleading manner.

The order in which one question is asked in relation to the others is significant, given the cumulative nature of the information produced in the interview. Once a question has been asked, the interviewee will take it into account when assessing the following questions asked, thus, influencing the perception of its content. The *Likert scale*, according to Hernández, Fernández & Baptista (2006), consists of a set of items presented in the form of statements or judgments to which the participants are asked to react. That is, each statement is presented, and the subject is asked to express his/her reaction by choosing one of the five points or categories of the scale. Each point is assigned a numerical value. Thus, the participant obtains a score with respect to the statement and at the end his or her total score, adding up the scores obtained in relation to all the statements.

The Cronbach's Alpha coefficient, which is a static technique, analyses the internal consistency of the scale as a dimension of its reliability by calculating the correlation between scale items. This statistic can be considered as a correlation coefficient. One interpretation of their results indicates that if the different items of a scale are measuring a common reality, the responses to these items will have to present a high correlation between them, otherwise, the existence of a low correlation between some items shows some statements of the scale that are not reliable measures of the construct. The value of *Cronbach's Alpha* can range from 0 to 1. If it is 0, it means that the scores of the individual items are not correlated with those of all the others. On the contrary, a higher alpha value means a higher correlation between the different items, thus increasing the reliability of the scale, taken from Molina, (2008). *Cronbach's Alpha* below 0.5 shows an unacceptable level of reliability; if it were to take a value between 0.5 and 0.6 it could be considered a poor level. If it were to be between 0.6 and 0.7, it would be a weak level. Between 0.7 and 0.8, it would refer to an acceptable level; in the interval 0.8-0.9 it could be qualified as a good level, and if it took a value above 0.9 it would be excellent (Gallardo, Sánchez, & Corchuelo, 2012). *Cronbach's Alpha* is a standard measure of reliability defined as: Where: σ i 2 = the variance of the q-th item score, q=1..., k σ x 2 = total variance k = number of items

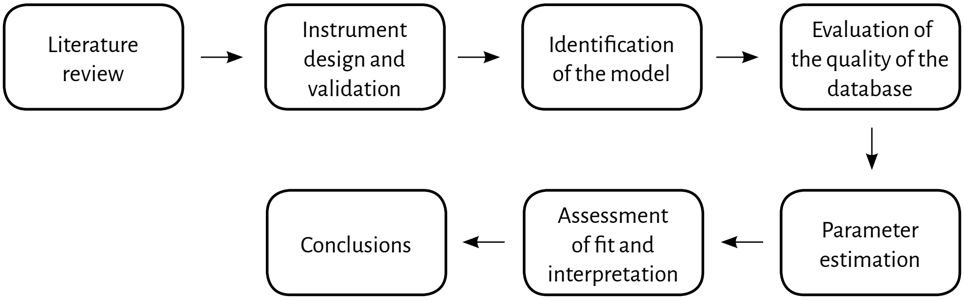
Factorial analysis, according to Pérez (2004), is a multivariate technique that aims to reduce the size of an excessively large data table due to the high number of variables it contains and to keep a few dummy variables that, although not observed, are a combination of the real ones and synthesize most of the information contained in their data. The factors should be enough to summarize most of the information contained in the original variables. Factor analysis can be exploratory or confirmatory.

Exploratory analysis is characterized by the fact that the number of factors is not perfectly known, and it is in the empirical application that this number is determined. In contrast, in confirmatory type analysis, the factors are fixed a priori, using hypothesis contrasts for their corroboration. According to Siegel & Castellan (1995), this coefficient is used when one wants to know the degree of association between k sets of ranks, so it is especially useful when experts are asked to assign ranks to the items, such as from 1 to 4. The minimum value assumed by the coefficient is 0 and the maximum 1, and its interpretation is the same as that of the Kappa coefficient. Nevertheless, it is necessary to review the rating given to each item since there may be a high degree of agreement in the aspects, an example of which is that the item is not appropriate (Escobar & Cuervo, 2008). Certainly, in this case, the item must be eliminated or modified completely until it fits the objectives of the measurement in an appropriate way.

According to Siegel et al (1995), a high value of the coefficient can be interpreted as a reflection that observers or judges are applying the same standards when assigning ranges to the items. This does not guarantee that the observed rankings are correct, as all judges may agree if they are all using the wrong criteria for ranking. According to Escobar & Cuervo (2008), Kendall's W concordance coefficient the hypotheses raised are H0: the ranks are independent, they don't match. H1: There is significant agreement between the ranges. Once the results are obtained, they are interpreted as follows: H0 is rejected when the observed value exceeds the critical value (with an alpha of 0.05) and when the significance level is lower than 0.05, the H0 is rejected, thus, it is concluded that there is significant agreement between the ranges assigned by the judges. Moreover, the strength of the concordance is interpreted, which increases when W approaches 1.

Proposal Methodology

Figure 3.1 *Proposed methodology for the development of the project.*



Source: *Own elaboration.*

The following sections present in detail what each of the above stages consists of.

Literature review

For the present investigation, a bibliographic review was carried out in different databases, as well as scientific articles, with the objective of identifying the Logistics Management Models and each one of its logistic factors (Bibliographic review, Design of instruments and validation of the Model, specification of the Model, identification of the Model, evaluation of the quality and validation of the Model, Model specification, Model identification, quality evaluation, estimation of the Parameters associated with the proposed Model and Evaluation and interpretation of the correct fit of the Model). The interpretation of the conclusions contributes to increase the competitiveness of SMEs. SMEs. In this way, it is possible to identify the similar factors used in the reviewed models that have contributed to the increased competitiveness of SMEs to the increased competitiveness of SMEs in their current and Industry 4.0 context.

Instrument design and validation

Once the logistical factors or indicators for each of the constructs have been identified, the variables are put into operation and a table containing the construct used is drawn up with its definition and indicators. The questions are scored with the *Likert Scale* to measure the impact of each of the logistical factors on competitiveness in the SMEs. The *Likert Scale* is shown in Table 3.1.

Table 3.1 *Likert Scale used*

1. Strongly disagree	2. Somewhat disagree	3. Neither agree nor disagree	4. Somewhat agree	5. Strongly agree

Source: *Own elaboration.*

The instrument designed is scored by experts to find out how well the questions match each other.

The index used was Kendall's W, which is particularly useful when experts are asked to assign ranges to items, according to the author Escobar & Cuervo (2008). Having Kendall's W value, a sample is made for convenience to different SMEs of the plastic injection sector to know the criteria validity using *Cronbach's alpha* index. This way, it can be known whether the instrument carried out is suitable for measuring the impact of logistical factors on the competitiveness of SMEs. Strongly disagree 2. Somewhat disagree 3. Neither agree nor disagree 4. It is important to know the distinction of the relationship between the variables, since if they are not mentioned by the researcher, it is assumed they are be equal to zero. The value of zero is given when there is a direct relationship between the expectation of results and academic performance, although the relationship between these two variables is measured by performance goals.

Identification of the model

When the correct theoretical model is known, the identification of the model continues. If all parameters are identified, then the model is also identified. To identify a model, the degrees of freedom are considered and they must be greater than or equal to zero.

Evaluation of the quality of the database

Once the model is identified, the evaluation continues. This stage examines all the variables to evaluate the quality of the database. Sample size is considered, and an adequate sample should have between 10 and 20 participants per parameter (Kline, 2005). Moreover, we must also consider the multicollinearity between variables, since correlation between variables is considered redundant, where values higher than 0.85 can mark potential problems in its correct implementation and proper interpretation. The existence of univariate and multivariate marginal scores (outliers) should also be examined. When an extreme score is presented for a variable, it is called "univariate cases", and multivariate cases arise when extreme scores are presented for more than one variable.

Parameter estimation

The above steps determine the values of the unknown parameters and their respective measurement error. Non-standardized and standardized coefficients of the parameters are estimated. Special programs are used to estimate the unknown parameters, such as LISREL (Linear structural relations), AMOS and EQS.

Assessment of fit and interpretation

Continuing with the steps, a goodness-of-fit diagnosis is made which refers to the accuracy of the assumptions of the model specified for the determination of whether it is correct and serves to approximate what is real. The most commonly used indicators are the chi-square statistic, the chi-square ratio over degrees of freedom (CMIN/DF), the change in chi-square between alternative models, the comparative fit index (CFI), the goodness-of-fit index (GFI), and the approximation mean square error (RMSEA). The resulting values range from 0 to 1, with 1 being the perfect fit.

Joint model fit

The overall model fit must be analyzed to ensure that it is an adequate representation of the full set of causal relationships. Each of the three types of fit quality measures are used.

Measures of absolute fit

The three most basic measures of absolute fit are the chi-square likelihood ratio (X 2), the goodness-of-fit index (GFI) and the square root of the mean squared residue (RMSR).

Incremental fitting measures

The model is evaluated in comparison with a null model. The null model is a single factor model without measurement error.

Parsimony adjustment measures

This type of measure provides a starting point for comparison between models of different complexity and objectives. One applicable measure for the evaluation of a single model is the measure of the standardized chi-square. A review of the three types of measures of joint fit reveals a consistent pattern of marginal evidence for the joint model as proposed.

Conclusions

After all the above steps have been completed, a conclusion is drawn regarding the achievement of the overall objective proposed in this project.

Results

This section presents the information and data obtained through the investigation of each of the stages already mentioned in the previous chapter. Starting with the review of literature and the operationalization of the variables, then the design and validation of the instrument, continuing with the application or data collection and finally with the application of the factorial model.

Literature review

Based on the literature review in the different Science Direct, emerald and Springer Link databases and in several scientific articles reviewed, the models used by various companies to increase their competitiveness are: Model of the Ministry of Economy of Mexico, Supply Chain Operations Reference Council of North America (SCOR-model) (Lee et al., 2012) , and other models proposed by Hector Diaz, Rafael Garcia and Nestor Porcell

(2008), Carlos Alberto Gonzalez, Jose Luis Martinez, Claudia Malcon and Judith Cavazos, Andres Velasquez Contreras and the Directorate General of Policy for Small and Medium Enterprises of Spain: customer service, supply, purchasing, warehouse operation, inventory management, transportation, distribution and production.

Instrument design and validation

Once the research has been reviewed and the logistical factors for the constructions have been obtained, the instrument is made operational. These factors are presented in the matrix in Table 4.1

Table 4.1. *Construction Definition Transport indicators*

Construct	Definition	Indicators
Transportation	This is the type of transport to be used for the delivery of orders. (Kabashkin & Lučina, 2015).	Travel time (minutes), Private or rented, Maintenance cost, Frequency of use, Vehicle capacity (volume and weight) (Salazar, 2012).
Distribution	Having a strategic location that allows your customers to locate them, and to deliver your products to the points of sale in optimal conditions and at the right time, and that your suppliers can supply them in a timely manner (K, 2020, Taherdoost & Brard, 2019).	Numbers of commercial operations Reduction of sales and transport costs. Network of sellers and/or distributors. Location between customers and/or suppliers (Calderón & Cornetero, 2014).
Inventory Management	It is the determination of the points of rotation, the forms of classification and the reinventory model determined by the control methods (which determines the quantities to be ordered or produced (Salazar, 2012).	Product Quantity Goods Turnover Index (Ratio between sales and average inventory. Indicates the number of times the invested capital is recovered through sales). Goods Duration Index (Ratio of final inventory to average sales in the last period. Indicates how many times the inventory lasts) (Calderón et al, 2014).
Production	To have an efficient production process that allows it to produce the same products as the competition, but at a lower cost. To have highly qualified personnel that allows it to have a high productivity (K, 2020).	Human resources Machines and equipment Materials and inputs (K, 2020).
Customer service	To ensure that the customer receives a product and/or service at the right time and place, as well as to fulfill any promises made from the beginning of the interaction process (Chen & Tsou, 2012).	Level of compliance with customer deliveries (Chen & Tsou, 2012).

Construct	Definition	Indicators
Warehouse operation	Storage Decisions on the determination of space required design and layout of products inside (Roodbergen, Vis & Taylor, 2015).	Available stocks Expiry time Notification of stock for orders Own or rented storage capacity. (Calderón et al, 2014).
Supply and purchases	This is the quantity of product, as well as the time in which the supply will be made, considering the selection of suppliers, location, communication relationship and order processing (Roodbergen, Vis & Taylor, 2015)	Quotation Request. Supplier selection (cost, quality, delivery times). Reliability of suppliers Purchase order. Follow-up. Reception. Invoice management. Purchase of goods during the period (Calderón et al, 2014).

Source: *Own elaboration based in literature review.*

With the operationalization of the variables, it was possible to obtain an instrument composed of 38 items and at the end a question was added to qualify the level of competitiveness that the company considers to be qualified with a scale from 1 to 10. Each of the items is a unit of information to measure each of the constructions, the measurement instrument is presented in annex 1. To carry out the validity of each of the constructs based on their indicators, an evaluation by experts or content validity was carried out, which consisted of submitting the questionnaire to the assessment of 4 experts in the field, who judged each of the items on a Likert scale of 1 to 5, where 1 meant totally disagree and 5 meant totally agree with the question posed and its relationship with the impact on competitiveness. Thus, the following results were obtained, which are presented in Table 4.2.

Table 4.2 *Kendall's W estimate*

N	4
Kendall	0.366
Chi-squared	54.204
Df	37
Sig	0.034

Source: *Own elaboration.*

Kendall's W index obtained in the SPSS statistical program was 0.366 and a significant value of 0.034, proving an agreement among the experts.

Once the content validity was obtained, the instrument was applied in 9 small plastic injection companies in Ciudad Juárez, Chihuahua in order to measure the reliability of the instrument. After capturing the data gathered in the SPSS statistical program, the reliability analysis was performed using the *Cronbach alpha* index, obtaining a result of 0.880, as shown in Table 4.3.

Table 4.3 *Cronbach alpha estimation*

Cronbach's Alpha	N of Items
.880	38

Source: *Own elaboration.*

To increase the Cronbach's alpha index, items associated with the Model were identified and upon their elimination from the analysis, theCronbach's alpha index significantly improved. The 5 items eliminated are shown below in Table 4.4.

Table 4.4 *Items eliminated with low correlation*

	Corrected Item-Total correlation	Cronbach's Alpha if Item Deleted
Use transport efficiently.	0.019	0.881
Capacity (volume and / or weight) of transport.	0.259	0.882
Have a high level of product (raw material, in process and finished)	-0.496	0.898
Know the levels of inventories.	0.068	0.883
Have availability of finished products.	0.159	0.881

Source: *Own elaboration.*

With the items eliminated, the analysis is carried out again to know the new *Cronbach's alpha* index (see Table 4.5), obtaining an alpha of 0.907, thus, increasing the reliability of the instrument and leaving the instrument with only 33 items.

Table 4.5 Cronbach's alpha estimate with items eliminated

Cronbach's Alpha	N of Items
0.907	33

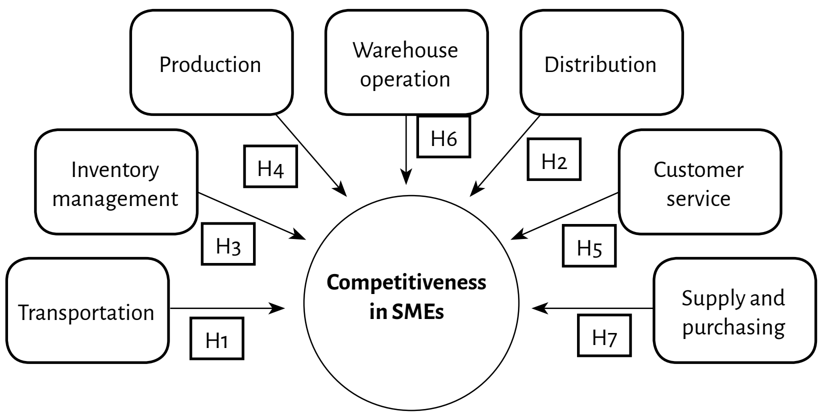
Source: *Own elaboration.*

Once the instrument was validated (survey), the complete study was performed on 20 plastic injection companies, located in Ciudad Juarez, Chihuahua.

Model specification

According to the theoretical foundation, a logistics model was designed for SMEs. The basic conceptual model is presented in Figure 4.1. The following hypotheses were proposed for this research: H1: The transport logistics factor contributes positively to the competitiveness of SMEs. H2: The distribution factor contributes positively to the competitiveness of SMEs. H3: The inventory management factor contributes positively to the competitiveness of SMEs. H4: The production factor contributes positively to the competitiveness of SMEs. H5: The customer service factor contributes positively to the competitiveness of SMEs. H6: The warehouse operation contributes positively to the competitiveness of SMEs. H7: The supply and purchase factor contribute positively to the competitiveness of SMEs.

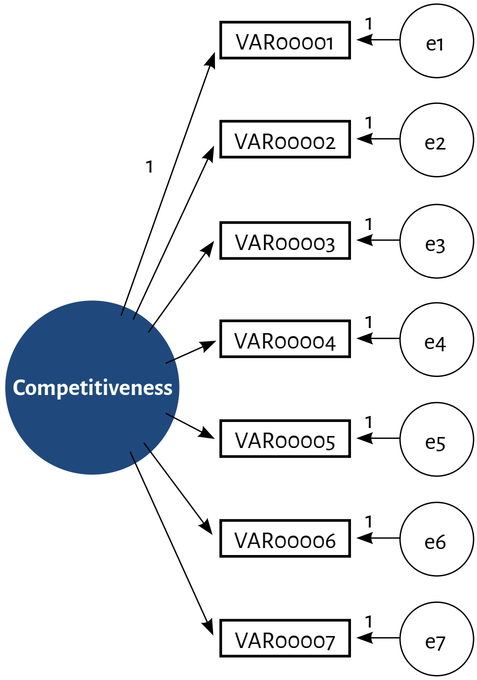
Figure 4.1 *Model based on the theory*



Source: *Own elaboration.*

The previous model (Figure 4.1) establishes that good management of each of the logistics factors present helps to increase the competitiveness of SMEs. Figure 4.2 shows the factorial model used for the elaboration of this project.

Figure 4.2 *Factorial model*



Source: *Own elaboration.*

The logistic factors are shown below with their respective codification (Table 4.6).

Table 4.6. *Logistic factors*

Logistic factor	Codification
Transportation	VAR00001
Distribution	VAR00002
Inventory management	VAR00003
Production	VAR00004
Customer service	VAR00005
Warehouse operation	VAR00006
Supply and purchasing	VAR00007

Source: *Own elaboration.*

Model identification

Once the model has been specified, the values for each parameter are identified and the degrees of freedom of the model are calculated using AMOS version 22. (Table 4.7).

Table 4. 7 Computerization of degrees of freedom

	Value
Value Number of moments of the sample	28
Number of parameters to be estimated	14
Degrees of freedom	(28-14) = 14

Source: *Own elaboration.*

Evaluation of the quality of the database

According to Kline (2005), an adequate sample to carry out a factorial model must have 10 to 20 surveys per parameter. In the AMOS program, this gives us a value of 14 estimates, therefore a minimum sample of 140 companies is required, however in Ciudad Juarez there are only 28 plastic injection companies and only 20 surveys were obtained from them. Due to this small sample size, the bootstrapping method is used to generate and increase the sample size by replicating the original sample, estimating the standard errors of each sample.

Conclusions and Recommendations

Conclusions

Multivariate analysis is a tool that helps through its different and diverse techniques to understand and estimate the effect and relationships between multiple variables associated with the model proposed in this project. The general objective of this project has been achieved by measuring the effect of each of the logistic factors that affect the competitiveness of an SME in the plastic injection molding sector, as well as the relative importance of each one of them. Once the importance of each of the logistic factors is known, the SMEs will be able to take them into account in order to increase their competitiveness. The identified logistical factors that can be considered by SMEs to increase competitiveness are: Customer service, which is the logistic factor with the highest estimated value of 0.906, contributing to competitiveness if the customer receives a product with zero defects, in addition to a low cost, the SME has certifications, and the customer is given some guarantee or maintenance to the purchased product.

Supply and purchases, this logistic factor with an estimated weight of 0.880, contributes to competitiveness if it considers its suppliers to be highly reliable (quality of raw materials, on-time deliveries, etc.), the management of purchase order formats and the handling of low-cost agreements with suppliers. *Inventory management*, this logistic factor with an estimated weight of 0.732, contributes to competitiveness by knowing the number of transactions and/or sales made, the management of specific lot sizes, as well as the use of a security inventory.

Transportation, a logistic factor with an estimated weight of 0.601, contributes to competitiveness if one considers the type of transportation to be used by minimizing the cost and time occupied for your deliveries. *The storage factor* with an estimated weight of 0.559, contributes to competitiveness by knowing the number of finished products in stock, determining the use of a warehouse according to the needs of the product and knowing the times of exit of your product.

Production is another logistic factor with an estimated weight of 0.342, which contributes to competitiveness if you have highly trained personnel, making use of standard components and flexible systems in the processes, besides considering new technology for your process. *Distribution* is the last logistic factor that has an estimated weight of -0.080, although this factor was determined in the research as a factor that affects the competitiveness of the SMEs, the results obtained does not show a significant value. It can be understood that SMEs are not considering important the variables that explain this factor, so it can be acknowledged as an area of opportunity if they reduce transport costs, customer waiting time and have some distribution center contemplating its location among customers and suppliers to help this factor contribute to competitiveness.

The results obtained in this research will help the SMEs in Ciudad Juarez identify the relative importance of each of the logistics factors that contribute to their competitiveness, thus, allowing them to make a better decision on the factors that have a greater effect on their competitiveness.

Recommendations

Disruptive innovations are changing the landscape and business models of many industries. Since processes are increasingly digitalized and sensitive data increases exponentially, supply chains are also affected by the fourth industrial revolution. Thus, the concept of the 4.0 supply chain must be analyzed, identified and expanded as well as its corresponding dimensions and indicators that promote an increase in competitiveness from a strategic management perspective considering other future frameworks associated with the implementation of certain technologies, such as virtual and augmented realities, 3D-Printing and simulation, big data analytics, cloud technology, cybersecurity, the IoT, miniaturization of electronics, the use of collaborative robots, drones and nanotechnology particularly the warehouse, transport logistics, procurement

In future investigations, competitiveness can be presented as an observable variable that can be measured with different indicators, for example: productivity, quality, human resources, production, innovation, environment, etc.

It is recommended that the logistical factors that had less weight be increased in the number of variables that describe it and, in this way, their impact on competitiveness be increased.

On the other hand, the information collected can be used to create a structural model. Lastly, it is recommended that this model be replicated in other SME sectors in order to generalize it. Moreover, these systems evolve through the adaptation and reconfiguration of their structures, i.e. through the dynamics of the structure.

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CHAPTER 8

Design Simulation of a Rotating Prototype for Arm Enhancement on an Exoskeleton

Sofia Maturino[1], Natalia E. Noriega*[1], Alberto Ochoa-Zezzatti[1]

[1] *Universidad Autónoma de Ciudad Juárez, Ave. del charro 610, Ciudad Juárez, Chihuahua, México*
**Corresponding Author: natalia.noriega@uacj.mx*

Abstract. According to data obtained from the National Institute of Statistics and Geography (INEGI) in the state of Chihuahua, up to 35% of people with disabilities have difficulty moving or using their arms (INEGI, 2017). The cause of their impairments may differ but ultimately causing them not to perform effectively their everyday activities due to lack of strength. This is why rehabilitation is used as a way to help improve or recover the movement of the upper limbs. The scientific community has shown interest in improving the way therapies are performed by using exoskeletons. There is vast research on the use of exoskeletons, most of which were designed to maintain a rigid posture centered on the back, legs and hips. Thus, it is of great interest to improve the design, increase comfort and reduce the effects caused by this condition, to provide strength to the upper extremities and thereby perform mundane activities without discomfort such as moving a box or putting a book on a shelf.

Keywords: Rotating prototype, exoskeleton, IIoT, Smart City

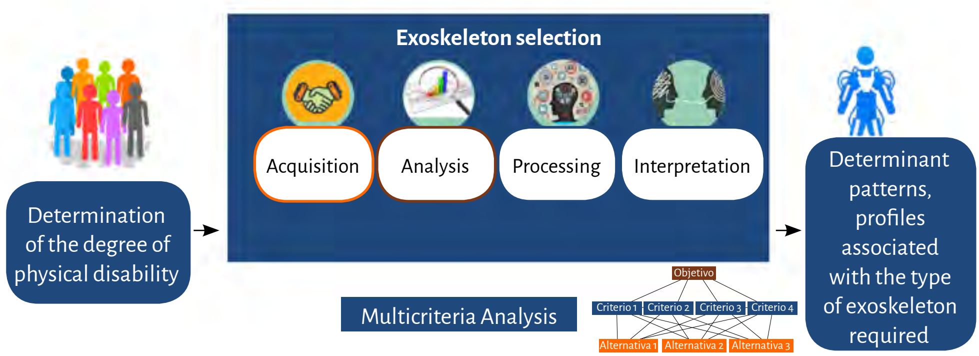
Introduction

Over the years, we have developed support and assistance devices to help us perform our activities. Therefore, we seek the development of mechanisms that can be used to assist in the rehabilitation of persons with disabilities. The emergence of rehabilitation robotics aims to apply areas of technology (mechanical, electrical, biomedical, etc.) to improve the current rehabilitation methods. Rehabilitation robotics is focused on re-establishing the independence of persons with disabilities when performing daily activities such as eating, dressing, turning pages, among others (Loos et al., 2008). One of the main causes of disability is attempted suicide, cause that has been in potential growth in the state of Chihuahua, which has one of the highest rates in the country and had more than 83 thousand people with arm disability (INEGI, 2017) in 2016 caused by suicide attempt. With the increase in the number of people with disabilities, the demand for the development of mechanisms that help rehabilitation with devices that assist human motor functions (ranging from a cane or a wheelchair to a prosthesis or an exoskeleton) to improve their quality of life is also increasing. The main objective of these devices is to achieve the reintegration of people with motor disabilities to their daily activities with the assistance or improvement of the affected limbs.

Proposal for an Intelligent Device

This project is based in the design and simulation of an exoskeleton component that will improve the functionality of an arm, benefiting people with disabilities who are limited in the movement of their upper extremities and require rehabilitation to improve or regain movement of the arms. In recent years, there have been designs or devices that are intended to adopt a specific posture. Nonetheless, many designs are focused on the lower extremities or back, which excludes tasks performed by the arms. Although there are exoskeletons aimed at the upper extremities, what is sought in this investigation is a design that helps people to perform simple activities, increasing the strength of the extremities through the exoskeleton and where the material used is comfortable and flexible. The design and simulation of the exoskeleton structure will be focused on improving people's the quality of life, taking into consideration the necessary parameters to ensure their anthropometric dimensions and thus, achieve the alignment of the joint axes with the axes of the device used as basic functional ranges that meet the working space of the arm to assist in physical therapies. Fig.1 details each of the components associated with our proposed device.

Fig. 1: *Smart Dispositive associated with an improved perspective of Ambient Intelligence based on selection of correct components of an Exoskeleton.*

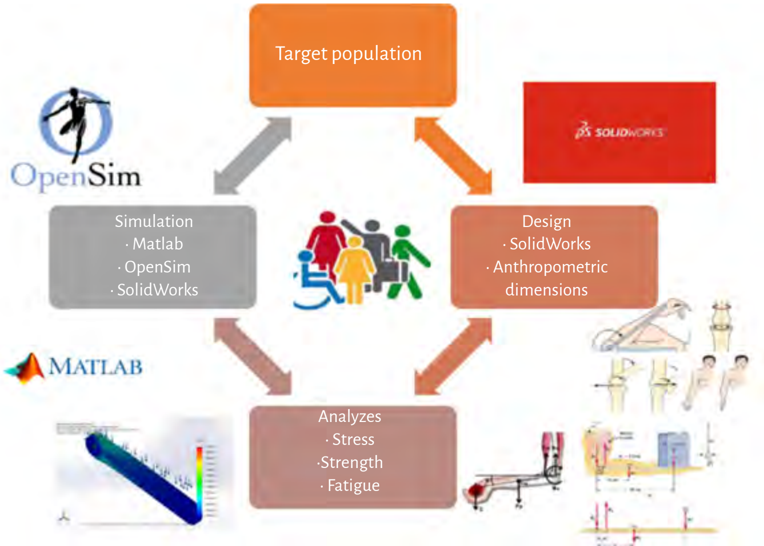


Source: *Own elaboration.*

Design and simulation of an exoskeleton component for the improvement of the functionality of an arm as part of an exoskeleton

It is necessary to determine the critical points to carry out a logical sequence for the design of an exoskeleton, as well as to have a clear objective of what is to be achieved by simulating the component. For this, it is necessary to define the characteristics, restrictions, materials and problems. When dealing with a person who has difficulty moving the upper part of his body, it is necessary to know the biomechanical requirements associated with the functionality of the exoskeleton component, as well as to propose the characteristics that the design must have to achieve its objective. The design of the exoskeleton contemplated a reduced number of components compared to the traditional ones, to achieve simple handling and transport, moreover, the prototype presented low density and costs in part due to the use of plastics that own these properties. After knowing the characteristics that are required, the design of the parts needed for the exoskeleton component can be carried out. To start with the simulation, it is necessary to have the assembly of the previously designed parts, as well as the programs that will be used to perform the required analyses to check the performance of the exoskeleton when subjected to different scenarios and to the different ranges of motion that are contemplated for the device. A process diagram of the exoskeleton is shown in Fig. 2.

Fig. 2: *Process diagram for the Exoskeleton development and the related mechatronics tools.*



Source: *Own elaboration.*

Kinematics is the field of mechanics that deals with the motion of objects without reference to the forces that create such motion. Kinematics describes the movement of bone segments including the type, direction, and magnitude of the movement, the location in space, and the rate of change or velocity. The three types of movement that a bone segment can have are translation (linear displacement), rotation (angular displacement), and a combination of translation and rotation. That is, all points on a segment move in the same direction at the same time. In rotation, the bone rotates about a fixed point (C., Cynthia Norkin, 2016). The *Denavit-Hartenberg* parameters are the four parameters associated with a particular convention for attaching reference frames to the links of space kinematic chain or robot manipulator.

The *Denavit-Hartenberg* parameters to define are:

- θ_i = It is the angle of the joint from the axis X_{i-1} up to the shaft X_i, measured relative to axis Z_{i-1}, using the right-hand rule.
- d_i = It is the distance measured from the origin of the system i_1, along with the axis Z_{i-1} to the intersection of the axis Z_{i-1} with shaft X_i.

- a_i = It is the separation distance between the origins of the reference systems i_1 and i, measured along axis X_i up to the intersection with the axis Z_{i-1} (or the shortest distance between the axles Z_{i-1} and Z_i, when these are not intercepted).
- α = It is the angle that separates the axes Z_i y Z_{i-1}, measured relative to axis X_i.
- σ = Joint type (rotational=0, prismatic=1).

After obtaining the *Denavit-Hartenberg* parameters, the homogeneous transformation matrix shown in Fig. 3 is made:

Fig. 3: *Homogeneous transformation matrix.*

$$
{}^{j-1}\mathrm{T}_j = \begin{bmatrix} \cos\theta_j & -\sin\theta_j & 0 & d_x \\ \sin\theta_j & \cos\theta_j & 0 & d_y \\ 0 & 0 & 1 & d_z \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} \cos\theta_j & -\sin\theta_j & 0 & d_x \\ \sin\theta_j & \cos\theta_j & 0 & d_y \\ 0 & 0 & 1 & d_z \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} \cos\theta_j & -\sin\theta_j & 0 & d_x \\ \sin\theta_j & \cos\theta_j & 0 & d_y \\ 0 & 0 & 1 & d_z \\ 0 & 0 & 0 & 1 \end{bmatrix} =
$$

$$
\begin{bmatrix} \cos\theta_j & -\sin\theta_j\cos\alpha_j & \sin\theta_j\sin\alpha_j & a_j\cos\theta_j \\ \sin\theta_j & \cos\theta_j\cos\alpha_j & -\cos\theta_j\sin\alpha_j & a_j\sin\theta_j \\ 0 & \sin\alpha_j & \cos\alpha_j & d_j \\ 0 & 0 & 0 & 1 \end{bmatrix}
$$

Source: *Own elaboration.*

Three softwares were used to carry out the design and simulation:

1) SOLIDWORKS® CAD software is a mechanical design automation application that enables designers to quickly sketch ideas, experiment with features and dimensions, and produce detailed models and drawings (Intro to SolidWorks. (n.d.)).
2) OpenSim is a freely available software package that allows the construction, exchange, and analysis of computer models of the musculoskeletal system and dynamic movement simulations. It can be used in a wide variety of applications, including biomechanical research, medical device design, orthopedics and rehabilitation sciences, neuroscience research, ergonomic design and analysis, sports science, computer animation, robotics research, biology, and education ("OpenSim Documentation , "n.d).
3) Matlab is short for "matrix laboratory". It is a program to perform numerical calculations with vectors and matrices, and therefore it is also possible to work with scalar numbers (both real and complex), with character strings and with other more complex information structures (M, n.d.). In Fig. 4, the programs used are shown.

Fig. 4: *Software used for the simulation.*

Source: *Google, 2021.*

Implementation of a component for an Exoskeleton

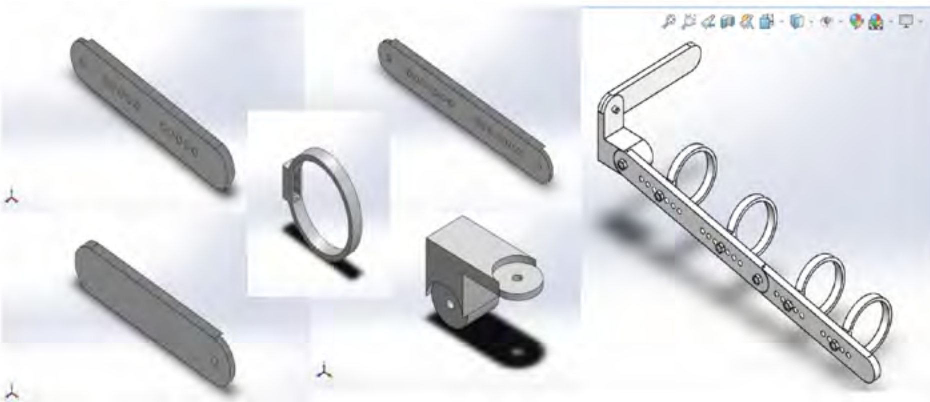
The use of exoskeletons is helpful for an individual with or without a disability, reducing physical demand in any given task (Theurel et al. 2018). The scientific community shows increasing interested in Rehabilitation Robotics. One of the specific and important aspects common to the field of Rehabilitation Robotics is the intrinsic interaction between humans and robots. This interaction has a double scenario, firstly, a cognitive interaction through which the human can control the robot while it transmits feedback to the human; secondly, a biomechanics interaction that leads to the application of controlled forces between both actors. On one hand, a typical example of cognitive interaction capacity is the one being developed through the EMG control of artificial robotic prosthetics (Rocon et al., 2005). Here, the human bioelectric signals are used to develop the control commands to operate an intelligent prosthesis. Force feedback can be applied by various means. A common example of biomechanics interaction is found in the functional compensation based on the exoskeleton of human walking.

In general, rehabilitation robots can be classified, see (Dislis 2020), under three categories:

1) Posture support mechanisms
2) Rehabilitation mechanisms
3) Robots to assist or replace body functions

The software chose to perform the design was SolidWorks. The design of several pieces for the realization of the exoskeleton was made, the purpose of each of the segments is to simulate the behavior of the human arm and help to perform a defined function, following the principle of being as simple as possible to avoid unnecessary weight and help facilitate mobility. Fig. 5 shows the parts designed for the exoskeleton.

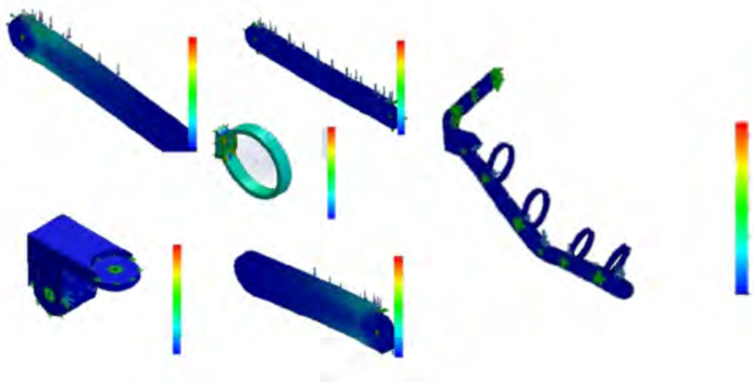
Fig. 5: *SolidWorks design of part of the arm exoskeleton.*



Source: *Own elaboration.*

Through physical-mechanical analysis, we seek to know the behavior that the pieces would present when subjected to a specific force and thus, know if the chosen material is a viable option. The following is the data from the analyzes performed in the SolidWorks program in the static force simulation on each of the parts of the exoskeleton prototype. A minimum force of 5 kg was applied to each of the pieces to observe the changes in the pieces and in this way we can know if it would present deformations or drastic changes in its structure after being subjected to this type of effort. In Fig. 6, the analyzes performed on the exoskeleton components are shown.

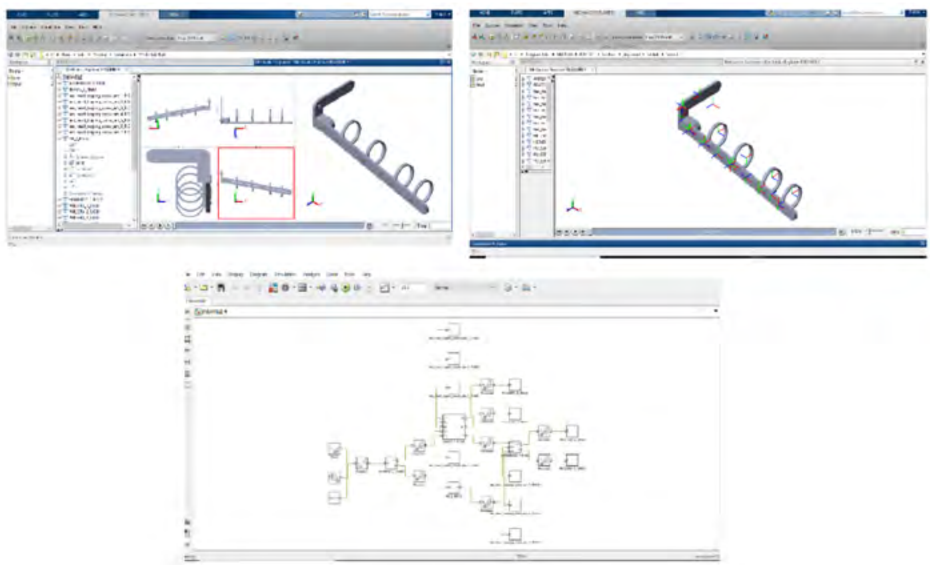
Fig. 6: Static deformation analysis of components.



Source: *Own elaboration.*

Through the Matlab software, each of the components can be seen. A reference frame is added, as well as the simulation of how each of the parts that make up the assembly moves can be seen. The exoskeleton prototype control system is obtained in Simulink in MATLAB, starting from the block diagram based on the design previously made in SolidWorks. In Fig. 7, the results obtained in the Matlab software are shown.

Fig. 7: Exoskeleton design in Matlab.



Source: *Own elaboration.*

Direct kinematics analysis is the description of movements that include position, velocity and acceleration, the joints perform various movements to achieve the different positions that people use to carry out everyday tasks. Fig. 8 shows the arm movement for every joint of the body and the model of the arm used to perform the necessary calculations.

Fig. 8: Axes of motion for joint analysis.

θ_i	Arm movement	Joint
θ_1	Rotation	Shoulder
θ_2	Abduction	Shoulder
θ_3	Flexion	Shoulder
θ_4	Flexion	Elbow

Source: *Own elaboration.*

To analyze the axes of movement that the joints have, the *Denavit-Hartenberg* parameters must be found. In Fig. 9, the parameters obtained are shown.

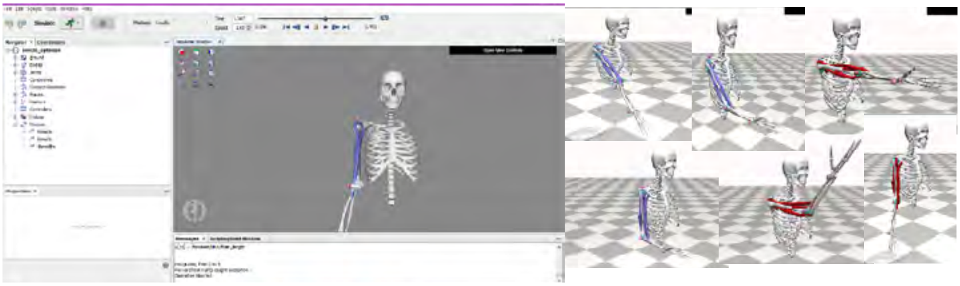
Fig. 9: *Denavit-Hartenberg parameters.*

i	θ_i	d_i	a_i	a_i
1	θ_1	0	0	$\pi/2$
2	$\theta_2 + \pi/2$	0	0	$\pi/2$
3	$\theta_3 + \pi$	0	a_3	0
4	θ_4	0	a_4	$\pi/2$

Source: *Own elaboration.*

By the OpenSim software, it is possible to visualize and simulate the movements made by the human arm, which are necessary to simulate the movements that the exoskeleton prototype must perform. With the help of the software, different positions of the human arm were chosen, which are intended to be simulated. Fig. 10 shows the positions of the arm that will be considered to carry out the simulation.

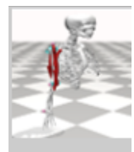
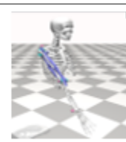
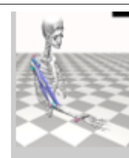
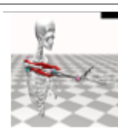
Fig. 10: *Upper limb model in OpenSim.*



Source: *Own elaboration.*

To make comparisons between the displacements obtained in open sim and Matlab, different angles were assigned to each of the positions. The comparisons are shown in Fig. 11,.

Fig. 11: *Displacements obtained in Matlab and OpenSim.*

Position (degrees)	θ_1	θ_2	θ_3	θ_4	Picture
1 (Initial)	0	0	0	0	
2	0	0	45	45	
3	0	0	45	45	
4	0	0	90	90	
5	0	0	0	90	

Source: *Own elaboration.*

Conclusions and future research

The virtual design method was used through co-simulation between SolidWorks, OpenSim and Matlab programs to design an exoskeleton. In each of the programs mentioned above, the different stages that were necessary to conduct the simulation were carried out; the activities performed in each of the programs are mentioned below. The SolidWorks program was used to design the necessary components for the assembly of the exoskeleton, and the simulation tool was used to perform the mechanical and motion analysis of the parts; Through the Open Sim program, the simulation of the movements performed by the human arm was obtained and the graphs of the chosen movements were generated to be compared with the movements of the exoskeleton assembly. The direct kinematics of the component could be obtained through the Matlab software and its connection with SolidWorks, the assembly was obtained, making it easier to observe the movement of the assembly as well as to obtain a control diagram through the Simulink program. Using this tools provided several advantages like not being necessary to physically create the modifications of the prototype. The tools used do not generate any cost and are relatively simple to use, the analyses can be performed with different materials and thus learn the behavior of each one and based on this select the one that best suits to achieve the required objectives.

Since only the design of the parts necessary for the construction of the exoskeleton and the simulation of the movement in specific positions for the human upper limb was carried out, the next step in the investigation would be to build the physical prototype of the model using the specifications that were used to perform the analyzes mentioned in the document as well as the material. After the construction of the prototype, it would be necessary to physically perform the mechanical and motion analysis and compare the results obtained through the simulation and the physical prototype, taking into account the realization of tests on real subjects and not only on the behavior obtained through a program and verifying the operation of the prototype. It is also necessary to evaluate the components such as motors and sensors necessary for the prototype to perform its function efficiently and test the control diagram obtained by Simulink to see its operation and make the necessary changes or make a new control diagram that meets the purpose of the exoskeleton prototype. Moreover, the functioning of the prototype must be examined by comparing the similarities of its movements with the natural motions that the human arm performs. The real purpose of the exoskeleton prototype is that it can be used in the rehabilitation area as a component that can aid people who cannot, or have difficulties with the motion of their arms and in this way, improve their quality of life.

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CHAPTER 9

Intelligent Humidifier for Humidity Control in a Smart City Using IoT and Type-2 Fuzzy Logic

Rafael Perez-Tejada[1], Natalia E. Noriega *[1], Alberto Ochoa-Zezzatti[1]

[1] *Universidad Autónoma de Ciudad Juárez*

* *Corresponding Author: natalia.noriega@uacj.mx*

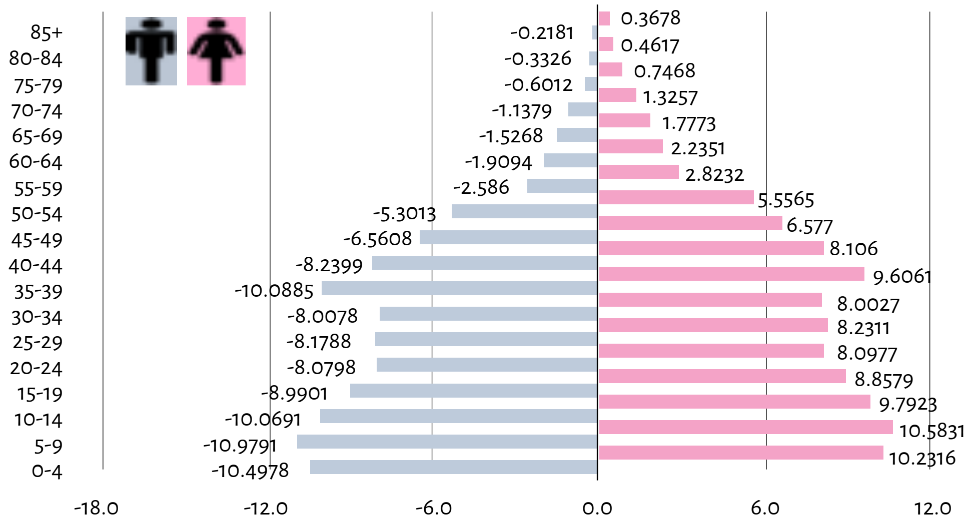
Abstract. As an integral part of Industry 4.0, the intelligent humidifier based on mechatronic control has a strong potential for both industrial and artisanal applications. This project is mainly based on the application of mechatronic engineering, where the branches of mechanical electronics and systems are implemented for the control of a device. This project intends to help and improve the quality of life of the population of Ciudad Juarez, Chihuahua, Mexico, through innovative technology and smart service. It is intended to apply a level control by programming a PID Fuzzy controller, using LabVIEWbased on IoT in a Smart city.

Keywords: *Smart City, Smart Application, IoT, LabVIEW, Arduino, PID Controller, Fuzzy Logic, Interface, Ultrasound Measurement, PWM Modulation, Real-Time Monitoring, Fuzzy Rules*

Introduction

Respiratory disorders and weather extremes are increasingly affecting more people throughout the globe. Senior citizens are the most vulnerable sector of societies to aquifer a disability from respiratory difficulties. These conditions are associated to the risks of inhalation acquired during their lifetime, prevailing among them: environmental pollution and work-related contaminants (Información et al., 2018). In order to contextualize the target sector, the National Institution of Statistics and Geography of Mexico (INEGI), through the following representation of the population pyramid in five-year intervals (Figure 1), demonstrates the percentage of adults over 60 years old who reside in the town of Ciudad Juarez, Chihuahua. The function of the respiratory system deteriorates with increasing age, thus, the organs comprising the respiratory system are the most affected. (García et al., 2009).

Figure 1. *Population pyramid of Juarez, Chihuahua.*

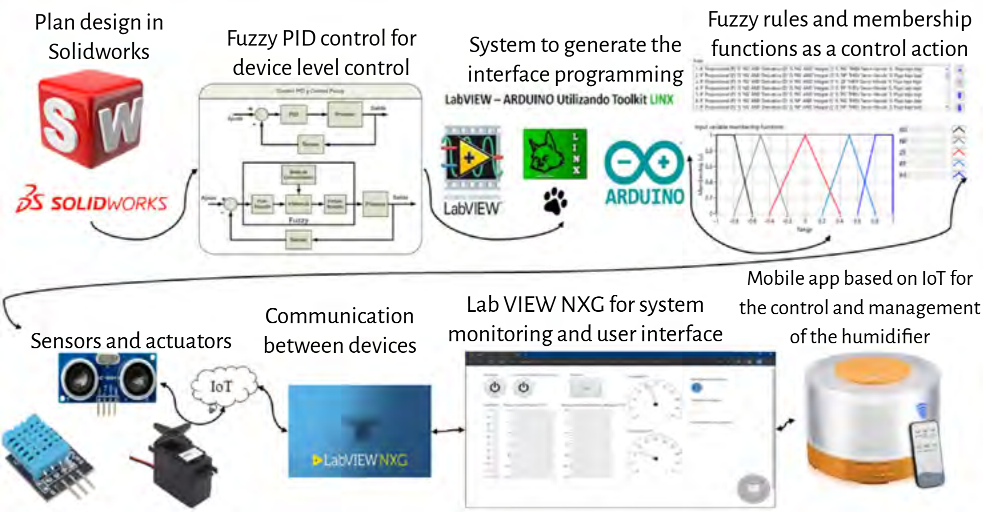


Source: *INEGI (2020), calculated on the basis of the 2015 Population Count.*

Proposal for an Intelligent Device

The humidifier is an intelligent device that will be controlled by an application. It will determine the state of the ambient temperature inside a room and according to the conditions detected by the device(warm or cold weather), it will act autonomously to make an improvement in the humidity of the room directed by a simple user handler. A mechanical design will be made according to the materials used for the implementation of the device. The physical construction will proceed from the design developed, taking into consideration mechanical, electrical and control details in order to avoid failures and deficiencies, and thus, achieving a functional device. Performance tests will be carried out for each component to verify that the operation and calibration is functioning efficiently in the system control that operates the device. Lastly, the integration of all components of the system will be completed to perform the programming for the control of the device and run error tests. In Figure 2, each component associated with our proposed intelligent device is described.

Figure 2. *Smart Dispositive associated with an improved perspective of ambient intelligence.*



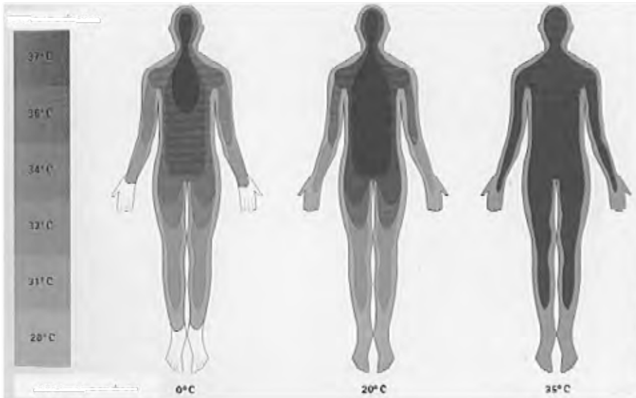
Source: *own elaboration.*

Development of a Smart Humidification system for older people

A humidification system for the airway (upper respiratory system) must meet two main requirements:

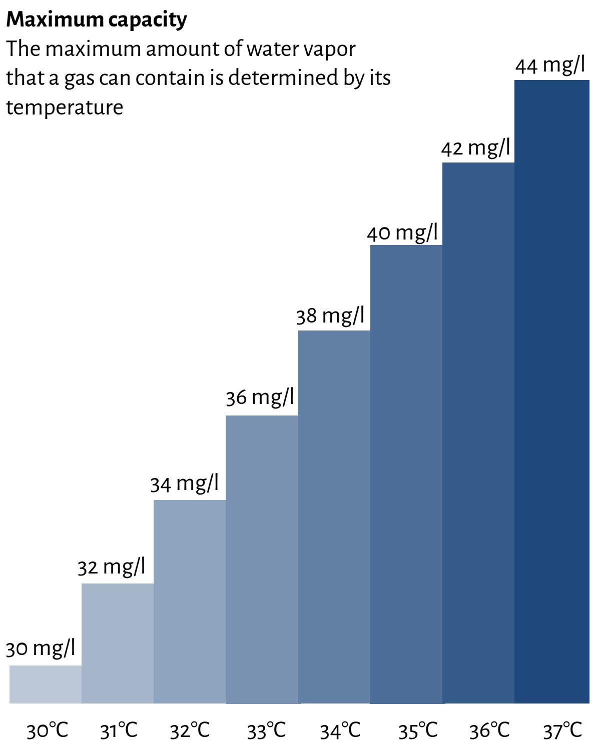
1) Ensure adequate temperature and humidity. The humidification system must heat the aspirated air to body temperature below 37 °C (Figure 3) and provide a humidity around 44 mg/l (Figure 4); temperature and internal humidity are considered normal.

Figure 3. *Internal body temperature for different ambient temperatures.*



Source: *Chavez, (2002).*

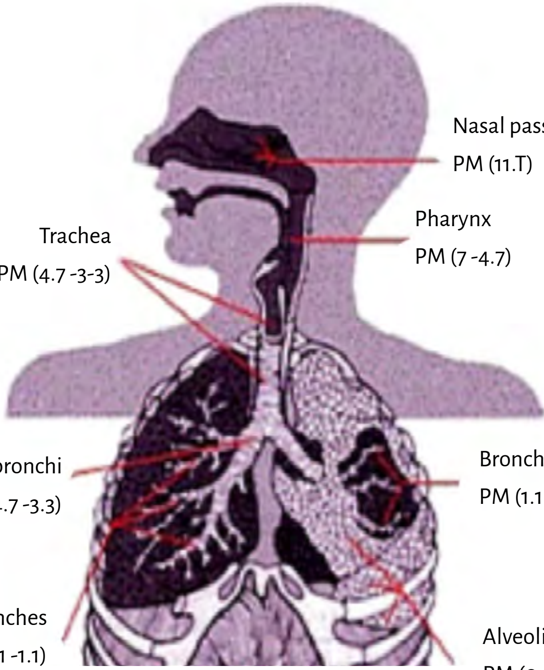
Figure 4. *Humidity capacity for different ambient temperatures.*



Source: *http://terapiarespiratoria2.blogspot.com/2009/08/terapia-de-humedad.html*

2) Avoid the possibility of airway contamination. The system cannot act as a vehicle for transporting bacteria or viruses to the respiratory tract (Figure 5) (Jarillo, 2014).

Figure 5. *Respiratory system.*



Source: *Stella et al.,(n.d.)*

Humidity variables (vapor pressure, absolute humidity, mixing ratio)

The term humidification usually refers to a mixture of a gas and a vapor. This is the process by which the specific humidity and the amount of heat in the air are increased. If this mixture obeys the ideal laws of gases, we can apply Dalton's law of partial pressures: "the total pressure (P_T) of a mixture of gases is equal to the sum of the partial pressures (p) of the constituent gases", as shown in the equation 1 (Pilatowsky Figueroa, 2002).

$$P_T = P_A + P_B + P_C \ldots\ldots + P_n \tag{1}$$

When water vapor enters the atmosphere, water molecules disperse rapidly, mixing with other gases and contributing to the total pressure exerted by the atmosphere.

Vapor pressure is simply part of the total atmospheric pressure due to water vapor content and is directly proportional to the concentration of vapor in the air (Thermodinamic process in the atmosphere 1., 2011).

Absolute humidity is defined as the mass of water vapor (commonly presented in grams) per unit volume (usually in m^3). Water vapor density is calculated from the following formula:

$$HA = \left(\frac{m_V}{V}\right) \tag{2}$$

The ***mixing ratio*** is the mass of water vapor (usually in grams) per unit of dry air mass (usually kg):

$$W = \left(\frac{w_V}{m_d}\right) \tag{3}$$

The ***specific humidity*** is the mass of water vapor per unit of air mass:

$$HE = \left(\frac{m_V}{m_d+m_V}\right) \tag{4}$$

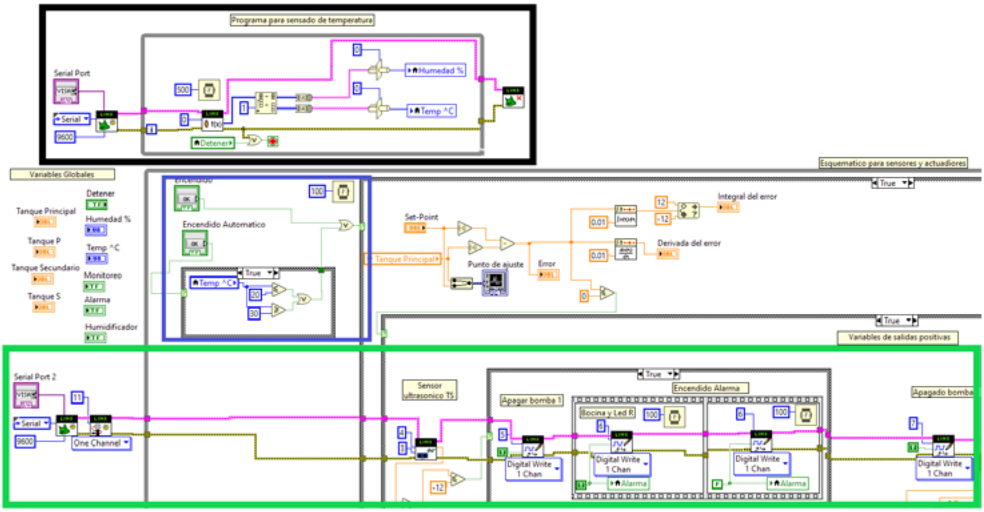
The ***relative humidity*** is the ratio between the real mixing ratio *w* and the saturation mixing ratio (The pressure exerted by water vapor) :

$$HR = \left[\frac{W}{W_s} \cdot 100\%\right]$$ (5)v

Implementation of our Smart Humidification System

To perform the simulations and tests of the device, it is required to install Toolbox, Control design & Simulation for PID control and download the libraries for the communication between the Arduino and LabView and the control of the sensors and actuators of the system.

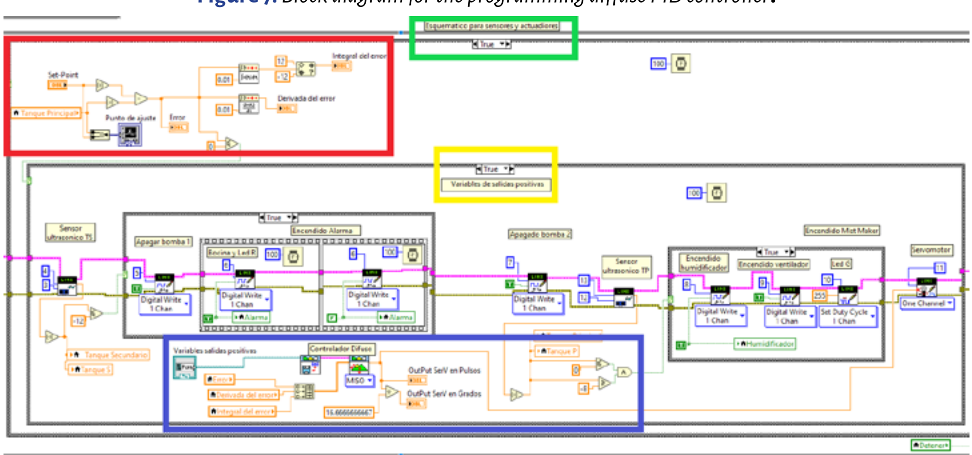
Figure 6. *Schematic programming.*



Source: *own elaboration.*

All codes will be integrated into a single VI to develop the conventional PID (Figure 6) and the Diffuse one (Figure 7), for level control using LabVIEW functions and tools.

Figure 7. *Block diagram for the programming diffuse PID controller.*

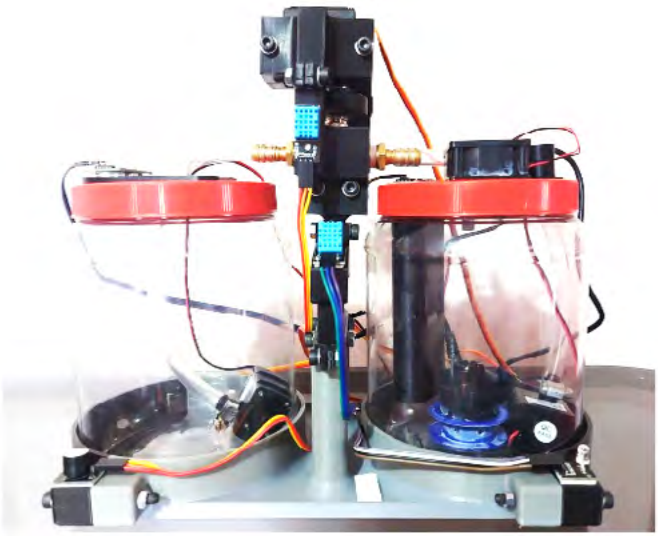


Source: *own elaboration.*

After the execution of the programs, the mechanical assembly and circuit connections will be carried out to realize the operation of the prototype elements (Figure

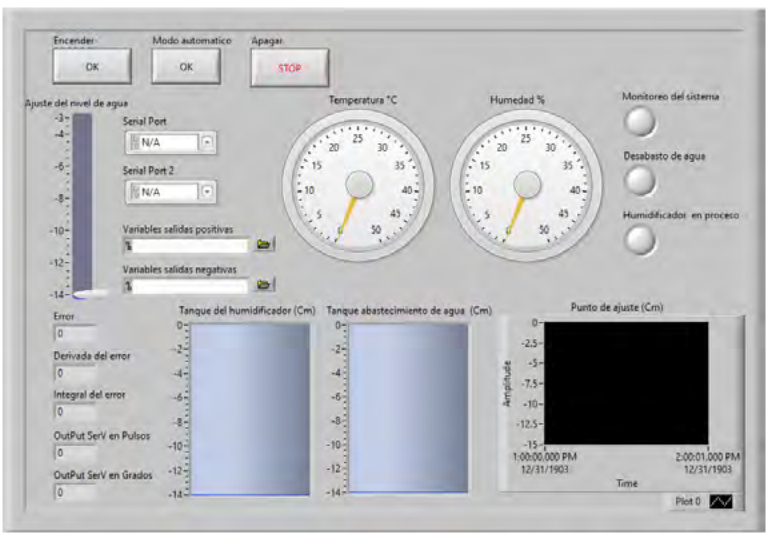
8) and by means of the graphical user interface (GUI) the behavior of the system will be manipulated and observed during its execution (Figure 9).

Figure 8. *Physical assembly of dispositive.*



Source: *own elaboration.*

Figure 9. *Graphical User Interface.*



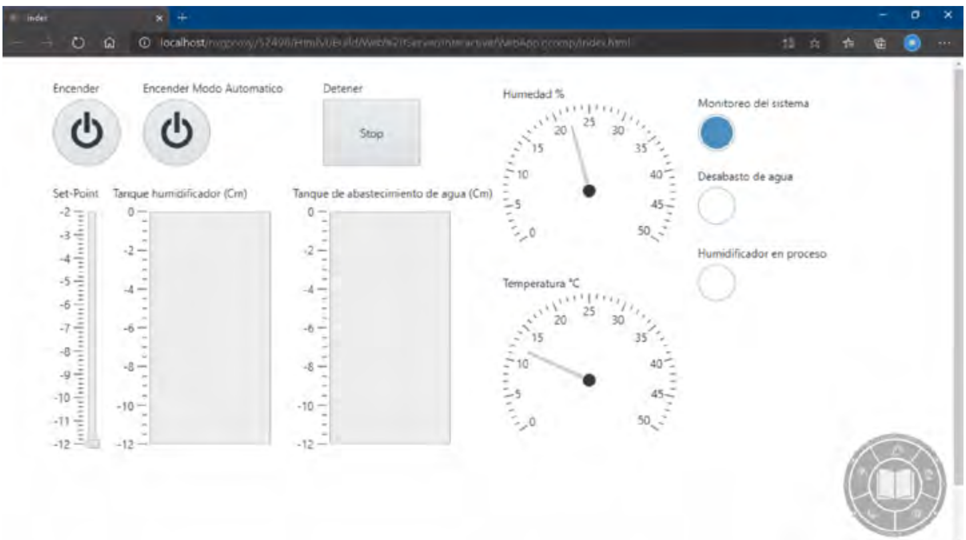
Source: *own elaboration.*

Mobile App Development supported by IoT

As part of this research, a mobile App based on IoT will be simulated for the control and management of the intelligent humidifier, the software proposed to develop the application is through Labview NXG.

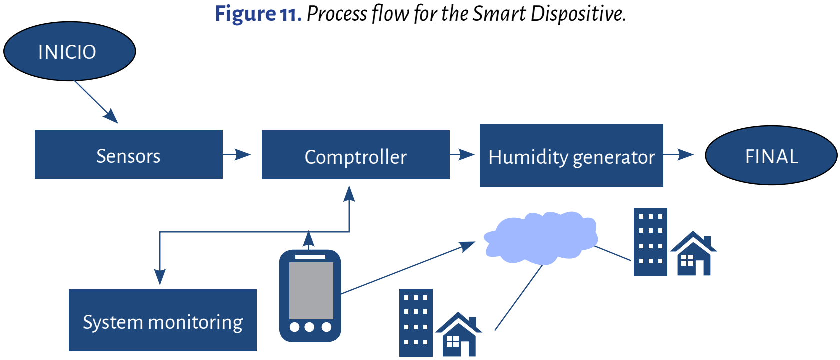
The LabVIEW NXG Web Module is a software add-on to prepare existing LabVIEW applications for the web. It also includes access to SystemLink Cloud, an NI-hosted cloud service that simplifies hosting, sharing, and creating web applications to monitor and control your test systems remotely and put the right data in front of your users. Run custom user interfaces on any modern web browser, tablet, or phone without the need for additional plugins or installers (Figure 10 and Figure 11).

Figure 10. *Remote control from a web server.*



Source: *own elaboration.*

Figure 11. *Process flow for the Smart Dispositive.*

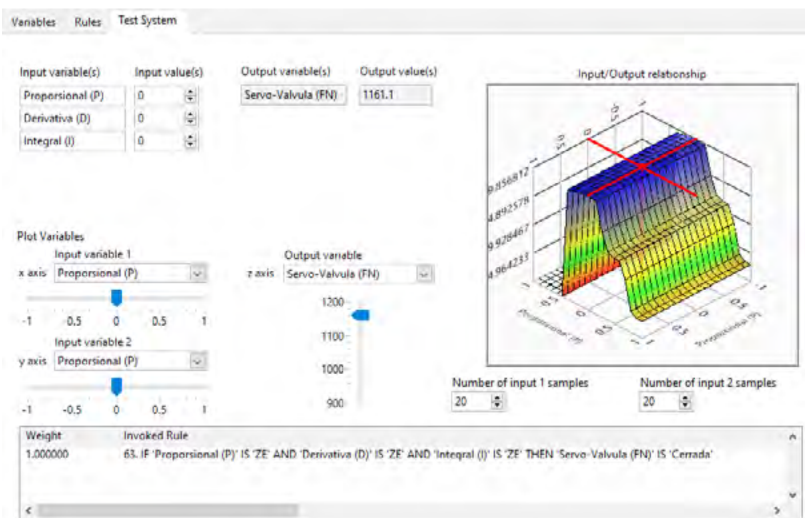


Source: *own elaboration.*

- PID level control

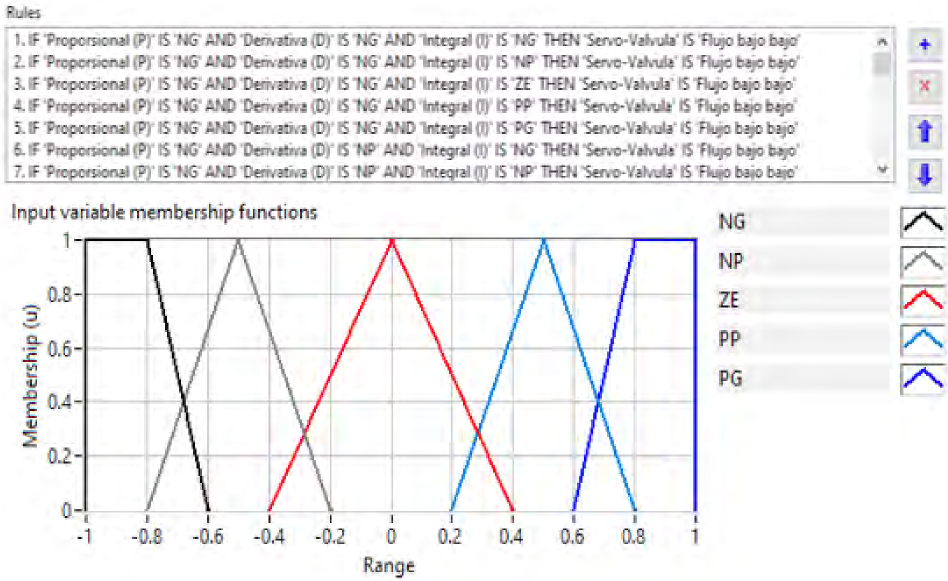
Julian Mauricio Agudelo Ardila, and Mauricio Hernández Arias from the University of Caldas, Manizales, Colombia, came up with a system to establish the water level in a tank using conventional PID controller (Figure 12) and diffuse PID control (Figure 13). It is necessary to make a history of mechanical electronics and software to perform a level control to carry out a series of steps to ensure its optimal development. To reach a system operation, it is important to have knowledge of the logical operation of a system of this type, Arduino, LabView and Matlab to know the transfer function and other issues at the end.

Figure 12. *PID level control developed in LabVIEW.*



Source: *own elaboration.*

Figure 13. *Fuzzy rules designed for the fuzzy PID controller.*



Source: *own elaboration.*

Conclusions and future research

As people grow old, their disabilities increase and assistance is required to perform daily activities. The continuation of respiratory ailments can be slowed down with an intelligent device that improves the humidity of the room and enhances the air quality. Therefore, the wellbeing of the elderly will ameliorate due to the absorbance of necessary oxygen, as well as the opportunity to develop technological upgrades in the future. Applying mechatronics and based on Internet of things (IoT), our prototype using Fuzzy Logic Type-2 was developed, shown in Figure 14.

Figure 14. *Fuzzy Logic Type-2 is used to determine times of humification in a room analyzed the ambient temperature.*

Source: *own elaboration.*

In 1974, The World Health Organization (WHO) defined aging as a physiological process that begins at conception and generates characteristic changes during the life cycle of each individual. The aging process is asynchronous, progressive, individual and universal (Records, 1971). For its implementation of the intelligent humidifier, these research approaches are considered.

1) Acquire knowledge and skills in the handling of a device and the creation of an application based on artificial intelligence.
2) Generate empathy with the difficulties of the elderly and thus contribute to the creation of a product that provides comfort in their lifestyle.
3) Implement a PID digital controller with LabVIEW and arduino interface using fuzzy logic type 2 for the intelligent management of a humidifier.

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CHAPTER 10

Essential Factor in the Survival of High-Tech SMEs: Relational Capital in the Machining Industry of the Juarez, Chihuahua

Blanca Marquez Miramontes*[1]

[1] *Universidad Autónoma de Ciudad Juárez, Ciudad Juarez, Chihuahua, México*
**Corresponding Author: bmarquez@uacj.mx*

Abstract. This chapter has a focus on Relational Capital as one of the principal elements that compose Intellectual Capital, which is made up of intangible assets related to the administration of high technologies along with the companies' interaction with its customers, suppliers and competition. Relational Capital consents companies to clearly identify the areas of opportunity that can be improved in organizations dedicated to technological development since it allows an assessment of the company's relations with its environment, ensuring permanence in the market and consequently decreasing its mortality rate. The Machining Industry in Ciudad Juarez, Chihuahua, Mexico is a clear example of under-management since it has high-level technology, but does not generate patents or have an expense in Research and Development. Moreover, its personnel are not specialized in engineering studies. In this way, it is comprehensible that the use of knowledge has intensified. Knowledge alone does not generate any competitive advantage, as it arises through the company's use of it, mainly those applications in the field of innovation.

Keywords: Relational capital, Intangible Assets, Machining Industry

Introduction

It is widely accepted that Relational Capital (CR) is a basic intangible asset given that it contributes to the development of the competitiveness of companies when it is managed and efficiently developed in companies that operate high-level technologies. However, it is difficult to identify the CR in organizations and it is complicated to achieve development and efficient administration. The CR is measured as part of the Intellectual Capital although, due to the importance it has in the results of the operation of the companies, a separate measurement is required to identify the areas of opportunity that threaten the permanence in the organization's market; There are models and methodologies that seek to identify the value of Intellectual Capital as a whole within organizations but it is difficult to find methods that specifically measure this intangible asset generating competitiveness. To study this measurement problem, the industrial machining sector of Cd. Juarez, Mexico was selected, as it is the national capital industry with the highest level of technological development and therefore, more suitable for measuring CR, especially since it has had a little significant progress, although they have a valuable content in fixed and intangible assets, highly qualified personnel, with extensive skills, skills and technical knowledge, so it is considered necessary to study the administration of these intangible assets, which are not visible, not they are identified in the financial statements and as a consequence it is difficult to manage and develop them in a way that increases competitiveness and decreases the death rate of these companies.

Every company with customers has a CR, which Saint Onge (1996) defines as the value of its representation, its progressive relationship with the people or organizations to which it offers its product. Out of the three categories of Intellectual Capital, CR is the most valuable. Customers pay bills and, therefore, the traces left by customers in financial statements are easier to follow than those of people, systems and skills (Stewart, 1997). Relational Capital refers to the "valuation of customer relationships." Historically, when mentioning the elements that integrate the key value, refers to customers and based on this inclusion, future expectations are reflected in the comparative advantages. Cañibao (1999) defines it as one that "has to do with customers, customer loyalty and satisfaction, distribution relationships and agreements, franchises, licenses, etc." Several studies show a direct link between intangible management and sustainable business

(Bueno, 2019).Brooking (1996), defined market assets "are those that derive from a beneficial relationship of the company with its market and its customers" and constitute the potential derived from intangible assets that are related to the market. Also included are brands, customers and their loyalty, business permanence, order reservation, distribution channels, various contracts and agreements such as licenses and franchises. For Kaplan and Norton (1992), the client's perspective allows identifying the customer and market segments in which the business unit will compete to articulate the market-based strategy that will provide future financial returns of a higher category, this is identified in the Balanced Scorecard, which considers a design of four perspectives that make it easier for managers to visualize in a general and integral way the organization of an entity, where the client's perspective shows how customers perceive the organization based on the services or products received.

The accounting profession has gathered the subject in the study of the IFAC (International Financial Accounting Committee) entitled "The measurement and management of Intellectual Capital: an introduction" considering that the client capital is formed by the brands, customers, loyalty of the same, company names, order accumulation, distribution channels, business collaborations, licensing agreements and favorable contracts. A satisfied customer is the reason why a company can be acquired for a sum greater than the value of its identifiable net assets.The cause of this surplus payment is that the buyers have detected that the company has a client portfolio and that, with the combination of an efficient team and a different organizational structure, it can generate an increase in future profits. Although customers are considered as a factor that creates future expectations of value, today, in a world where competition is not limited to the local level, but reaches global levels, trying to meet the needs of customers has become a of the fundamental goals of any company (Cegarra y Rodrigo, 2003). In a highly competitive environment like the aforementioned, companies must anticipate the needs of their customers if they wish to have a permanent establishment. The emergence of new technologies determines the achievement of these objectives, but no entity could achieve them if strategic planning is not carried out and resources are allocated for this purpose.

Relational Capital represents the value that the organization possesses in the sense of its relations with the outside world, also called social capital by Camisón, Palacios and Devece (2000). In these relationships, suppliers and competitors can be mentioned, since both play an important role in the service and quality that the organization offers.

Bueno (1998) contemplate the relationship of three components of the CR: the improvement of quality, the reputation of an organization in the market and customer satisfaction.

- *Quality* can be understood as the set of characteristics of a product or service that meet the needs of customers. Garvin (1998) establishes what he calls quality dimensions that encompass all those intrinsic and extrinsic characteristics of the product or service that will serve him to better meet the competition, the needs of the market sector to which it is addressed.
- *Regarding reputation*, consumers have the potential to strengthen or weaken public opinion regarding a company or its brand, as used correctly or incorrectly (Cegarra y Rodrigo, 2003).
- **Customer satisfaction** represents the evaluation made by the client between the service he has received and the one he expected to receive, between the planned and the received. According to Bueno (1998), when something is not done well and is quickly solved, loyalty and trust is generated between the clients and the organization, and with that a more tolerant and more prone audience is achieved in maintaining their confidence in times of crisis.

In recent years the search for methodologies and models that contribute to improve the management capacity of intangible assets has been increased, and then some of these more representative efforts or experiments are cited by grouping them into three categories:

A. Those carried out by consulting companies, such as Ernest and Young, who through their "Center for Business Innovation (CBI) and their" Center for Business Knowledge" (CBK) have pioneered the promotion, financing and stimulation of intellectual capital management. . The most notable result of these initiatives has been the development by Kaplan and Norton of the model called "Balanced Scorecard"
B. Those made by financial institutions and insurance companies. Among the efforts made by financial institutions and insurance companies, SKANDIA, whose director of Intellectual Capital Leif Edvinson has written together with Michael Malone, has written a book entitled "Intellectual Capital: Realizing Your Company's True Value by Finding Its Hidden Brainpower ". This book describes the fundamental philosophy of Leif Edvinson regarding Intellectual Capital and what is more important explains the model used by SKANDIA to manage said Intellectual Capital. Since this model is the only one that tries to link the Intellectual Capital indicators with the financial results through a "balanced scorecard" that is delivered to the shareholders and the public.

C. Those made by high tech companies. They refer to research conducted by Hewlett Packard, Dow Chemical, Hughes Space and Communication, Merck and Nova Care. All of them focus on the CI of the Innovation and Research and Development functions, although with many variants and different approaches.

Knowledge generates value and Intellectual Capital is the key to the success of companies that compete in the economic, political, social and technological context of the current era, and their role in the future will surely be more and more relevant.

Machining Industry of Juarez, Chihuahua

According to the National Institute of Statistics and Geography (INEGI) in Mexico there are more than 800 companies of the Industrial Machining Industry (IMI), mostly concentrated in the northern border. Vera-Cruz, Dutrenit and Gil (2003), in their research on metalworking SMEs, argue that the first machining workshops in Cd. Juárez, Chihuahua, arise in the early 1940s aimed at the production of spare parts for various types of machinery used for agriculture and the industry, which was not possible to buy abroad because of the limitations that the war brought. These workshops were considered artisanal, where the only employee was the master turner. The owners did not offer their work; the clients were the ones who came to them.

The integration of a regular machining market and consequently the machining workshops of the industrial type that exist today in the region arise in the 70s, as a response to the needs of the Export Maquiladora Industry (IME) to obtain tools and spare parts for harness production.

In the beginning, the local workshops did not have the capacity to produce this type of tooling because it required the use of numerical control and computer numerical control (CNC) machine tools. Thus the maquiladora plants often had to make their own tooling.

Since at that time the maquiladoras were not open to hiring Mexican personnel to occupy high-ranking positions in the plants, many of these technicians trained in the maintenance workshops of the maquiladora plants chose to set up their own mechanical workshops, often with equipment used to buy from the maquiladora plants, becoming independent suppliers, and as the IME was aware of its capacity, began to hire its services. In this way, from the relationship that existed between the new owner and his former employee, the contractual relationships between the machining workshops and the maquiladora companies are initiate. This facilitated the growth and multiplication of the workshops in Cd. Juarez in the 1970s.

This industry had its greatest growth in the 90's, along with the maquiladora industry, and although it has been more than half a century since it emerged in this City, its development has not been significant, since most companies are identified micro and small (table 1), with family organizational structure, non-innovative technology, neither much importance is given to process certification issues, this being possibly a consequence of those responsible for managing these companies having little interest in generating changes to the interior of the organization.

Table 1. *Classification of industrial companies according to the number of employees*

Stratum	Industry	Commerce	Services
Micro	0 30	0-5	0-20
Little	31-100	6-20	21-50
Median	101-500	21-100	51-100
Big	501	101	101

Source: *Nafinsa*

The tangible assets of the workshops vary, from those with assets in machinery and equipment of around $ 10,000 to those with investments of around $ 2,000,000. Many of these establishments have an age of 10 to 15 years; no more than five workshops are those that are more than 20 years old. In the case of intangible assets, they are not fully identified and the lack of knowledge of the assets content in companies reduces competitiveness to organizations. This sector has an important potential market in the Export Industry as its main client and with product requirements with certain technological complexity.

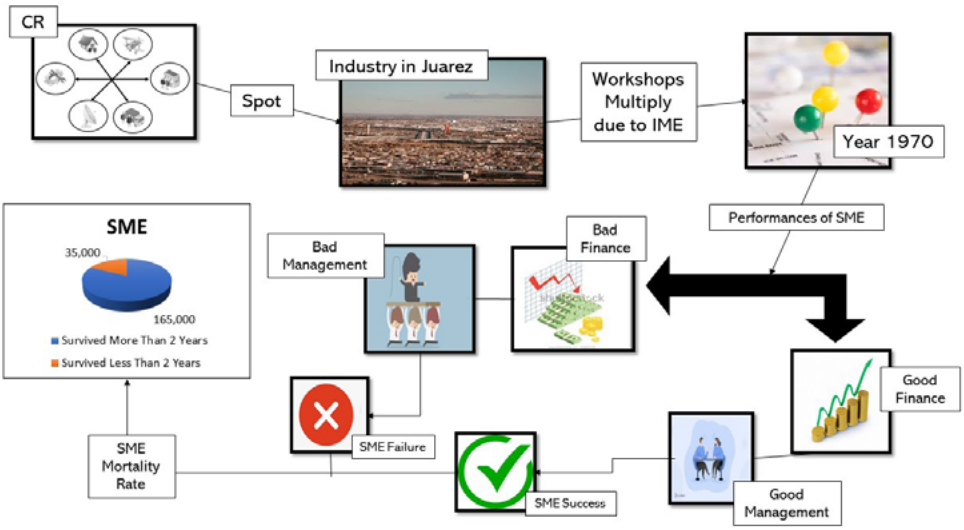
High mortality of SMEs

In Mexico, 200,000 companies annually open their doors, however only 35,000 survive two years later (Dutrenit, G., et al, 2003), this death rate is common to metalworking SMEs companies, even in developed countries. In the United States, 24% of new businesses have closed two years after opening and 53% before four years (Tan et al, 2007). Thus the risk inherent in the SME segment is naturally high, much higher than that corresponding to large companies, which explains a good part of the higher rates they have to pay the credit and the reluctance of the banks to grant them.

A central concern of the economic policy of developing countries has been to promote small and medium-sized enterprises as a means to set up a larger business group that generates productive employment. For this purpose, strategies have been articulated to support these business units with credits, which have contributed to their expansion. However, the lack of confidence of entrepreneurs in loans from financial institutions has not allowed this objective to be met. Other measures taken to strengthen the administrative area of small businesses apart from financial support are credit supplements, tax reductions, and promotion of technological development.

Figure 1 shows a diagram of the state that the Relational Capital holds in the Industry of Ciudad Juarez, representing the Maquiladora Industry, machining companies and suppliers thereof.

Figure 1. *Diagram of CR Industry.*



Source: *Own elaboration*

Industry Study

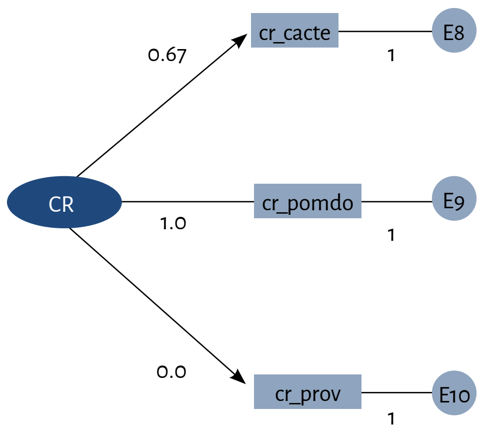
The first interest was to analyze the management of the CR and its impact on the competitiveness and permanence of the machining companies. Once the study problem and the relevant objectives were defined, it was considered under this criterion and a field investigation with a mixed approach, in addition to being considered a prospective work since all the information is obtained for the specific purposes of the project; with transversal and descriptive data when looking for associations between variables within the same population, without trying to modify any of the factors involved in the process described. To analyze the problem, a measuring instrument was created and used among several industrial machining organizations through applied surveys, once this information was obtained; it was analyzed statistically and through confirmatory analysis using the Structural Equation Model from which the final results are obtained. The survey consists of 3 sections, one for sociodemographic variables, and another for the CR element and a third for manufacturing practices. A semi-directed interview was also conducted in which important data that the owners of the machining companies provided were identified. The instrument was applied in two parts, in the first one a pilot test was applied, in which not only the instrument but the conditions of application and the procedures involved are tested, in this way it was analyzed if the instructions were understood and that the items will work properly, language and writing were also evaluated as recommended by Hernandez, Fernandez and Baptista (2016). Through this first application, editorial modifications and number of items were made to the survey. The second was the formal application of the instrument, which was first contacted by telephone for the presentation and appointment of data collection. The Validation of the survey was carried out through expert judgment and its reliability through the Cronbach Alpha reliability coefficient was 0.9644, being a high reliability (Benavides et al, 2005). The survey indicators are represented in 3 variables that try to explain to the CR such as: Customer capital (cr_cacte), Market positioning (cr_pomdo), Suppliers (cr_prov. These were analyzed to establish the correlation between them, as well as the explanation that 100% is expected of them towards the CR, which is also explained by an error or latent variable called (ecr).

Discussion

The components of the IC, like the relational capital, include the analysis of intangibles assets as a set of stock of resources, is important but really partial due to the fact that IC and knowledge continuously change. In this light, the focus on activities and processes help in understating how the firm manages the intangibles assets. In the SME, formal and informal knowledge coexist but in different areas of the firm (Marzo and Scarpino, 2016). In the Relational Capital, the characteristics of the target market and the support derived from the framework of contacts and alliances are analyzed. All this is complemented by the social field in which assets as significant today are valued as notoriety, image and status (Bueno, 2008). It is well known that in the Ciudad Juarez market, SMEs, suppliers of *Maquila*, whose owners were at the time engineers working in the mentioned industry (*startups*) (Dutrenit et al, 2002), that is why their relationship and knowledge of the supplier is from first source. This results in them being able to meet the demands of the Maquiladora Industry, however, the competitive position vis-à-vis their American competitors is not very encouraging and, in addition to this, it is observed that there is not a good integration in the sector, despite the Recent efforts of the MACH Cluster, a group formed by industrialists, which aims to strengthen regional companies, fostering their development, working in teams linking different actors of the industrial activity with which it is intended to deal with technological changes dynamically. In Juárez "The production processes with the highest demand in the Automotive industry are CNC machining, rolling, stamping, traditional machining, extrusion, injection and coating of metals.

Today, competitive advantages are less supported in tangible assets to open the way to the prominence of intangible resources linked to knowledge, which have become one of the driving productive forces of companies (Borrás and Arango, 2020). The environment of shortened business cycles and rapid technological changes, intangible assets represent the main dynamics of value creation of the company. In the "age of knowledge", the exploration of the roles of explicit and tacit knowledge encourages the creation of value of the elements in support of commercial strategies (Hubert, 1996). Once the data is analyzed using the AMOS software for modeling by structural equations, it is obtained that the variables that explain the CR do not correlate with each other, but explain in full to the CR according to the adjustment that the model showed, the explanatory weights of the variables in the case of client capital (cacte) is relatively significant, but not that of the market positioning variable (pomdo) that explains 100% to the CR, however the suppliers variable (prov) has no explanation in the model as exposed in Figure 2.

Figure 2: *CR and the results with the application of structural equation modeling*



Based on the behavior of the variables, it is concluded that companies know perfectly the position they hold in the market. This would not be a permanence problem since they have mostly identified customers, however, what encourages them to disappear is the result of the suppliers variable (cr_prov) that has an explanatory weight of

0.00 (as exposed in Table 2). In this regard, the company is aware of its market place, as well as its low relationship with suppliers, because they have no financing or lines of credit. Its competitiveness is affected in this regard as entrepreneurs buy cash raw materials and sell their products or services for credits of up to 90 days to the Export Maquiladora Industry.

Table 2. *Explanatory weights of the variables in the element of relational capital.*

Relation	Estimate
cr_cacte	.670
cr_pomdo	1,000
cr_prov	.000

Source: *Own elaboration.*

Conclusions

Intellectual capital enables the success of companies, thus, the accumulation of knowledge is related to the accumulation of expertise within organizations, which is considered, along with information, the fundamental raw material of the economy and its products. In this sense, it is understood that the use of knowledge has intensified. Organizations have the potential to provide knowledge that adds value, this is observed in the case of industrial machining companies since they hire less specialized personnel without studies, once within the organization they give them the skills and training they require, from this, they condition the quality of the service offered by the company, as well as the degree to which it uses the intangible resource to manufacture goods or services and achieve greater customer satisfaction. The amount of organizations that base their competitiveness on high-level technology has also increased. This allows us to presume that competitiveness depends on the ability to innovate and improve, in addition to the productivity and productive efficiency of organizations. However, in recent times, it has been questioned whether having state-of-the-art facilities guarantees organizations a competitive position in the markets. The case of the Machining Industry in Juarez is a clear example since it has high-level technology, but it does not generate patents or have an expense in Research and Development, and it is that with personnel without specialization or without engineering studies, it can do little to respect. Nor should it be forgotten that these organizations require highly qualified personnel, with extensive skills, abilities and technical knowledge, however, it is also observed continuously, that these resources, which are also important, are managed with low levels of effectiveness.

A critical factor is that the machining companies have a serious financing problem, because they do not have credit lines granted by suppliers, as mentioned, these companies have as their main client the Export Maquiladora Industry (IME) to whom They are practically financing, since these companies pay the IMI in terms of up to 180 days in some cases, this makes the purchases of the machining industry be in cash as expressed by the entrepreneurs and as previously identified in Table 3. For the item of relational capital to contribute to competitiveness, profitability and finally to permanence, two factors are required: The first, that the IME as the main client, pays them in less time, strengthening its liquidity; and the second factor, which have longer credit lines than those paid by the IME, this refers to the urgent revision of its cash management policies. One of the sources of wealth is the value of knowledge, in this sense, it is likely that intellectual assets are worth more than the material value established in the accounting books, in addition, successful companies are those that constantly create, acquire and transfer the new knowledge, they spread it throughout the organization and incorporate it into their new technologies and products.

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CHAPTER 11

Future Determination of Programmed Obsolescence and Future Paradigm Shifts in Technology Consumption of Generation Z Using an Innovative Metaheuristics

Alberto Ochoa-Zezzatti*[1], Liliana Gamez[2]

[1] *Doctorado en Tecnología, UACJ,* [2] *Universidad Politécnica de San Luis Potosí*
** Corresponding Author: alberto.ochoa@uacj.mx*

Abstract. In recent times, the continuous use of technological innovation leads us to live in a world of programmed obsolescence, an aspect that characterizes the day-to-day life of modern civilization. The phenomenon of the "culture of tolerance" in which we place economic, political or military interests, among others, above the values and rights of the person, as is the case with the phenomenon of programmed obsolescence, in which both businessmen and consumers are involved. Corporate technology companies seek their own enrichment through the sale of pre-programmed products, limiting the quality of the products and their duration, while consumers, are presented as the victims, carrying out an unstoppable consumption of "obsolete" products. Nonetheless, this investigation distinguishes the discontinuation of products due to advertising and fashion (symbolic obsolescence) as well as the depreciation of items due to the appearance of better ones (technical obsolescence), from technical failures intended for profit (programmed obsolescence). Moreover, this research focuses on the time of use of a dispositive which is reduced because we believe that symbolic obsolescence has an advertising rather than an economic focus, and technical obsolescence deals with mere errors, rather than intentional fallacies or manipulations. One of the principal questions that motivated this research was: could there be a sustainable economy with programmed obsolescence? It is important to understand the concept of "sustainable economy" as something that satisfies the needs of the consumer who acquires the technology without it compromising the possibilities of future generations to realize this purchasing behavior and the use of modern technology. Throughout this work, the origin, consequences and possible solutions of this social behavior phenomenon will be analyzed by using an innovative metaheuristic called: "African Buffalo Optimization". Moreover, we managed to model the future trend of increasing programmed obsolescence and its consequences on generation Z.

Keywords: Optimal social behavior in Industry 4.0, Model the future trend of increasing programmed obsolescence, Generation Z. and African Buffalo Optimization.

Introduction

Planned obsolescence causes the disposal of thousands of tons of electronic goods which, if they can continue to be used, create a constant flow of products that end up being dumped in Third World countries. This violates the laws imposed in international treaties, such as the Basel Convention, which prevents the use of developing countries as "dumping grounds" for Western countries. Nonetheless, companies from highly developed countries hide behind the term "recycling" or by naming such waste "second-hand products" (Maurer, S., 2014). Today, production is developing in an uncontrolled way, leading landfills to increase in size rapidly (about 40,000 tons in 2010). Countries like China, Nigeria, India or Ghana are countries that have become dumping grounds and, therefore, accumulators of technological devices that are toxic and dangerous for the health of their inhabitants. Most of these electronic devices end up being burned or destroyed, leaving the chemical products they are made of (such as lead, arsenic, selenium, cadmium, thallium, tantalum, among others) in contact with the environment and people. These materials have serious consequences for health, such as infertility, damage to the nervous system, rashes, cancers and even abortion. This is why when we address programmed obsolesce, the term "Corporate Social Responsibility of companies" is used. This term is defined as the "set of legal and ethical obligations and commitments that companies assume to care for and improve the impact of their activities on the labor, social and environmental spheres" (Dallemagne, D. 2014). China is the largest recipient of the commonly named WEEE (Waste Electrical and Electronic Equipment), receiving one million of obsolescence diapositives per year from all over the world. Furthermore, Ghana is known as "the new dump" in Europe, as it hosts a similar amount of waste: "It is obvious that nobody wants to have waste in their garden, because it is harmful to the environment, and that is why it is sent to Ghana. But there are no places available here to recycle this waste." (Maurer, S. 2014) Authors specialized in this research area also claims that when it rains, toxic substances from computers and televisions are washed away by the rivers, killing fish and mollusks in their path. Due to the increase in these types of problems, the World Bank published the report "What a Waste: A Global Review of Solid Waste Management", which estimates the level of waste at 2.2 billion tons in 2025 from the 1.3 billion tons per year we find today. This problem was described as "urgent" by Rachel Kyte, who also stated that "once the scope of this problem is recognized, local and national leaders, as well as the international community, will mobilize to implement programs to reduce, reuse, recycle or recover as much waste as possible before burning or otherwise disposing of it. Measuring the magnitude of the problem is a critical first step in solving it. The investigation concludes that the problem of planned obsolescence and excessive waste production is a consequence of mass consumption.

Theoretical Framework and state of art

Despite the consequences that programmed obsolescence has on the environment and on people's health of, we cannot ignore the effect it has on the family economy. By this we refer to the need of having to buy a new product when it one cannot be repaired or having to invest more money in repairing it. An example of this can be found in the case of Andrew Westley against Apple in 2003. Westley sued the Apple for creating iPod batteries with limited life, whose only solution was the purchase of a new device. Westley's attorney, Elizabeth Pritzker, alleged that Apple was not complying with environmental policy and was programming the product's usefulness (accusing them of creating obsolete products). After conducting an analysis of the product, consumers became more aware that they could not accept high-tech products that were disposable and that there were laws that could protect them from this commercial behavior of companies.took over the lawsuit, which brought consequences for the company such as being able to change the battery of the devices and increase the warranty to two years. Likewise, the Apple company again provoked user discontent in 2013 when, three years after the release of the iPhone 3G mobile device, customers were deprived of the use of the instant messaging application Whatsapp, (Meseguer P. M., 2014). The problem arose when a new application update appeared that required a more up-to-date version of the terminal's operating system. "The hardware of that phone cannot support such an advanced version. If customers want to use that application, they have to get a new handset," said Steve Jobs, co-founder and CEO of Apple Inc. Another notable case is Nike's new "Nike Mayfly" tennis shoe model, which was advertised as "lasting only 100 km". This is why it could be said that we are living in an "anti-economic system", because in addition to not taking care of the basic principles of life and the responsible use of resources, the only purpose of large companies is to sell more by failing to comply with certain responsibilities and obligations when manufacturing. Most companies invest significantly more money in advertising than in the manufacturing process of their products. Nonetheless, in the documentary "Buy, pull, buy" American manufacturers were forced to produce light bulbs with a limited life span in the 1920s. This raises an important question: if it was possible to create durable products at the beginning of the 20th century, why is it not possible to do so now with all the technological advances and resources available? And how, in times of crisis, can we afford to waste our money continuously renewing our electronic devices? (Saura, A., 2013), having tangible evidence that it can be accomplished like the OEP Electrics, which under Benito Muros Perfecto's "No Programmed Obsolescence" created a lightbulb that did not need to be replaced until it reached 80 years of useful life.

Methodology proposed

African Buffalo Optimization (ABO) is an attempt to develop a user-friendly, robust, effective, efficient, algorithm that will demonstrate exceptional capacity in the exploitation and exploration of the space investigation. ABO attempts to solve the problem of pre-mature convergence or stagnation by ensuring that the location of each buffalo is regularly updated in relation to the particular buffalo's best previous location and the present location of the best buffalo in the herd. For instance, in a situation where the leading (best) buffalo's location is not improved in a number of iterations, the entire herd is re-initialized. Tracking the best buffalo ensures adequate exploration of the search space and tapping into the experience of other buffalos enables the ABO to achieve adequate exploitation. The algorithm begins by initializing the population of buffalos.

It does this by allocating a random location to each buffalo within the N-dimensional space. Next, it updates each buffalo's fitness within the search space. If the fitness is better than the individual buffalo's maximum fitness *(bp_{max})*, it saves the location vector for the particular buffalo. If the fitness shown in Figure 1. ABO algorithm is better than the herd's overall maximum, it saves it as the herd's maximum (bg_{max}) (Singh, Pushpendra et al., 2020). Finally, the algorithm checks if the best buffalo is updating its location. If it is, then it moves on to validate the stopping criteria. At this point, if our global best fitness meets our exit criteria, it ends the run and provides the location vector as the solution to the given problem. The ABO algorithm is shown is Figure 1. The algorithm's movement equation has three parts: the first $w._k$ represents the memory of the buffalos past location (Almonacid, Boris et al., 2019). The memory of each buffalo is a list of solutions that can be used as an alternative for the current local maximum location. There is a probability of choosing one of the target list of solutions of the buffalo's memory instead of the present herd's maximum point. The second $lp1r_1(bg_{maxt.\,k} - m._k)$ is concerned with the cooperative part of the buffalos and is a pointer to the buffalo's social and information-sharing experience and then the third part $lp_2r_2(bp_{max.\,k} - m._k)$ indicates the intelligence part of the buffalos. So the ABO takes advantage of the memory, intelligence and caring capabilities of the buffalos in arriving at solutions, as seen in Figure 1.

Figure 1.- *Description of the metaheuristics used.*

The ABO algorithm is presented below:

(1) Initialization: randomly place buffalos to nodes at the solution space.

(2) Update the buffalos fitness values using

$$m.k + 1 = m.k + lp1\,(bg\max - w.k) + lp2\,(bp\max.k - w.k)\,, \qquad (1)$$

where $w.k$ and $m.k$ represent the exploration and exploitation moves, respectively, of the kth buffalo ($k = 1, 2, \ldots, N$); $lp1$ and $lp2$ are learning factors; $bg\max$ is the herd's best fitness and $bp\max.k$ the individual buffalo k's best found location.

(3) Update the location of buffalo k ($bp\max.k$ and $bg\max$) using

$$w.k + 1 = \frac{(w.k + m.k)}{\pm 0.5}. \qquad (2)$$

(4) Is $bg\max$ updating? Yes, go to (5). No, go to (2).

(5) If the stopping criteria are not met, go back to algorithm step (3); else go to (6).

(6) Output best solution.

Source: *(Beneoluchi Odili, Julius et al., 2016).*

Buffalo Movement

Two main equations control the movement of buffalos within the solution space. These are Equations (1) and (2) (refer figure 1). The movement equation (1) provides the actual movement of the herd using their specific speed. The maaa update equation (2) provides movement adjustment given the two competing forces *(bp_{max} and bg_{max})*. The λ parameter which defines the discrete time interval over which the buffalo must move is usually set to 1.0. The result is a new location for the animal (Jiang, Tianhua et al., 2020). The second equation has two major parts, namely, the global maximum and the personal maximum positions: each defining the representative influence over the animal's choices. The algorithm subtracts the maaa element (asking the animal to explore more solutions) $m._k$ from the maximum vector and then multiplying this by a random number ($r_{1,}$ r_2) usually between 0.0 to 0.6 and a learning factor ($lp_{1,}$ lp_2). Using the random numbers between 0.0 to 0.6 has so far proved effective in obtaining fast convergence. Further investigation is ongoing to get figures that may yield better results. The sum of these products is then added to the waaa element (asking the animals to move on, explore) for the given dimension of the sector. It should be emphasized that the random numbers give an amount of randomness in the path to help the animals move throughout the solution space. Doing so by giving more or less emphasis to the global solution (Beneoluchi Odili, Julius et al., 2016).

Proposed solution

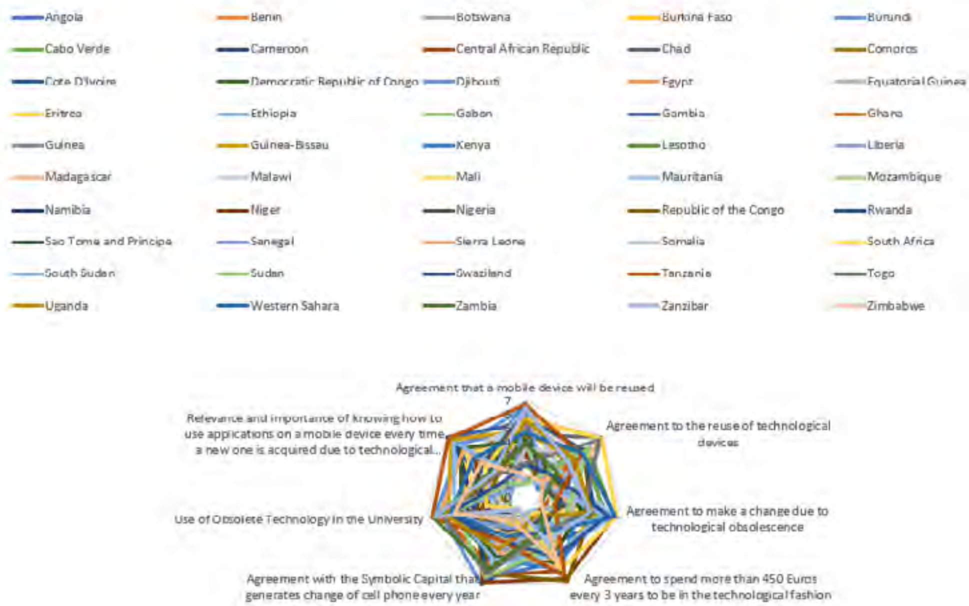
Having analyzed the origins and consequences of programmed obsolescence, the question that we wanted to clarify with this investigation begins to become clearer: Could a sustainable economy with programmed obsolescence work? The fight against programmed obsolescence has been impulsed by new initiatives such as Closed Cycle Production Living Local Economies, Renewable Energies, Green Chemistry or Zero Waste, as well as by non-governmental organizations such as Greenpeace. Nonetheless, the European Union is beginning to support the issue by introducing laws to regulate and prohibit the practice: France has been the forerunner of these punishments and is already followed by countries such as Germany and Spain with proposals for legislation.

Collaborative Economy

One solution to programmed obsolescence is the Collaborative Economy, whose basic principle can be summarized in the word: "sharing". This refers to four projects or initiatives: exchange of goods (the best example is stock market time banks, which exchange services), recirculation of goods (through sites such as eBay), optimization of assets (such as the car-sharing that has developed in recent years thanks to sites such as Sidecar) and construction of social connections. This new economic model has grown to 25% in 2013 in the United States alone, reaching 3.5 billion dollars (according to FORBES magazine). In addition, Times magazine named "Prevention of programmed obsolescence" as one of the ten ideas that would change the world, since it would allow "fixing the worst problems, from war and disease, to unemployment and deficit". Thomas Friedman, a columnist for The New York Times, said it "creates new ways of doing business and a new concept of ownership. However, this model also has flaws, among which we can highlight the reduction of jobs linked to the production process of goods. Moreover, this practice is closely linked to social networks and the Internet, thus, another problem of a cultural nature arises, being that not everyone would have access to them. It is also a system based on trust, so education and values are extremely important for the success of this economic system.

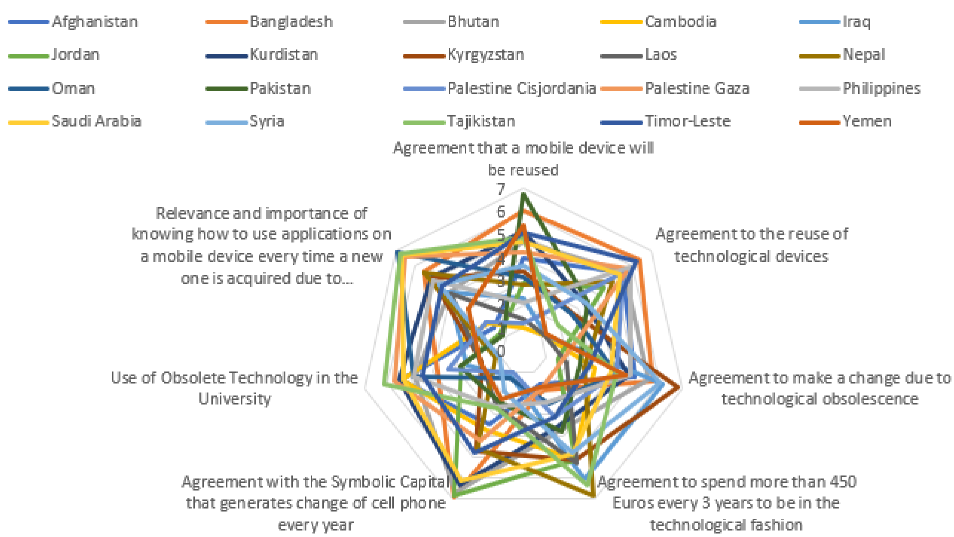
That is why it must be emphasized that the success of these initiatives depends on the procedures with which they are carried out, on the thinking that guides them. Returning to the examples we have given above, eBay, a platform which began solely with the idea of facilitating the sale and exchange of second-hand objects, has now incorporated the sale of new products for profit only. There are also examples, of course, where the opposite is true, and the companies and platforms continue with their initial principles. Another of the most significant novelties of the collaborative economy is the discontinuation of currency as a payment method, this implies a new way of payment "by the hour", that would provide greater equality. In the face of the problems that this method may present, the "completeness model" also arises, as described by Juliet Schored in 2018, member of Economists without Borders, which combines the use of currency as a form of exchange and hourly exchange. But as Economists without Borders says: "The fact that these problems appear does not mean that the model presented is invalid. On the contrary. As this model seeks from the outset the triple economic, social and environmental value, it is already better than another based on the individual accumulation of goods. Using our Metaheuristics we constructed these results by continent, figure 2 (Africa), figure 3 (Asia), figure 4 (America), figure 5 (Oceania), figure 6 (Europe):

***Figure 2.-** African societies representation.*



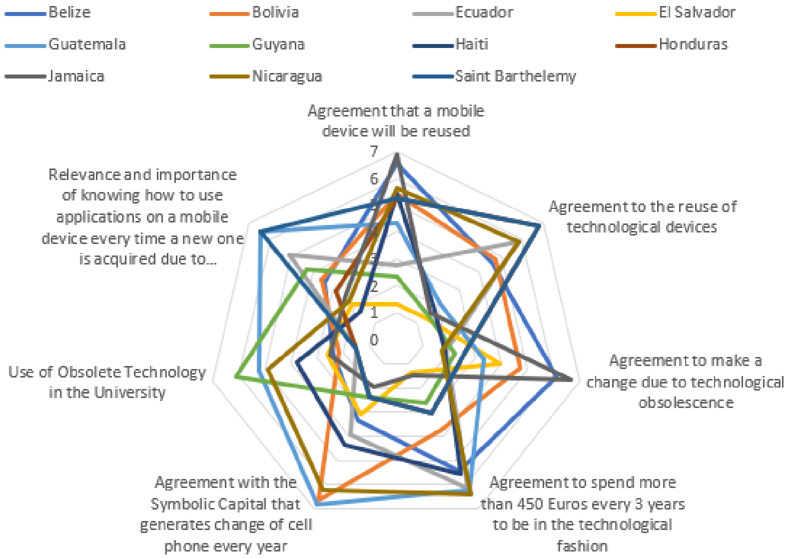
***Source** Own elaboration.*

***Figure 3.** Asian societies representation.*



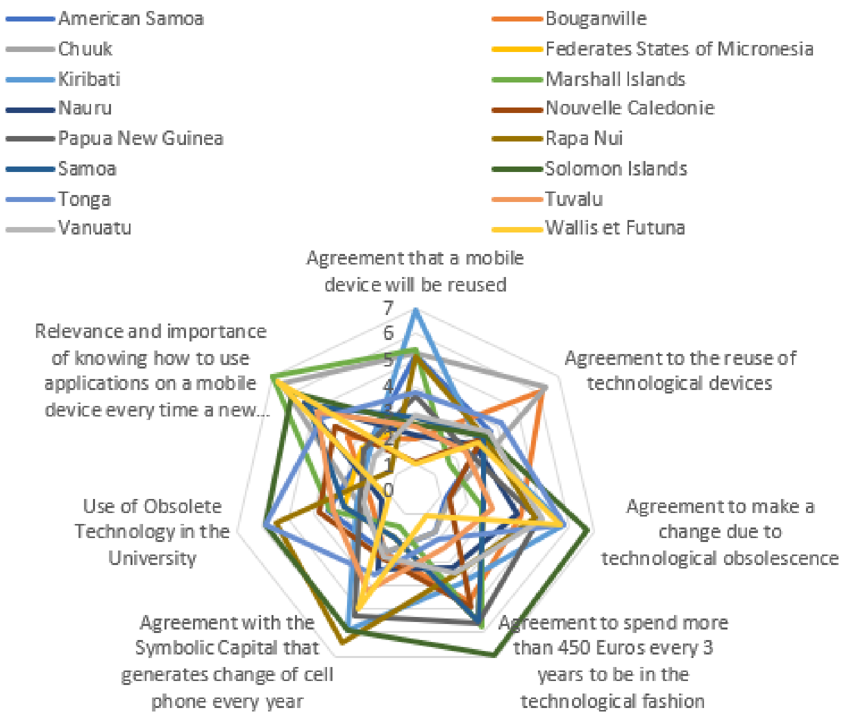
***Source:** Own elaboration.*

Figure 4. Americas societies representation.



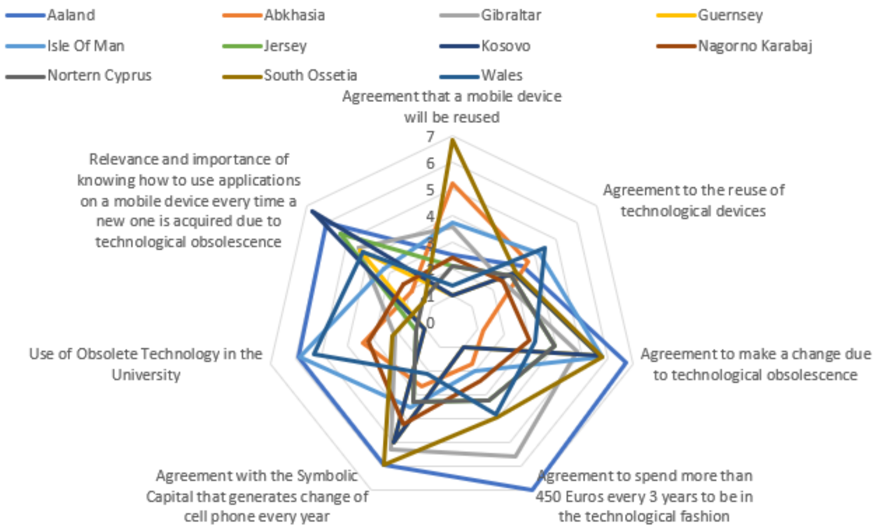
Source: Own elaboration.

Figure 5. Oceania societies representation.



Source: Own elaboration.

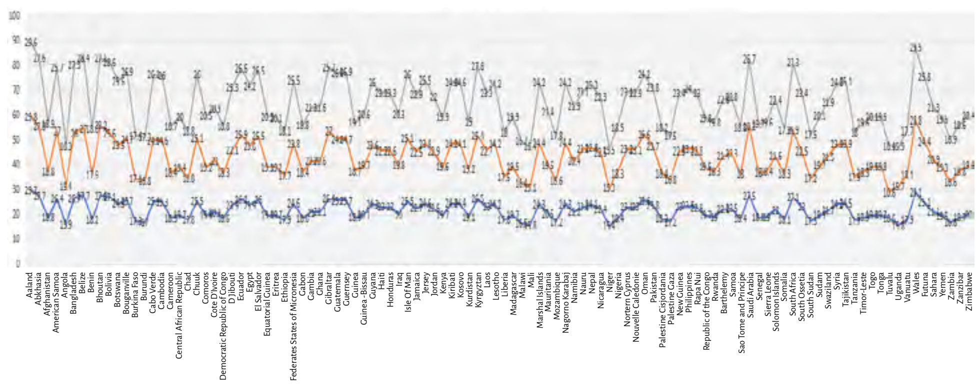
Figure 6.- European societies representation.



Source: *Own elaboratiom.*

And finally, a comparative of our sample of societies, including five continets, which is shown in figure 7:

Figure 7.- Comparative societies representation.
Median age by country.



Source: *Own elaboration.*

Conclusions and future research

The term "planned obsolescence" is unknown to many people, although much of the public is already aware that there is something causing products to fail earlier than they should. Nevertheless, it is little known to what extent this phenomenon affects our daily lives. Although there is big business behind this phenomenon, this research confirmed to us that, even if it is not very ethical, timing the death of products is necessary to maintain a stable economy. Experts like Bernard London also claimed that this was the most viable method to get out of the crisis, following the theory that the production of indestructible goods would lead to the break of factories and, consequently, the economy would collapse. In addition, the job creation generated by this is another important advantage, since manufacturers, salespeople and workers related to advertising are needed because of the constant renewal of products. Another key argument made by the same author in the 20th century, is that programmed obsolescence stabilizes the economy, so that supply and demand would be balanced. Moreover, authors defended that programmed obsolescence forces companies to invest in R+D+i (Research, Development, Innovation), because of the desire to renew and the pressing need for new products, as well as to improve production techniques (Saura A., 2013). The exercise of this phenomenon generates competitiveness among companies and this, in turn, lowers the cost of products, which is advantageous in times of crisis. However, by delving into the research and thanks to authors and economists such as Serge Latouche and Benito Muros, we realized some of the fallacies contained in this idea like the ecological problem. Pollution is one of the most significant issues as well as resounding consequences of programmed obsolescence, as we have seen throughout this research. Another drawback is the slowdown of research in certain aspects, since all the money that goes to the appearance of goods and their renovation is money that cannot be invested in their technical development and improvement. George Nelson stated in 2020 that "[...] design is an attempt to contribute through change. When this is not done or cannot be done, the only process available to produce the illusion of change is aesthetics." Nonetheless, one of the main problems is the depletion of raw materials, since "anyone who believes that unlimited growth is compatible with a limited planet is either crazy or an economist" (George Nelson, 2020). Moreover, Nelson argues that raw materials are not unlimited, encouraging us to leave behind the extreme individualism of our society and to seek a specific sustainable development in several societies which "consists of continuing to make progress in all areas without destroying the environment", not only because of environmental ethics but also because of the impact it would have on future generations.

Because of this research we were able to answer the question "Could there be a sustainable economy with planned obsolescence?" The answer was negative.

In the environmental field, problems include the depletion of raw materials and the accumulation of waste. From the ethical point of view, it would be an economy based on profit as an end and not as a means to achieve well-being. Finally, and affecting the level of innovation, investment in R&D&I would be reduced in favor of product aesthetics. After analyzing all these problems, we asked ourselves, how has programmed obsolescence triumphed? Benito Muros answered this question by stating that "the current economic model has allowed most of the wealth to be concentrated in 8% of the hands, mainly in banks and large corporations. That is why we are in the situation we are in". We would have been interested to see if balancing the amount of waste with the use of recycled raw materials, the system would have worked properly. It would also have been interesting to explore other more environmentally friendly alternatives to ensure a sustainable economy. Lastly, after investigating the phenomenon of planned obsolescence, we concluded that its origin reflects the prevailing materialism in today's society, based on economic expansion as the ultimate goal. In this way, we set aside the concept of economy as a neutral value for the achievement of real objectives, such as the satisfaction of citizens' basic needs: "we have created a world in which zero growth is considered synonymous with crisis and in which economists claim that growth of more than 2% per year is necessary for unemployment to fall by 23%. Indeed, the very idea of GDP used as an indicator of the value of goods and services produced annually in a country is a case in point. It is true that material progress offers us inexhaustible opportunities for consumption, but inner progress offers us the opportunity to be happy and to fulfill the ultimate goal of the ultimate goal of a concept defined as *groutier*. Thus, each individual should also begin to realize that, despite having almost unlimited resources, a proper distribution of these resources should be sought so that the quality of life of each individual could be improved. Effectively, this correct distribution of resources would be so that each individual could develop his or her capabilities to the maximum, and thus improve the future environment of Generation Z and its descendants.

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CHAPTER 12

Side Effects of the 4.0 Industry on Generation Y: A Review of Technological Changes from an Automotive Labor Perspective at Continental in Ciudad Juárez

Víctor Cabral*[1], Sarahi Sánchez[1], Alberto Ochoa-Zezzatti[2]

[1]El Colegio de Chihuahua, [2]Doctorado en Tecnología, UACJ
** Corresponding Author: victorcabral1313@gmail.com*

Abstract. Technological changes throughout history have represented great challenges for companies that work with technological innovations in their production processes. From a historical context, innovations and their adaptation have broken old paradigms in different sectors, technology brings beneficial changes in different areas, such as labor, commercial, distribution of goods and services, among others. The objective of this review is to show a critical analysis of different authors, their theoretical and empirical research evoked to the collateral effect with the introduction of Industry 4.0 to regular manufacturing operating environments, their descriptive concepts based on a practical model in automotive manufacturing at Continental. This represents a challenge that materializes in the new uses of the internet, connectivity, cybersecurity, Internet of Things, augmented reality in the operational area and its industrial application.

Keywords: Industry 4.0, collateral impact, innovation, adaptation

Structural equation model

After the beginning of the first industrial revolution in the 19th century, the textile mills in England were besieged by the textile craftsmen of the time, who were dedicated to sabotage and destroy the new machines in a form of protest against the new workers who, with little training and no experience, were turning secondary work into the new source of technical work (Gavalda, 2012). Considering that since the first industrial revolution at the end of the 18th century, technological changes have impacted society both directly and indirectly, this transition changed the way of working life that came from the Middle Ages with the use of animals in the plowing of the land and the windmill for farming, as well as the use of rudimentary tools for the production of goods and crafts for marketing. (Schwab, 2017)

To evaluate the concepts of sets of variables in the study, the system of structural equations is used to work with the different measurements and relate them to each other for the purpose of the study.

$$ILO = ET^{BT} \left[RI4.0 + \sum_{i=1}^{n} \#EIA\,(X \mid Y)\right] \pm CBO^{(ECO)}$$

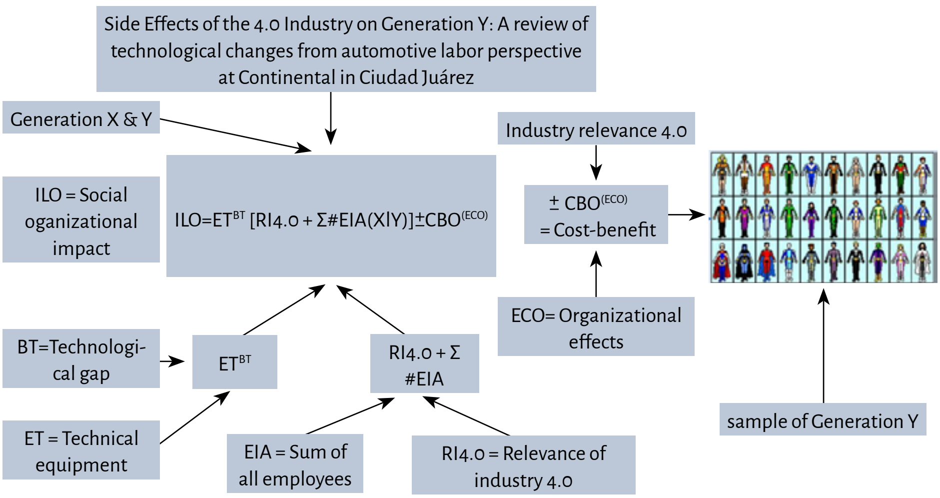
Where:

ILO	Social-organizational impact
ET	Technical equipment 600k USD
BT	Technology gap
RI4.0	Industry relevance 4.0
X, Y	Generation X, with respect to Y
i	Amount of data in the Sample.
#EIA	Number of employees in the automotive industry
CBO	Organizational cost-benefit 8k USD
ECO	Organizational Side Effects in the time

Development

As a consequence of the first industrial revolution, the economy benefited due to the new trade routes and the facilitation of access expanding the market. Nonetheless, the technological changes after World War I consequently led to the second industrial revolution with the mass production as was the case with Henry Ford's Model T assembly plant (Bearzotti, Industry 4.0 and the supply chain management: the challenge of the new industrial revolution, 2017). As previously stated, the Ford Company was the first episode of the automotive industry in the United States, followed by the mass production of automobiles in Japan after World War II. Toyota was having the highest productivity under the philosophy of "Global body lines", which is based on the defect detection and quality controls, revealing inefficiencies and eliminating production costs and producing customer's demand on time (Mortimore & Barron, 2005).

Figure 1.- *Conceptual diagram of structural model equation.*



Source: *Self-made figure.*

The next aspect of the third industrial revolution known as the "scientific-technical" one, begins with the first automation systems, the use of analog and the first digital computers with binary languages and with the ability to store data from the sixties to the early nineties, abruptly entering in the manufacturing industry by mimicking its productive processes, opening new opportunities and creating new academic training (Marín, 2010). Recently, at the Hannover Fair in Germany in 2011, the topic of Industry 4.0 was discussed to refer to the change in organizations and how it will impact supply chains globally creating smart factories. Klaus Schwab argues that "The fourth industrial revolution generates a world in which virtual and physical manufacturing systems cooperate with each other in a flexible way all over the planet. This allows for the absolute customization of products and the creation of new operating models" (Klaus Schwab, The fourth industrial Revolution, p. 21, 2017). This term is not only about creating intelligent systems for factories, but its meaning leads to areas involving nanotechnology, renewable energies and connectivity of the needs of companies, suppliers and consumers at the same time, making the fourth industrial revolution an industrial trend unlike any-thing seen before. The same applications are about to be implemented in the automotive industry, as is the case of the company Continental in Ciudad Juarez. William O. Rey (2009) illustrates the complexity of industry 4.0, explaining that it would be necessary to be aware of the policies in the industrial area and guide the change for development processes in the absence of capacity of educational institutions to create new technological research careers and not massively train engineers who will stagnate in the face of the new demands of new technologies. According to Klaus Schwab (2017), the government and business leaders need to change their mental and conceptual structure in the face of the technological changes that are coming. He also points out the competitive advantage it brings to companies by adapting in a flexible way with critical capabilities, self-awareness, empathy and motivation if they want to succeed in Industry 4.0. It is worth mentioning that technological changes and innovations in automotive manufacturing affect workers positively or negatively, companies reflect the cost-benefit impact with the use of Industry 4.0 in terms of rate of return on investment, the improvement of their processes and the little need for the human factor (Rüßmann et al., 2015).

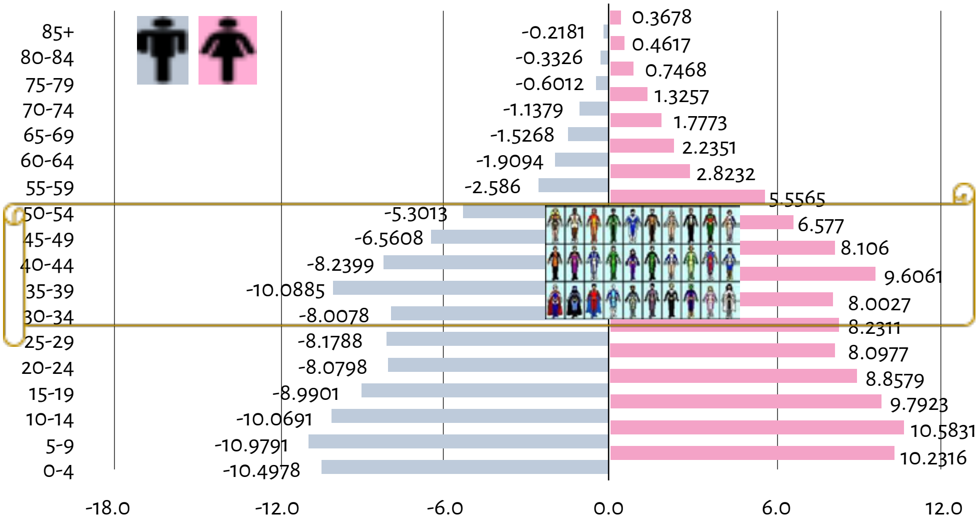
Forbes magazine noted that Industry 4.0 could not have immediate effect in countries such as Mexico, due to the cost-benefit of investment in the manufacturing industry in terms of automation equipment, cobots, artificial intelligence, augmented reality, 3D printing equipment and cyber security. Another characteristic of the situation in Mexico are the different aspects of industrialization, according to Michael Mortimore and Faustino Barron (2008), industrialization in Latin America represents a challenge due to the fact that a large part of the inputs are mainly from North American and Asia, which which is a great challenge to increase productivity due to the lack of effective communication between supplier and customer. Nevertheless, there are studies that mention the possible negative aspects of the introduction of new information technologies regarding working conditions and adaptation (Salanova et al., 1999). These negative results lack laws that protect workers when they are displaced from their activities, which implies a disadvantage in the automotive field since there is a lack of legal regulations that determine the future of the worker before the introduction of new technologies, Lorena Bearzotti (2017) is of the opinion that there is a legal vacuum and security failures for the adaptation of technological changes knowing the risks that this implies. The lack of adaptation would condemn automotive manufacturing companies to non-competitiveness.

Regarding supply chain connectivity, the authors Michael Rüßmann, Markus Lorenz, Philipp Gerbert, Manuela Waldner, Jan Justus, Pascal Engel, Michael Harnisch (2015), state that the transformation of machinery and information systems will be connected in the value chain and beyond a single company. Inés Sitton Candenado, Sara Rodriguez González and Lilia Muñoz, (2017) in *Diseño de un modelo predictivo en el contex-*

to de la industria 4.0 define this connectivity as cyber-physical systems that can interact with data from other companies to predict failures and configure themselves to adapt to changes forcing both customers and suppliers of the automotive industry to redesign their systems to those of the Industry 4.0 as there is the possibility, according to Klaus Schwab (2017), that low-income countries run the risk of possible relocation of industrial buildings due to the lack of adaptation to new technology. While further studies by Lorena Bearzotti (2017) in *Industry 4.0 and Supply Chain Management*: the challenge of the new industrial revolution tells us that "in recent years, organizations have been faced with significant changes produced primarily in the area of information and communications technologies, as well as changes in the links with other actors in their supply chains". Likewise, William O. Rey (2009) highlights the disadvantage in the implementation of new technologies due to the lack of change processes in education and pedagogical to add value to the demand for the implementation of new technologies in Industry 4.0. Moreover, according to Arellano (2017, p. 3) in "*La digitalización y la industria 4.0 impacto industrial y laboral*" another drawback is the practical training in hardware and software since repetitive activities in the automotive manufacturing industry will be replaced by machines creating an environment of social insecurity, as a consequence, it is not possible to determine the scope of technological changes and their impact on society. Technological changes in the automotive industry represent a great challenge and both positive and negative aspects can be identified. A radical change in the collective culture, government policies, and in the academic environment is necessary to be able to adapt to technological disruptions by creating awareness in the decision-making process of automotive manufacturing companies.

In a globalized world with a changing nature of employment, the World Bank affirms that the new technology associated with Industry 4.0 will generate "more prosperity than it will destroy". Nonetheless, this does not deny that it concentrates wealth and accentuates social inequality. According to the World Bank, the era when a worker remained in a job, or in a company, for many decades is disappearing. Certainly, the technological advances in robotics and smart industry (4.0) are accelerating changes in the quality and quantity of labor demand. Technology is changing the skills employers are looking for. The pace of innovation will continue to accelerate, so workers are likely to engage in many different activities throughout their careers, which will require them to continue learning throughout their lives; this is mainly the case with Generation X. See Figure 2. The World Bank released its World Development Report 2019 entitled "The Changing Nature of Work." Warning us that technological innovations will eventually accentuate the gap between nations in the use of technology. The analysis stresses that, "in countries with the lowest level of investment in human capital today, the workforce of the future will be between one-third and one-half of what it could be if people were fully healthy and highly educated. Developing countries will need to take swift action to ensure that they can compete in the economy of the future. He recommends that governments invest more in human capital (education, health and social protection) so that workers develop the skills demanded by the labor market.

Figure 2.- *Representation of generation X in the distribution of population in Ciudad Juárez to 2016 with data from CONTEO's INEGI 2015.*



Concentration of wealth and greater social inequality

"The Changing Nature of Work" echoes forecasts of massive job losses due to the expansion of smart industry, the editors acknowledge that "innovation and technological progress have caused disruption, but have generated more prosperity than they have destroyed". We are now facing a neuralgic point because of its economic, political and social impact on the immediate future of humanity, since the changes in the labor market are not only qualitative, but also quantitative. From the beginning of the first industrial revolution, the issue has been the subject of great controversy and debate among experts. Unlike previous revolutions, which did not have a widespread impact on the contraction of labor demand, robotization and smart industry are accompanied by a depth, speed and geographical dimension, exponentially greater than all previous revolutions. These changes will negatively impact current social security systems, as technological unemployment will accentuate job informality and poverty. In addition, it will contract contributions to retirement plans, increasing deficits and reducing the financial impact of so-called "generational solidarity". Although the new technological revolution will offer new opportunities that will increase social wealth, the study does not delve into how its results will be distributed, and how it will affect each generation associated with Industry 4.0. Certainly, the new technology will generate "more prosperity than it will destroy," but this does not deny that it will accentuate both the accumulation and concentration of global wealth. The best proof is that today the seven richest people concentrate more income than 3.6 billion poor people in the world.

Case of study: Continental

On October 8, Continental-Caoutchouc- und Gutta-Percha Compagnie is founded in Hanover as a joint stock company. In the central factory, located in Vahrenwalder Street, soft rubber products, rubberized fabrics and solid tyres for wagons and bicycles are produced. In 1892, Continental was the first German company to manufacture bicycle tires, and in 1898, in Hanover-Wahrenwald, it initiated the production of treadless automobile tires. In 1950, Continental had a workforce of 13,500 employees in the parent plant. Annual sales amounted to DM 309 million, equivalent to around 158 million euros. In the 1970s, the largest hose manufacturing infrastructure in Europe was established at the Korbach plant. All hose production is moved from Hanover to Korbach, and in the late 1970s the tire business of the European company Uniroyal, Inc. is acquired in the USA, giving Continental a broader base in Europe. Continental then acquires Siemens VDO Automotive AG (Ciudad Juarez, Mexico) in 2007 and becomes one of the five most important suppliers to the automotive industry worldwide, while strengthening its market position in Europe, North America and Asia. Continental's Plant 1 is a German company and has been operating in Ciudad Juarez for 11 years. The plant is dedicated to the assembly of automotive parts such as actuators, valves and sensors for the Mexican, North and South American, European and Asian markets. Its customers include Ford, Chrysler, Mercedes Benz, Mahle, Lamborghini, Audi and BMW, among others, and it currently employs 1,583 people, including direct and indirect personnel.

Results

The initial phase was the collection of data in the company by means of a 19-reagent questionnaire mainly directed to operating personnel where the advanced engineering team designed, programmed and implemented equipment of cobots in the production lines in repetitive operations, as well as material dispensing robots who are in transition of working next to a cobot or being relocated in another area in the company.

Characteristics of the sample

The sample included in the study is made up of 387 participants representing 30% of the total of population sampled according to the guidelines and policies of the company.

Figure 3. *Gender and Generational Age.*

Gender

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	male	160	41.5	41.5	41.5
	female	226	58.5	58.5	100.0
	Total	386	100.0	100.0	

Generational age

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Generation X	45	11.7	11.7	11.7
	Generation Y	324	83.9	83.9	95.6
	Baby boomers	17	4.4	4.4	100.0
	Total	386	100.0	100.0	

Source: Self-made *table using IBM's SPSS Statistics 22.0*

A total of 226 women and 160 men work at Continental, of which 324 belong to generation Y, 45 to generation X and 17 belong are "baby boomers".

Figure 4. *Frequency of perception of business competence.*

Ind. 4.0 contributes to the company's competitiveness

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes, it is competitive and improves staff development	16	4.1	4.1	4.1
	Yes, it is competitive it develops new technologies	71	18.4	18.4	22.5
	Yes, it is competitive and reduces the cost of human resources	39	10.1	10.1	32.6
	Yes, it is competitive optimizes production and work	100	25.9	25.9	58.5

Continued...

Ind. 4.0 contributes to the company's competitiveness

	Frequency	Percent	Valid Percent	Cumulative Percent
No, it's not competitive, it's not efficient	13	3.4	3.4	61.9
No, it's not competitive, it will create unemployment	52	13.5	13.5	75.4
No, it's not competitive, it eliminates activities with value	46	11.9	11.9	87.3
No, it's not competitive, there's no staff development	44	11.4	11.4	98.7
9999	5	1.3	1.3	100.0
Total	386	100.0	100.0	

Source: *Self-made table using IBM's SPSS Statistics 22.0*

The data shows that 297 individuals have a positive perception of technological change and development in the company, while the remaining 160 do not positively share the change with the industry 4.0.

Inmediate effect of ind 4.0. Trends: unemployment or new forms of work. Generational age Crosstabulation.

Figure 5. *Trends about immediate effects of industry 4.0, human displacement in the face of artificial intelligence and robotics against generational age.*

Count

Generational age			Trends: unemployment or new forms of work			Total
			It will displace the human work	It will create new ways of working	9999	
Generation X	Inmediate effect of ind 4.0	Improvments in my work	12	23	0	35
		it would generate jobs	0	2	0	2
		unemployment	4	1	0	5
		nothing would change	1	0	0	1
		9999	0	0	2	2
	Total		17	26	2	45
Generation Y	Inmediate effect of ind 4.0	Improvments in my work	146	115	0	261
		it would generate jobs	3	5	0	8
		unenmployment	43	3	0	46
		nothing would change	5	2	0	7
		9999	0	0	2	2

Continued...

Count

Generational age			Trends: unemployment or new forms of work			Total
			It will displace the human work	It will create new ways of working	9999	
	Total		197	125	2	324
Baby boomers	Inmediate affect of ind 4.0	Improvments in my work	6	8	0	14
		unemployment nothing	1	0	0	1
		would change 9999	1	0	0	1
			0	0	1	1
	Total		8	8	1	17
Total	Inmediate effect of ind 4.0	Improvments in my work	164	146	0	310
		it would generate jobs	3	7	0	10
		unemployment nothing	48	4	0	52
		would change 9999	7	2	0	9
			0	0	5	5
	Total		222	159	5	386

Source: *Self-made table using IBM's SPSS Statistics 22.0.*

It can be seen from the cross-data results that Generation Y has a perception of unemployment in the face of the immediate effects of the introduction of new technologies on work despite improvements with industry 4.0.

Conclusions and discussions

The results obtained in the study indicate a positive perception of the 386 workers at the Continental plant in Ciudad Juárez regarding the competitiveness of the company and the immediate effect of the introduction of new technologies, it is interesting to emphasize that the perception of unemployment in the cross data shows the possible impacts on manufacturing production in relation to employment and human displacement by the use of Cobots in areas of repetitive production. Although this could indicate a readjustment of jobs, it is possible that new jobs will be generated such as robotics technicians, cybersecurity programming, mechatronics maintenance. This trend in new jobs has been seen in developed countries, according to studies in the United States, the increase in productivity by new technologies would generate 150. 000 jobs in this area. Thus, it is necessary to deepen future studies on how educational training in underdeveloped countries is settled to fill these gaps of qualified personnel for Industry 4. 0.

Colegio de Chihuahua

Encuesta de Industria 4.0

El objetivo de este cuestionario es recopilar datos que permita medir la percepción acerca de la industria 4.0 y su impacto en la industria maquiladora automotriz.

La información es confidencial. Por favor responda a todas las preguntas.

1. *Año en que nació* _____
2. Género: Masculino ☐ 1 Femenino ☐ 2
3. ¿Cuál es su Código postal? ________
4. ¿Cuál es su último nivel de estudio terminado
   Secundaria ☐ 1 Preparatoria ☐ 2 Profesional ☐ 3
   Posgrado ☐ 4
5. ¿Qué puesto ocupa en su trabajo?
   Operador ☐ 1 Multifuncional ☐ 2
   Administrativo ☐ 3 Supervisor ☐ 4 Gerente ☐ 5
6. ¿Cuál es su área funcional dentro de la empresa?
   ____
7. *¿Conoce la industria 4.0 y sus aplicaciones?*
   Si ☐ 1 No ☐ 2
8. ¿Sabe si la empresa ha realizado un proyecto de industria 4.0?
   Si ☐ 1 No ☐ 2
9. Si la respuesta fue afirmativa ¿Qué proyecto fue?
   ____
10. ¿Qué impacto podría tener la introducción de nuevas tecnologías en el trabajo?
    Mejoras en mi trabajo ☐ 1 Generar empleo ☐ 2
    Desempleo ☐ 3 No pasaría nada ☐ 4
11. ¿Cuáles considera que son los cambios significativos en la forma de gestionar a las empresas del siglo XXI?
    Modelos sustentabilidad ☐ 1 Generar nuevos empleos ☐ 2 Desarrollo tecnológico ☐ 3
    Adaptación a nuevas tecnologías ☐ 4
12. Las herramientas que ofrece la industria 4.0 ofrece posibilidades de competitividad
    Si ofrece competitividad al sector industrial ☐ 1
    No solo ofrece si son aplicadas por grandes empresas ☐ 2 El conjunto es conveniente para proveedores de esta tecnología ☐ 3
13. Considera que la industria 4.0 es una oportunidad o una amenaza para la industria manufacturera.
    Es una oportunidad para la empresa. ☐ 1
    Es una amenaza para la empresa ☐ 2
14. En grado del 1 al 5, dónde 1 está en desacuerdo y 5 con certeza estar de acuerdo ¿considera que la empresa está preparada para la industria 4.0 en el corto plazo?
    Muy en desacuerdo ☐ 1 Algo en acuerdo ☐ 2
    Ni acuerdo ni en desacuerdo ☐ 3
    Algo de acuerdo ☐ 4 Muy de acuerdo ☐ 5
15. ¿Cómo piensa que debería de responder la educación preparatoria y profesional al reto de la industria 4.0?
    ____
    ____
16. De acuerdo a tendencias en inteligencia artificial y a la robótica, la primera asevera que desplazará el trabajo humano y formará un gran número de desempleados en la industria maquiladora, la segunda concuerda a medida que los trabajos operativos repetitivos se estandarizan tecnológicamente a la industria 4.0, se crearán nuevos trabajos especializados para la revolución digital, donde los jóvenes y los nativos digitales podrán desarrollar su potencial y proponer nuevas formas de trabajar y relacionarse con el mundo del trabajo.
    ¿Qué opina usted al respecto?
    ____
    ____
    ____
    ____

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CHAPTER 13

Automatic Recognition for Models of Detection of Arachnid Bites in Images Through the use of Deep Learning, a Solution Based on AmI

Ivette Mendoza[1], Eddy Sánchez-De la Cruz*[1], Alberto Ochoa-Zezzatti[2]

[1] *Tecnológico Nacional de México, Campus Misantla, Misantla, Veracruz, México*
[2] *Universidad Autónoma de Ciudad Juarez, Ciudad Juárez, Chihuahua, México*
* *Corresponding Author: esanchezd@misantla.tecnm.mx*

Abstract. Misantla is a city located in the mountainous region of the central zone of the state of Veracruz, Mexico, it is a region with a warm and humid climate and has a large ecosystem with a diversity of species. In it, arthropods play an important role in the ecosystem. Arachnids are chelicerate arthropods and represent one of the largest classes of invertebrates within the animal classification. Most spider venoms do not harm people because they are too weak and can cause sharp or stabbing pain, like a bee sting. Nevertheless, in cases of severe bites, the surrounding skin may die within a few hours. On the other hand, Industry 4.0 is known to lean towards automation and data exchange in technologies, as well as alluding to the fourth industrial revolution. Therefore, the objective of this chapter is the detection of spider bite accidents, especially in children in the Misantla region in order to automate medical diagnostic processes from the AmI approach. Because of their size, children usually have low defenses and, therefore, are the main victims of spider venom. The studies on the detection of arachnid bites worldwide are few and inconclusive, and the research literature reports few studies dedicated to the analysis of the detection of spider bites worldwide. No research work is recognized in Mexico whose objective has been to identify the bite of a spider, as well as its species and above all to suggest a center of specialties to be treated after being bitten. This is why Ambient Intelligence within this study is related, since it is currently responsible for solving this type of problems related to everyday life and with the correct operation of the implementation of deep learning techniques for the detection process, obtain a classification with the best accuracy with a minimum margin of error and thus, with a R-CNN Faster model based on a device, determine the places to go in case of an arachnid bite accident in infants in the city of Misantla. If a smart application for citizens is required to be implemented, citizens would undoubtedly have more information about possible arachnid accidents and which medical centers they should attend before an accident occurs.

Keywords: Arachnid bite, Smart application, Faster R-CNN, Deep Learning and AmI.

Introduction

Industry 4.0 remains understudied although over the past few years it has seen tremendous growth (Schroeder et al. 2019; Moeuf et al. 2020; Muhuri, Shukla, and Abraham 2019). Establishing Industry 4.0 is a deep process, which is an end-to-end integration (Wang et al. 2016), as organized strategies are required for its implementation. On the other hand, Ambient Intelligence (AmI) is rapidly rising as a multidisciplinary approach that can enable many areas of research to have a significant beneficial influence on society (Alfonso, 2019). Ambient intelligence systems improve the quality of life of users because they offer a greater variety of high-value services (personalized services), in addition to providing new forms of easy and efficient communication to interact with other users and systems (Díaz, 2017). In Mexico, however, the most likely to suffer more severe damage from spider venom are children, this is the reason for frequent pediatric consultations, since the degree of envenomation depends on factors such as whether the arachnid has just moved, eaten or mated (CONABIO, 2009). This is why the risk of being bitten increases in summer, when children are more exposed and the arachnid reproduces and goes out to hunt for food. Between 50 and 75% of children require treatment to avoid amputations, permanent sequelae or even death (Salud, 2016). In addition to the problems associated with an arachnid bite, it is impossible to determine the type of spider or bite. Therefore, the objective of this study is the detection of the main venomous spiders (black widow, fiddler, hobo, brown widow and golden silk weaver) by implementing Deep Learning techniques, with the R-CNN algorithm for detection and with the use of AmI is possible.

Furthermore, due to the recent success presented by deep learning techniques (ADAS-CVC, 2016) (Zhang et al., 2017), in this research a method for arachnid bite detection using a large number of images and convolutional neural networks, namely Faster R-CNN (Konig et al., 2017) (Heo et al., 2018) type architectures (Heo et al., 2018), to obtain a recognition system was implemented. Therefore, a new multiscale Faster R-CNN architecture is presented, which is evaluated under the test sets of spider databases, bites and their spider webs. The results show improvements especially when detecting accidents caused by arachnids.

Implementation of the R-CNN

It is important to know the distinction between an object classifier and an object detector. The image classifier is that algorithm that is responsible for classifying an entire image into a category. For example, you are given a picture of a car and only the algorithm mentions that the predominant object in the picture is a car. In contrast, object detection is the algorithm that is responsible for detecting various elements within an image and classifying them. For example, it is given an image containing a traffic stop and it must identify that there is a traffic light, cars, traffic signs, trees, etc.

Convolutional networks, are networks that are used to process images, they can learn input-output relationships, where the input is an image and, they are based on convolution operations; which consists of filtering an image using a mask. For this work, the Faster R-CNN architecture is used, which allows detecting objects within an image. Therefore, the operating logic of this algorithm is not described, only the algorithm is trained to detect the desired objects within an image (i.e. the 5 different types of arachnids, their bites and spider webs).

Requirements:

In order to carry out the development of this work in its entirety, it is important to have the following softwares installed

- Python 3.8.0
- Tensorflow
- Numpy
- Pandas
- Matplotlib
- Graphics card (Recommended to be able to do a quick training, although it is possible to do it without GPU, which can take hours or days without an NVIDIA graphics card).

Test development

The data with which the program will be trained were prepared. For which, about 1500 images of different types of spiders (the black widow, fiddler, hobo, brown widow and golden silk weaver) taken from the internet were downloaded among them. There were 100 images for each species, their bites and their webs for each object we need to detect (if in an image we have more than one object we want to learn to detect, this could count for 2 or 3 images, depending on the objects tagged within that image).

When we tag the images, we need to tell the program in which coordinates of our images it can find each of the objects we want it to detect, this can be a somewhat tedious task, but we can use a tool that will facilitate the task.

It is important that we have a varied data set, i.e., that we have the objects we want to detect from various angles, lighting types, positions, etc. Likewise, it is also important that our images are not of large size because they can be too much for our computer, so it is advisable to make a modification in the size so that an image does not weigh more than 0.5 MB.

It is worth mentioning that you can select different elements in the same image, as required so that our program can be detected.

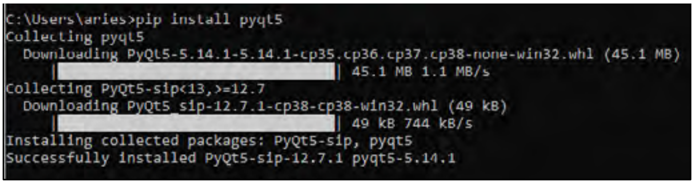
Tagged images with labelImg,

We used a program called labelImg that facilitated the labeling of our 1500 images. LabelImg is a graphical image annotation tool. It is written in Python and uses Qt for its graphical interface. The annotations are saved as XML files in PASCAL VOC format, the format used by ImageNet. In addition, it also supports the YOLO format. In this case, they will be saved in XML format.

Installation of Python libraries to be used from the console:

- Pqt5 library

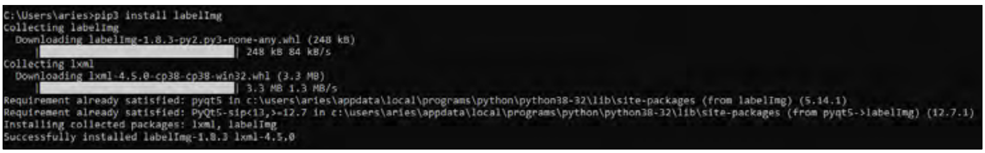
Fig. 1: *Pyqt5 installation in Python.*



Source: *Own elaboration.*

- labelImg library

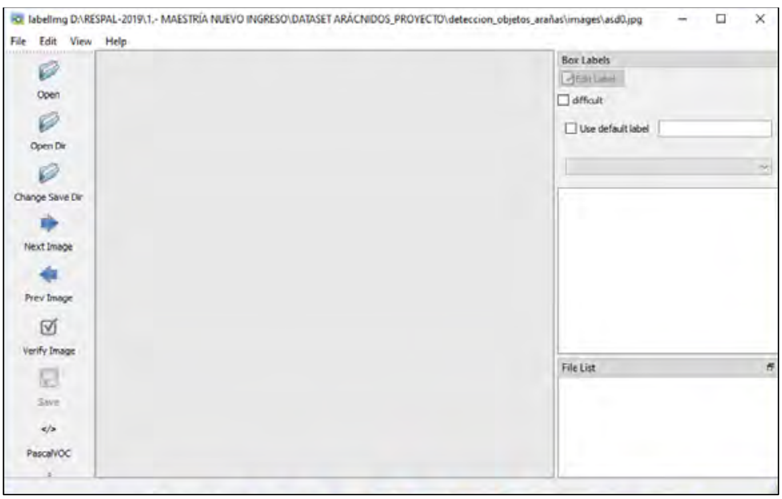
Fig. 2: Installation of labelImg in Python



Source: *Own elaboration.*

Once the libraries are installed, the labelImg tool is opened from the console to start labeling the images that make up the dataset to be used for training.

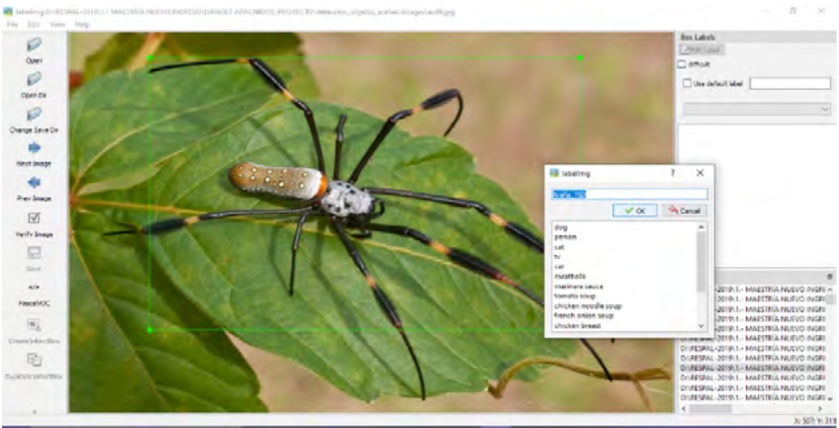
Fig. 3: LabelImg from Python.



Source: *Own elaboration.*

The folder containing the images to be used for training is selected as well as what is to be identified in order to save the region by coordinates, a label will be placed by species and according to the case (spider, spider web or spider bite).

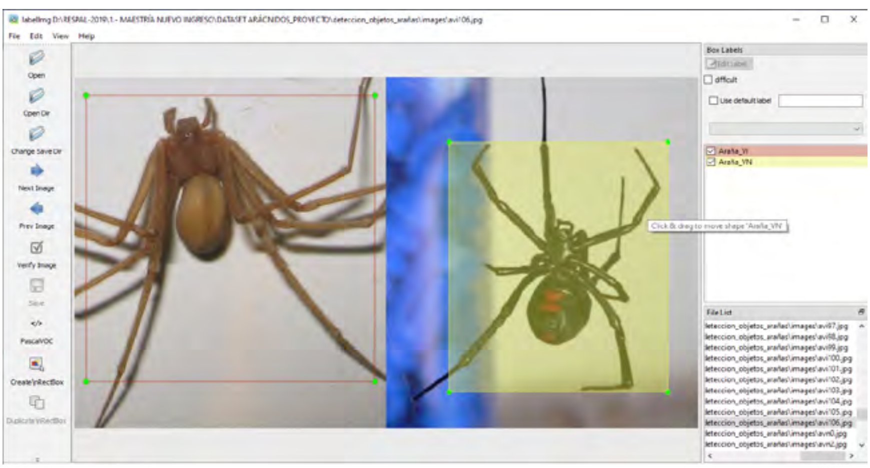
Fig. 4: Region to be labeled in an image.



Source: *Own elaboration.*

If there is more than one object to be identified in the image, they are selected and labeled with a name. If there is more than one object to be labeled in an image, then they are selected and labeled with their respective names (see Fig. 5).

Fig. 5: *Label on more than one object within the image.*



Source: *Own elaboration.*

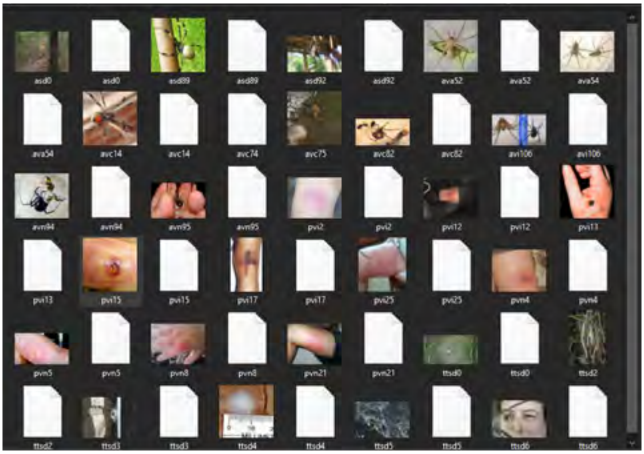
Once all the images have been tagged and saved, each one of them will generate its respective .XML with the coordinates and tags, as marked.

Fig. 6: *.XML files of the regions to select within an image to process.*

Source: *Own elaboration.*

Finally, the folder shows the .XML of both arachnids and spider webs and the bites that each one produces on the person's skin when bitten.

Fig. 7: Images of arachnids, bites and spider webs with their respective XML of the region to be detected by R-CNN.



Source: *Own elaboration.*

a) **Data preparation**

The data for training are prepared in this section, i.e. the coordinates where the required objects are detected are marked in a training set. For this purpose, a program started from the Python console is used, which performs it in a simple way and also generates an XML file with the required information. Then, the XML data is converted to TFRecord and TFrecord as these two are the image format that the algorithm needs to be able to train.

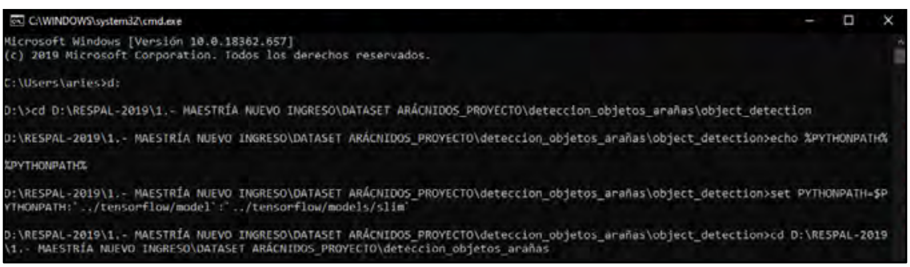
Once you have all the images with their respective XML marking their coordinates, you have to convert them to a format called TFRecord, this type of file allows the neural network in Tensor Flow to be trained, the TFRecord will contain the information of all the images and the coordinates we mark in a single file. To get them into TFRecord, we first convert all the XML into a single CSV file and then to the final CSV format.

For this, the images must be duplicated, then, we create two folders called 'img_test' and 'img_training' in the first one we put approximately 10% of our images with their respective XMLs and in the second one the remaining 90% (only the images are duplicated, that is to say, in the images folder we will still have 100% of the images).

Once we have the images in this structure in our terminal (cmd in windows), in the folder 'object-detection / object_detection' we execute the following command. (If we do not execute this command when executing the following ones, we will encounter the error that our python does not find the package 'object_detection'.

- set PYTHONPATH=$PYTHONPATH:`../tensorflow/model`:`../tensorflow/models/slim`

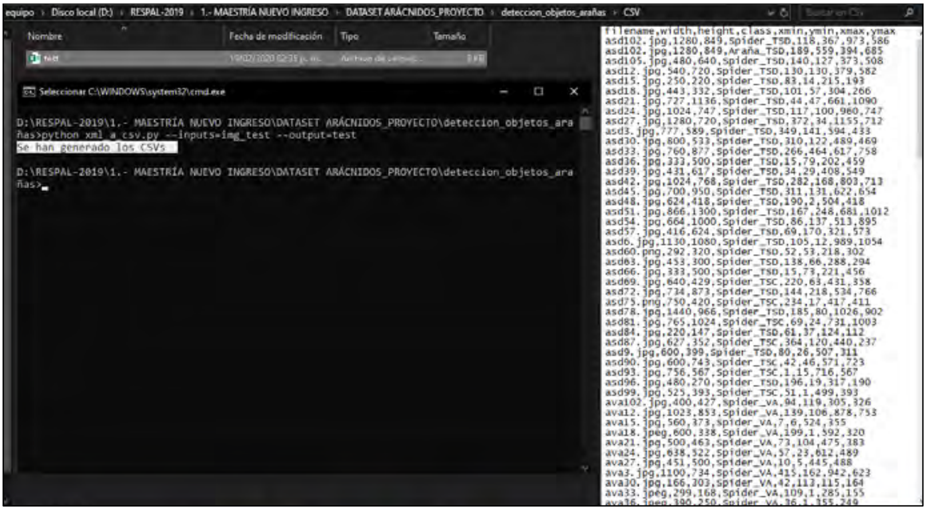
Fig. 8: Preparation of data from console.



Source: *Own elaboration.*

The conversion of all the XML files remained in a single generated CSV file (see Figs. 9 and 10).

Fig. 9: XML files to a single CSV.



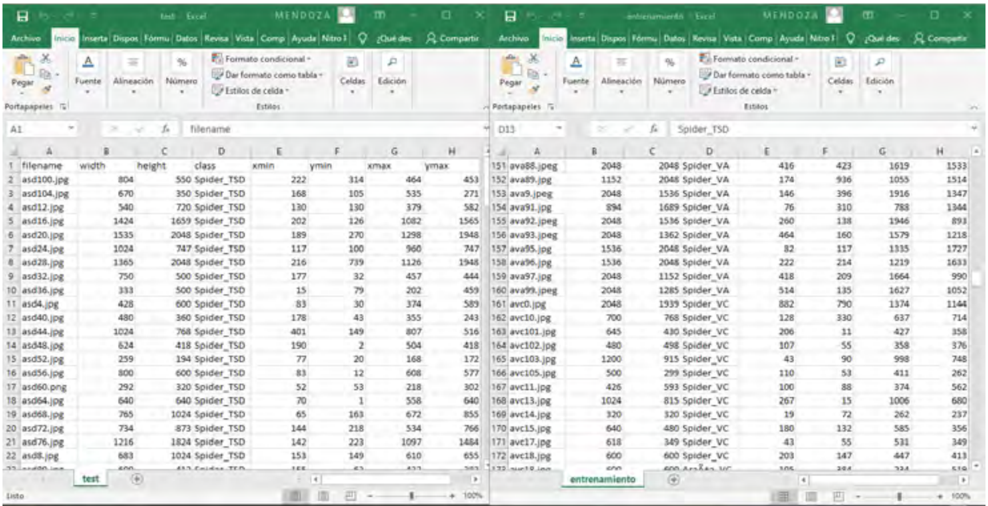
Source: *Own elaboration.*

After that, we return to the root folder of the project (spider_object_section) and execute the following four commands.

- python xml_a_csv.py --inputs=img_test --output=test
- python xml_a_csv.py --inputs=img_entrenamiento --output=entrenamiento
- python csv_a_tf.py --csv_input=CSV/test.csv --output_path=TFRecords/test.record --images=images
- python csv_a_tf.py --csv_input=CSV/entrenamiento.csv --output_path=TFRecords/entrenamiento.record --images=images

Assuming that the scripts ran without problem, a folder called TFRecords must have been created containing two files, training.record and test.record. These two files already contain the information of all the images and the coordinates of the objects that we mark.

Fig. 10: CSV of the dataset generated with the images.



	A	B	C	D	E	F	G	H
1	filename	width	height	class	xmin	ymin	xmax	ymax
2	asd100.jpg	804	550	Spider_TSD	222	314	464	453
3	asd104.jpg	670	350	Spider_TSD	168	105	535	271
4	asd12.jpg	540	720	Spider_TSD	130	130	379	582
5	asd16.jpg	1424	1659	Spider_TSD	202	126	1082	1565
6	asd20.jpg	1535	2048	Spider_TSD	189	270	1298	1948
7	asd24.jpg	1024	747	Spider_TSD	117	100	960	747
8	asd28.jpg	1365	2048	Spider_TSD	216	739	1126	1948
9	asd32.jpg	750	500	Spider_TSD	177	32	457	444
10	asd36.jpg	333	500	Spider_TSD	15	79	202	459
11	asd4.jpg	428	600	Spider_TSD	83	30	374	589
12	asd40.jpg	480	360	Spider_TSD	178	43	355	243
13	asd44.jpg	1024	768	Spider_TSD	401	149	807	516
14	asd48.jpg	624	418	Spider_TSD	190	2	504	418
15	asd52.jpg	259	194	Spider_TSD	77	20	168	172
16	asd56.jpg	800	600	Spider_TSD	83	12	608	577
17	asd60.png	292	320	Spider_TSD	52	53	218	302
18	asd64.jpg	640	640	Spider_TSD	70	1	558	640
19	asd68.jpg	765	1024	Spider_TSD	65	163	672	855
20	asd72.jpg	734	873	Spider_TSD	144	218	534	766
21	asd76.jpg	1216	1824	Spider_TSD	142	223	1097	1484
22	asd8.jpg	683	1024	Spider_TSD	153	149	610	655

	A	B	C	D	E	F	G	H
151	ava88.jpeg	2048	2048	Spider_VA	416	423	1619	1533
152	ava89.jpg	1152	2048	Spider_VA	174	936	1055	1514
153	ava9.jpeg	2048	1536	Spider_VA	146	396	1916	1347
154	ava91.jpg	894	1689	Spider_VA	76	310	788	1344
155	ava92.jpeg	2048	1536	Spider_VA	260	138	1946	891
156	ava93.jpeg	2048	1362	Spider_VA	464	160	1579	1218
157	ava95.jpg	1536	2048	Spider_VA	82	117	1335	1727
158	ava96.jpg	1536	2048	Spider_VA	222	214	1219	1633
159	ava97.jpg	2048	1152	Spider_VA	418	209	1664	990
160	ava99.jpeg	2048	1285	Spider_VA	514	135	1627	1052
161	avc0.jpg	2048	1939	Spider_VC	882	790	1374	1144
162	avc10.jpg	700	768	Spider_VC	128	330	637	714
163	avc101.jpg	645	430	Spider_VC	206	11	427	358
164	avc102.jpg	480	498	Spider_VC	107	55	358	376
165	avc103.jpg	1200	915	Spider_VC	43	90	998	748
166	avc105.jpg	500	299	Spider_VC	110	53	411	262
167	avc11.jpg	426	593	Spider_VC	100	88	374	562
168	avc13.jpg	1024	815	Spider_VC	267	15	1006	680
169	avc14.jpg	320	320	Spider_VC	19	72	262	237
170	avc15.jpg	640	480	Spider_VC	180	132	585	356
171	avc17.jpg	618	349	Spider_VC	43	55	531	349
172	avc18.jpg	600	600	Spider_VC	203	147	447	413

Source: *Own elaboration.*

With this ready, the necessary files are prepared for our training and the training of the model we want.

b) **Training**

For the data training part, 3 main points to consider were used, which are:

1) The choice of the model to be trained.

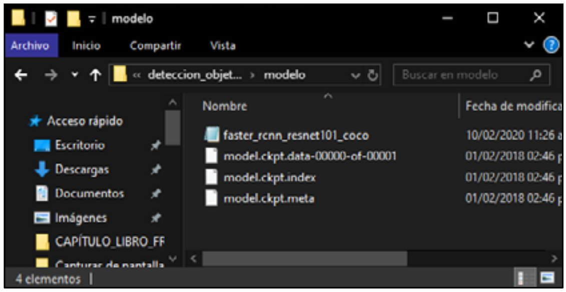
This work uses the *faster_rcnn_resnet101_coco* model, which gives us faster predictions. In turn, another file of type config that matches the model we are going to train, *faster_rcnn_resnet101_coco.config*.

But the files that interest us to train a model from scratch are:

- *faster_rcnn_resnet101_coco.config* (here is the configuration on how we will train the model).
- *Model.ckpt.index*
- *Model.ckpt.meta*
- *Model.ckpt.data-000000-of-00001*

Let's take the files with the format '.ckpt' as well as the .config, they must be transferred to the folder called model 'within our project.

Fig. 11: Main files for model training.



Source: *Own elaboration.*

2) Prepare the files for training

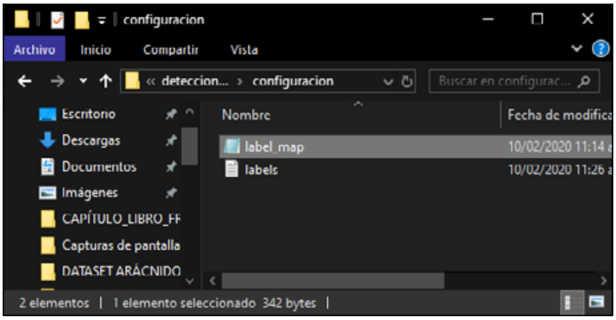
- Model configuration (have approximately 1500 images that are made up of 5 types of species; spiders, cobwebs and bites).
- Training labels.
- Computational graph of the model.

Once the model to be trained is chosen, it is time to prepare some configuration files, these files will indicate to our training script, where to find the model, where to find the images to train, which are the labels that we are going to use (the objects that we want to train) among other parameters. These files are located in the folder called 'configuration'.

i. Tags (label_map.pbtxt)

The (configuration / label_map.pbtxt) file will tell our algorithm which are the labels on which we are going to train it. The name that we put to the labels must be the same that we use in the labelImg tool (including capital letters and spaces). Basically, this file has a series of 'item' elements with their respective identifier 'id' and class name 'name'.

Fig. 12: File containing the tags in the images.

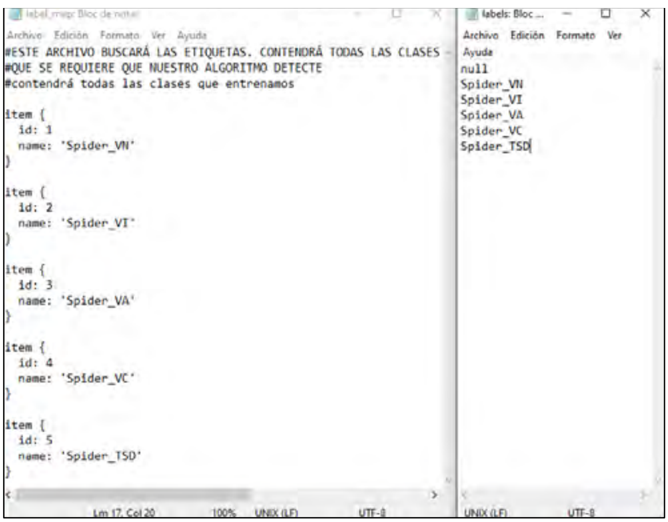


Source: *Own elaboration.*

ii. Labels.txt

This file is similar to the past but much simpler, it is only a list of the elements we want to detect, being the first element (in the first line) always the null value.

Fig. 13: Label label.map and labels.txt.



Source: *Own elaboration.*

iii. Training settings (faster_rcnn_resnet101_coco.config)

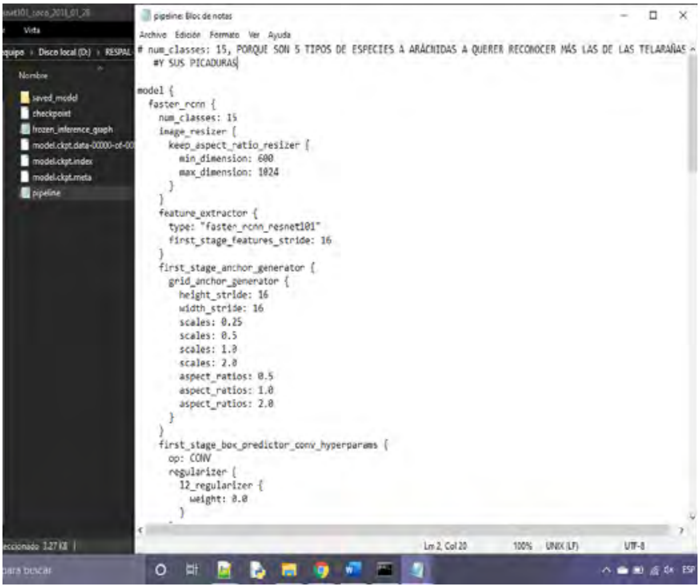
All the edited files have a degree of importance, but the most important is this one. This is the file that we must have in the 'model' folder.

This file is the one that our training script will read to know extremely important parameters, such as:

- Where to get the tfrecords.
- Where to get the label_map.pbtxt tag files
- Where to find the required files of our model (the checkpoints that appear as .ckpt).
- The number of steps to train.
- Batch_size (Number of images that we will train in each iteration, we can start with a low number like 1 and upload it if we see that our computer supports it)

To change these parameters, we must open the pipeline.config file and change all the fields that say 'path_to_be_configured'.

Fig. 14: *File that contains all the training settings that will be made to the images.*



Source: *Own elaboration.*

3) Training the model.

Finally, we start training our algorithm in only 60 epochs. Having everything ready, the training will be simple, just run the following command in our terminal and wait for the results.

- python object_detection/train.py --logtostderr --train_dir=train --pipeline_config_path=modelo/faster_rcnn_resnet101_coco.config

If everything went well, something similar to this should appear in the terminal:

Table 1: Training results of the Faster R-CNN algorithm from Python.

Paso global: 23070	0%	acc: 0.9531	pérdida: 1.5081	7369.4 muestra/segundo
Paso global: 23080	3%	acc: 0.9453	pérdida: 1.5159	7511.6 muestra /segundo
Paso global: 23090	5%	acc: 0.9844	pérdida: 1.4764	7154.6 muestra/segundo
Paso global: 23100	8%	acc: 0.9297	pérdida: 1.5307	7204.4 muestra/segundo
Paso global: 23110	10%	acc: 0.9141	pérdida: 1.5462	7091.4 muestra/segundo
Paso global: 23120	13%	acc: 0.9272	pérdida: 1.5314	7162.9 muestra/segundo
Paso global: 23130	15%	acc: 0.9297	pérdida: 1.5307	7174.8 muestra/segundo
Paso global: 23140	18%	acc: 0.9375	pérdida: 1.5231	7140.0 muestra/segundo
Paso global: 23150	20%	acc: 0.9297	pérdida: 1.5301	7152.8 muestra/segundo
Paso global: 23160	23%	acc: 0.9531	pérdida: 1.5080	7112.3 muestra/segundo
Paso global: 23170	26%	acc: 0.9609	pérdida: 1.5000	7154.0 muestra/segundo
Paso global: 23180	28%	acc: 0.9531	pérdida: 1.5074	6862.2 muestra/segundo
Paso global: 23190	31%	acc: 0.9609	pérdida: 1.4993	7134.5 muestra/segundo
Paso global: 23200	33%	acc: 0.9609	pérdida: 1.4995	7166.0 muestra/segundo
Paso global: 23210	36%	acc: 0.9375	pérdida: 1.5231	7116.7 muestra/segundo
Paso global: 23220	38%	acc: 0.9453	pérdida: 1.5153	7434.1 muestra/segundo
Paso global: 23230	41%	acc: 0.9375	pérdida: 1.5233	7074.5 muestra/segundo
Paso global: 23240	43%	acc: 0.9219	pérdida: 1.5387	7176.9 muestra/segundo
Paso global: 23250	46%	acc: 0.8828	pérdida: 1.5769	7544.1 muestra/segundo
Paso global: 23260	49%	acc: 0.8219	pérdida: 1.5383	7959.7 muestra/segundo
Paso global: 23270	51%	acc: 0.8984	pérdida: 1.5618	6638.6 muestra/segundo
Paso global: 23280	54%	acc: 0.9453	pérdida: 1.5151	7035.7 muestra/segundo
Paso global: 23290	56%	acc: 0.9609	pérdida: 1.4996	7129.0 muestra/segundo
Paso global: 23300	59%	acc: 0.9609	pérdida: 1.4997	7075.4 muestra/segundo
Paso global: 23310	61%	acc: 0.8750	pérdida: 1.5842	7117.8 muestra/segundo
Paso global: 23320	64%	acc: 0.9141	pérdida: 1.5463	7157.2 muestra/segundo
Paso global: 23330	66%	acc: 0.9062	pérdida: 1.5549	7169.3 muestra/segundo
Paso global: 23340	69%	acc: 0.9219	pérdida: 1.5389	7164.4 muestra/segundo
Paso global: 23350	72%	acc: 0.9609	pérdida: 1.5002	7135.4 muestra/segundo

Paso global: 23360	74%	acc: 0.9766	pérdida: 1.4842	7124.2 muestra/segundo
Paso global: 23370	77%	acc: 0.9375	pérdida: 1.5231	7168.5 muestra/segundo
Paso global: 23380	79%	acc: 0.8906	pérdida: 1.5695	7175.2 muestra/segundo
Paso global: 23390	82%	acc: 0.9375	pérdida: 1.5225	7132.1 muestra/segundo
Paso global: 23400	84%	acc: 0.9844	pérdida: 1.4768	7100.1 muestra/segundo
Paso global: 23410	87%	acc: 0.9766	pérdida: 1.4840	7172.0 muestra/segundo
Paso global: 23420	90%	acc: 0.9062	pérdida: 1.5542	7122.1 muestra/segundo
Paso global: 23430	92%	acc: 0.9297	pérdida: 1.5313	7145.3 muestra/segundo
Paso global: 23440	95%	acc: 0.9297	pérdida: 1.5301	7133.3 muestra/segundo
Paso global: 23450	97%	acc: 0.9375	pérdida: 1.5231	7135.7 muestra/segundo
Paso global: 23460	100%	acc: 0.9881	pérdida: 1.5362	7341.5 muestra/segundo

Source: *Own elaboration.*

A low "loss" is what is desired, at least below 1.5, since upon reaching this number, we can complete the training by typing CTRL + C from the terminal.

As can be seen in Table 1, for the first epoch, the accuracy was 95.31 %, but upon completion of the sixty rounds in a second run, it reached a m of 98.81 %. Therefore, the network in only 60 epochs showed favorable results.

CNN Evaluation

Once the network is trained, the evaluation phase is next. For this, the network is instructed to classify test.record, and the classification performed by the CNN is compared with training.record (actual classifications) and thus visualize the degree of success of the network.

model.evaluate(test.record, entrenamiento.record)
10000/10000 [===================] - 1s 109us/step
[0.5471649462819099, 0.8912]

That is, an accuracy of 89.12%, which is not bad at all.

c) **Freeze the trained model**

Once the training is finished, a folder called 'train' that will have several checkpoints (that will serve in the future if we want to retrain what we have already done) will be created along with a graph.pbtxt. These files are the ones that contain the necessary information to be able to make predictions in the future, but the model must be 'frozen', that is, we will convert our ckeckpoints into a final model.

To do this, only one command has to be executed, the STEP_NUMBER part must be changed to the last checkpoint we have generated, i.e. the highest value.

- python object_detection/export_inference_graph.py --input_type image_tensor --pipeline_config_path modelo/faster_rcnn_resnet101_coco.config --trained_checkpoint_prefix train/model.ckpt-684 --output_directory modelo_congelado

After running this successfully, we will have a file in a folder named 'frozen_model', this is our file ready to generate predictions.

d) **Prediction**

Finally, images are provided to the program to detect the objects in it. Now it is time to generate the predictions. To do this you have to put the images in which we want to generate the object detection in the folder called 'img_tests' and execute the following command, the result will be obtained in a new folder called output.

- python object_detection/object_detection_runner.py

Training time

The following Table 2 shows the time spent training the net in the 60 epochs:

Table 2: Network training time results

Device	Batch size	Time	Accuracy [%]
NVIDIA GeForce 840M	128	8m 4s	89,12
Intel i5 4210U	128	3hrs 30min	78,91

Source: *Own elaboration.*

Convolutional neural networks are a deep learning technique for current visual recognition tasks. As all deep learning techniques, convolutional neural networks are highly dependent on the size and quality of the training data (images).

Therefore, it can be concluded that, with a well-prepared dataset, convolutional neural networks are capable of outperforming humans in visual recognition tasks.

Conclusions and future research

Industry 4.0 is an area of great entrepreneurship, where technologies are used to promote new models. Industry 4.0 is a space of new opportunities, creativity and innovation. Specifically, Ambient Intelligence disseminates the design and development of appreciable, transparent and intelligent technologies, without leaving aside a humanistic orientation to help us in our daily tasks and thus facilitate, simplify, improve and enhance our interactions with the environment, preventing us from performing routine tasks. Comparing the work presented and the state of the art, acceptable results were obtained, although these results could be improved using different architectures if desired.

One of the main objectives of this work was the recognition of arachnid bites, at this point we have seen the high performance offered by the algorithm, with a capacity percentage of 89.12% on the detected elements.

We have evidenced the importance of the example images used by the algorithm and how it is essential to have a good number of them with all the elements that we subsequently want to detect, since they will serve for the system to make the best choice (the most probable state in terms of Deep Learning) before an unknown image. Therefore, the use of a good set of images (with a large number of images and elements) for training is a fundamental factor for conferring high performance to the algorithm. It is worth mentioning that in this aspect, the greater the number of images, the higher the computational cost and, therefore, the time used for identification, so the size of the set of samples used must allow a high degree of success without producing a loss in execution time, since the balance between accuracy and speed depends on the number of images processed in the training stage of the algorithm. Therefore, it is intended that all the training that was done with the neural network for the recognition of objects in the images is adapted to an intelligent application that is able to recognize through images in real time an accident caused by an arachnid and, in turn, this application may generate recommendations to the patient of a specialty center near the region.

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CHAPTER 14

Implementation of a Convolutional Neural Network for the Detection of Avian Pests in Citrus Using Smart Drone

Antonio Romero[1], Eddy Sánchez-De la Cruz[1], Alberto Ochoa*[2]

[1] *Tecnológico Nacional de México Campus Misantla,*
[2] *Universidad Autónoma de Ciudad Juárez*
* *Corresponding Author: alberto.ochoa@uacj.mx*

Abstract. The focus of this work is to implement an intelligent drone that replaces direct visual inspection in order to reduce future damage in citrus production generated by pests, where the use of a convolutional neural network will serve to detect the coloration of the leaves that present diseases derived from bird pests, as well as their location within the image and thus improve the activities involved in the cultivation of citrus. This will reduce the effect of bird pests, which significantly reduce productivity in the agricultural sector annually. Therefore, through the implementation of unmanned aerial vehicles, we can provide visual recognition and avoid the indirect effects generated by the type of pests and with this, migrate the detection of birds to a mobile application in order to provide greater control of crops and optimize agricultural tasks in citriculture. The use of drones in agriculture presents great benefits that currently in Industry 4. 0 serve for the digitization of spaces, shortening inspection times in places that are difficult to access, as well as reducing the risk of accidents by replacing operators with drones. In this manner, labor-intensive tasks in agricultural and industrial environments are automated.

Keywords: Smart drone, Citriculture, Bird pests, Neural Network.

Introduction

The main problems faced by farmers are plant pests that affect a large part of the crops and cause significant losses and threaten food security, as well as economic problems for the farmer. Currently, the technique used to detect bird attacks on crops is direct visual inspection, a traditional method of control in the fields that consists of personally supervising the planting visually. Having to go to the area of interest, this method is slow and is not applicable to large areas of land (Bokolonga et al., 2016). Nevertheless, there are other methods that provide efficiency, but at a higher cost, such as by aerial means. Nonetheless, an airplane cannot be optimal for monitoring crops with problems of this type, in this way, drone technology offers a solution to the problems or difficulties that currently exist for a farmer, since they allow to extend the inspections in a more extensive and complete way, thus achieving an aid to the work in the agricultural sector. In addition, manual work is reduced with the implementation of this collaboration, as it benefits the activities in the field since the UAV becomes the eyes of the citrus and facilitates this task, which with the help of the cameras captures images in which they show if the crop presents pests as well as show the state of the plantation and improve crop control techniques (Vatalaro et al. , 2016). On the other hand, there are a variety of artificial intelligence techniques that can be implemented and that could help improve the agricultural sector. We worked with a neural network, which will be trained with images of bird crops to achieve greater accuracy in the detection of pests and that after this, it is intended to migrate this detection work to a mobile application for greater control and also allow better management (De Rango et al., 2019).

Object detection with Tensorflow

It is important to differentiate between an object classifier and an object detector, an image classifier is an algorithm that is responsible for classifying images within a specific category. For example, an image of a pest crop was assigned and it only mentions that the predominant object in the photo is a particular bird, while an object detector is an algorithm that is responsible for detecting various elements within an image and classifying them for example, it is given an image containing a citrus crop and it identifies that there is a pest, a bird, a tree, etc. in the image.

1. Development

To achieve the detection of objects, in this case the detection of birds in the field, it was important to divide the project into 4 main steps, which will be explained below to determine the series of steps that were followed to obtain the detection (see Figure 1).

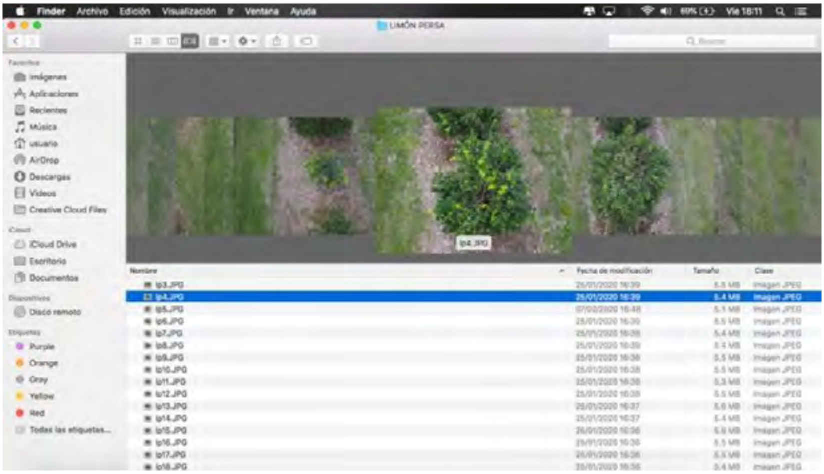
Figure 1: *Application interface that shows the height of the drone.*

Source: *Own elaboration.*

Step 1: Obtain the images.

The images (in JPG format) were obtained by a DJI Mavic mini drone, at a height between 6 and 12 meters high in Persian lemon and Valencia late orange crops (see figure 1), are sectioned and stored in folders depending on the species, which are named in the form of acronyms. For example, Persian lemon as "lp" followed by the image number and so on for each and every image obtained, in the same way for the images of the other citrus fruits (see figure 2). Therefore, it is important for the project to save it in JPG format for the labeling step.

Figure 2: *Figure: Images sectioned and stored in folders according to the citrus species.*



Source: *Own elaboration.*

Step 2: Labeling the images.

For the second step, in which the images obtained by the drone must be labeled, LabelImg, a graphical image annotation tool was used, written in the Python programming language using Qt for its graphical interface, where the Annotations are saved as XML files in PASCAL VOC format, the format used by ImageNet (Tzutalin, 2017). In addition, you should keep in mind that to avoid possible problems, make sure that the images are saved in JPG format.

In this case, a Python 3.5.5 virtual environment was used and to compile a laptop with macOS High Sierra was used. First, the installation or update of libraries and packages is required (see Figure 2) where the required elements are shown for the detection to be carried out.

Figure 3: *Items to install on the MacOS terminal.*

Python 3 + Qt5 (Recommended)

```
brew install qt  # Install qt-5.x.x by Homebrew
brew install libxml2

or using pip

pip3 install pyqt5 lxml # Install qt and lxml by pip

make qt5py3
python3 labelImg.py
python3 labelImg.py [IMAGE_PATH] [PRE-DEFINED CLASS FILE]
```

Source: *Own elaboration.*

Figure 4: *Items installed and ready to open the LabelImg tool.*

```
usuario — python3 ~/env/bin/labelImg — 103×14
Last login: Fri Feb 14 17:57:39 on ttys000
(base) Usuarios-MBP-3:~ AntonioRomero$ python3 -m venv --system-site-packages env
(base) Usuarios-MBP-3:~ AntonioRomero$ source env/bin/activate
(env) (base) Usuarios-MBP-3:~ AntonioRomero$ pip install -U pip
Requirement already up-to-date: pip in ./env/lib/python3.7/site-packages (20.0.2)
(env) (base) Usuarios-MBP-3:~ AntonioRomero$ pip install labelImg
Requirement already satisfied: labelImg in ./env/lib/python3.7/site-packages (1.8.3)
Requirement already satisfied: pyqt5 in /anaconda3/lib/python3.7/site-packages (from labelImg) (5.14.1)
Requirement already satisfied: lxml in /anaconda3/lib/python3.7/site-packages (from labelImg) (4.2.5)
Requirement already satisfied: PyQt5-sip<13,>=12.7 in /anaconda3/lib/python3.7/site-packages (from pyqt
5->labelImg) (12.7.1)
(env) (base) Usuarios-MBP-3:~ AntonioRomero$ labelImg
Invalid locale
```

Source: *Own elaboration.*

The first step is shown in Figure 3, once the above commands are installed, the terminal will look more or less as in Figure 4.

After the above steps, LabelImg runs python labelimg.py, and after that an interface like the following will open (see Figure 5).

Figure 5: Start interface of the LabelImg tool.

Source: Own elaboration.

Now it is possible to proceed to label the images. The Open Dir function is very useful since we have all our images in one folder. The Change Save Dir function can also be used to keep all my output in one place. Also make sure your save format is PscalVOC (Zientara et al., 2018).

Figure 6: Labeling of the images obtained by the drone.

Source: Own elaboration.

In the labeling step, the aim was to identify the images to determine which of them had pests and thereby be able to train the network with all the images obtained (see Figure 6). For the repair of the data in the training, i.e., to mark in a training set the coordinates where the objects to be detected are located. It uses a program that helps to do this easily and provides an XML file with the information required.

Convert XML data to TFRrecord.TFrecord is the image format needed by the algorithm to be able to perform the training, the model to be trained must be chosen, the files for training must be prepared, the model configuration and the training tags that refer to the type of pest, in this case birds (Cienciacinetica, 2019). The preparation of the data is the first thing to predict, since before starting it is necessary to prepare the data with which the program will be trained. To do this, it is necessary to have the images provided by the drone, at least 200 images for each of the objects we want to detect. At the time of labeling the images, the program is set in which the coordinates of the images can find each of the objects that are intended to detect, this can be a somewhat tedious task, but we used a tool that facilitated its realization which is LabelImg (Huuskonen & Oksanen, 2018).

It is important to have a varied set of data, i.e., possessing the objects to be detected from various angles, types of illumination, positions, etc.Likewise, it is also important that the images are not large because they can be a lot for the computer to handle, so it is recommended that a size modification be made so that an image weighs no more than 5.4 MB. Basically, what is done with this program in general is to open an image, select a box to mark the object that the program wants to learn to detect and generate an XML with the information of the coordinates where the position of that object is located (Di Luca et al., 2020).

The implementation of the artificial vision system allows to increase that more farmers have a higher level of information about pests and diseases of citrus crops. In addition to having greater security in the supply of agrochemicals. After the study, it was concluded that the implementation of the artificial vision system as a pest and disease identifier showed a decrease in the average time taken by a farmer to perform the identification process.In addition, the mobile application helped the farmer not take long to find out the necessary information about pests, diseases and agrochemicals, showing that with the application it can be achieved in approximately 4 seconds. Thus, allowing citrus growers to have a complementary tool that performs the same process carried out by an expert, which helps the farmer's budget not to increase, concluding that the system is cost-effective.

Step 3: Convert the images to TFRecord,

Once you have all the images with their respective XML marking their coordinates, they must be converted to a format called TFRecord, this type of file is special so that the neural network in Tensor Flow can be trained, the TFRecord will contain the information of all the images and the coordinates that were marked in a single file. In order to take them to TFRecord, all XMLs are first converted into a single CSV file, then these CSVs are already converted to the final format (Jin et al., 2018).

Assuming that the scripts ran without problem what should now be a folder called TFRecords in which there will be two files, training.record and test.record These two files already contain the information of all the images and the coordinates of the objects that have been marked. With this ready you will proceed to prepare the necessary files for the training of the desired model (Rokade & Doye, 2015).

Step 4: Prediction

The final step, now is the time to generate predictions. For this you just have to place the images in which you want to generate object detection in the folder called 'img_tests' and we will run the following command "python object_detection / object_detection_runner.py", the result will be obtained in a new folder called output.

Conclusions and future research

The increase in citrus productivity in crops represents an increase in profits in the economic system, which will cause an improvement in the economy of citriculture since with the implemented technology it will be possible, to have a tool capable of reducing pest attacks and, at the same time, optimize the monitoring process of farmers. In addition, this research represents how the implementation of drones as intelligent systems, is a great innovation in the agricultural sector and now, it is a reality to say that this sector will also innovate with the use of this technology, which will benefit not only the productivity and stability in the agricultural sector, but also the economy of farmers and citrus workers. Drones are of great help to agribusiness since they are capable of checking the field, digitizing results, monitoring crops and analyzing the terrain for good planting and optimal precision agriculture, to mention the competitive advantages that a drone can offer to agribusiness and field care. Thus, this sector is digitized to move to a renewal in which there will be a better control of the harvest.

Nonetheless, although drones can offer a useful service, there is a continuous evolution for its application in agriculture. For the service to be convenient, it is necessary that the information they provide is increasingly easier to collect depending on the area or type of terrain in which it is implemented. Drones are one of the tools with the greatest future projection in prevention and protection of natural resources and precision agriculture. With the use of drones it is possible to fly over the crops quickly and capture effective information for those who manage the production, and with only an unmanned aircraft it is possible to monitor hectares with precision, which allows to evaluate, in general terms, the state of the sowing, this includes aspects such as hydration, temperature, growth rate, premature location of diseases, attack of avian pests, etc.

The task of predicting what an image symbolizes is called image classification. An image classification model is trained to recognize various types of images. An example of this is the model worked with above that has been trained to recognize images of citrus crops. Thus, when a new image is provided as input to the model, the model will generate probabilities that the image represents each of the crop types for which it was trained. In addition, during training, an image classification model receives images and their associated labels, where each label is the name of a different concept or class, which the model will learn to recognize with enough training data, often hundreds or thousands of images per label, an image classification model can learn to predict whether new images belong to one of the classes it was trained on to which this prediction process is called inference. On the other hand, drones are not new, as they have been implemented for some time in reconnaissance and search tasks, these are part of the growing trend of precision agriculture and although this technology is not new, it should be implemented in different sectors. In addition, one of the main recommendations or rather future work raised in this research work is the migration of pest detection to a mobile application to provide more optimal access and management.

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CHAPTER 15

Study to Determine the Relationship Between Clinical Variables Associated with Infection and Death from Rickettsiosis in Mexicali, Baja California, Mexico

Ana Dolores Martínez Molina*[1], Rafael Villa Angulo[1], Javier Molina Salazar[2], Teresa Franco Esquivel[3]

[1]*Universidad Autónoma de Baja California, Mexicali, B. C., México*

[2]*Universidad Autónoma de Ciudad Juárez, Ci udad Juárez, Chihuahua, México*

[3]*Secretaría de salud del estado de Baja California, Mexicali, B. C., México*

* *Corresponding Author: ana.dolores.martinez.molina@uabc.edu.mx*

Abstract. Worldwide, ticks are the second most common vector (after mosquitoes) in the transmission of infectious diseases to humans. In particular, the brown tick (Rhipicephalus sanguineus), found in several areas of Mexico, often takes the human body as an accidental host during its life cycle, causing serious public health problems. This is why health personnel should be familiar with the risk factors, signs and symptoms of tick-borne Rickettsiosis. Much of the complexity in mitigating Rickettsial infection because it can be difficult to diagnose since the symptoms are similar to those of other pathologies. At present, a timely and appropriate diagnosis depends largely on the clinical expertise of the primary care physician. On the other hand, Industry 4.0 and its main information and communication technologies are completely changing the world of services and production and it is to be expected that it will also affect the healthcare field. The internet of things, smart factory design, the use of Artificial Neural Networks (ANNs), health information systems, artificial intelligence, cloud computing and big Data, to mention a few, are increasingly enabling the digital transformation of medicine and healthcare, moving it towards Healthcare 4.0. The present research aims to provide new insights to enable early detection and prevention of deaths due to Rickettsiosis infection. A regression analysis was performed using the open source software R-studio on 1883 patients and the symptoms by which they were declared with possible Rickettsiosis in the municipality of Mexicali, Baja California, Mexico from 2014 to 2018. This study suggests a series of variables associated with both the acquisition of Rickettsiosis and death from the infection.

Keywords: Linear regression, R-studio, Healthcare, disease diagnosis, Rickettsiosis

Introduction

According to (Montesino Soraca et al., 2020), Industry 4.0 has its origin as a strategy that seeks the development of technology in the industrial sector, cost reduction and streamlining of internal processes while preserving their high quality. In this sense, medical care would benefit significantly from the implementation and integration of Industry 4.0 concepts and technologies, allowing, among other things, to provide better care to people and treat diseases in an optimal, fast and timely manner by creating efficient models for the diagnosis of diseases (Aceto et al., 2020; Montesino Soraca et al., 2020; Santacruz Fernández et al., 2019). Montesino Soraca et al. (2020), also highlights some applications and technologies of Industry 4.0 in the healthcare sector such as: Internet of Things, Smart Factories, ANN, Health Information Systems, Artificial Intelligence, Big Data, Cloud Computing and Augmented and Virtual Reality, to mention a few.

Furthermore, the application of artificial intelligence techniques, such as regression techniques, have been used in research (Blanton, 2019; Gerardi et al., 2019; Tena et al., 2018; Yaglom et al., 2018) to obtain relevant information on infectious diseases that represent a public health problem, such as vector-borne diseases (VBD). VBD represent more than 17% of all infectious diseases and cause more than 700,000 deaths per year worldwide (Who, 2017). The distribution of vector-borne diseases is determined by demographic, environmental and social factors (Who, 2017). Globally, ticks are the second most important vector, after mosquitoes, in the transmission of infectious diseases to humans (Chisu et al., 2018; Klein et al., 2017; Parola and Paddock, 2018)(Chisu et al., 2018; Klein et al., 2019; Parola & Paddock, 2018)[4]–[6]. All particular species and biotypes of ticks favor certain environmental conditions to determine their geographical distribution and, consequently, areas of risk for diseases transmitted by them (Almazan et al., 2016; Chisu et al., 2018; Parola and Paddock, 2018). The genus Rickettsia consists of different species of gram-negative bacteria and is framed within the Rickettsiaceae faimly. All species of the genus are intracellular parasites and are the cause of several epidemics worldwide (Bernabeu and Segura, 2005; Santamaría et al., 2018; Montenegro et al., 2017). The global impact of diseases caused by these microorganisms remains considerable due to their high prevalence and morbidity (Bernabeu and Segura, 2005; Casal et al., 2019; CDC, 2016; Tomassone et al.,). Although Rickettsia is considered a rural disease, it is increasingly common in urban areas (Bernabeu and Segura, 2005). During its life cycle, rickettsia infects several hosts, mostly mammals and vectors such as ticks and fleas. The most lethal of the febrile diseases is known as the Rocky Mountain Spotted Fever (RMSF) caused by Rickettsia Rikettsii (Parola and Paddock, 2018), in addition to this disease there are endemic typhus caused by Rickettsia typhi and epidemic typhus caused by Rickettsia prowazekii, all transmitted through vectors such as lice (R. prowazekii), ticks (R. rickettsii) and fleas (R. typhi) (Luce, 2015; Santamaria et al., 2018). Rickettsia rickettsii, R. prowazekii and R. typhi have been reported in Mexico, especially the brown tick (Rhipicephalus sanguineus) has been seen in several areas of the country (Escarcega et al., 2018) and during its cycle takes humans as an accidental host, causing serious public health problems. To date, they continue to cause serious problems and death in otherwise healthy adults and children, despite the availability of effective antibacterial therapy (CDC, 2016). Early recognition in the clinical course is critical as this is the period when antibacterial therapy is most effective. Early signs and symptoms of these diseases are nonspecific or resemble those of other diseases, which can hinder diagnosis, which becomes erroneous in most cases at the patient's first visit for medical care, even in areas where awareness of RMSF is high (Alvarez et al., 2017; Blanton, 2018; Buckingham et al., 2007; CDC, 2016; Souza et al., 2014) To increase the likelihood of early and accurate diagnosis, health care providers should be familiar with the risk factors, signs, and symptoms consistent with tick-borne rickettsial diseases (Blanton, 2018; Buckingham et al., 2007). In these cases, timely clinical diagnosis, careful evaluation of the epidemiological aspects of the disease, and appropriate patient care are determining factors in reducing the mortality rate (Oliveira et al, 2018; Traeger et al.,2015). Much of the complexity in mitigating Rickettsia infection is due to the diseases caused by this bacterium can be difficult to diagnose, as symptoms are common among other pathologies (Alvarez et al.,2017; CDC, 2016; Santamaria et al., 2018). RMSF, caused by Rickettsia rickettsii represents a health problem along the US-Mexico border as the incidence is higher in several northern Mexican states (Álvarez et al., 2017; Blanton, 2018; Casal et al., 2019; Escárcega et al., 2018; Sosa et al., 2016). Diagnosis is performed by serological tests specific for the Rickettsia group, which represents a challenge especially in disease endemic areas due to the occurrence of high levels of baseline antibodies (Kiran and Narang, 2018; Paris and Dumler, 2016; Paris et al., 2016). The most commonly used serological tests in the diagnosis of Rickettsiosis are the Polymerase Chain Reaction (PCR) which is widely used for its great versatility as an analysis technique in infectious diseases through molecular epidemiological studies (CDC, 2016; Ines et al., 2017; Gerardi et al., 2019; Montenegro et al., 2017). Likewise, there is also the Indirect Immunofluorescence (IIF) study, in which antibodies are detected between 7 and 10 days after the onset of the disease (Gerardi et al., 2019; Santamaría et al, 2018), which represents a risk for the patient since this disease can have severe clinical results and even become fatal in eight days if not treated in a timely manner (Casal et al., 2019; Traeger et al., 2015). The objective of this research is to find through the application of regression techniques, the relationship between the clinical variables that occur in patients diagnosed with Rickettsiosis, as well as the relationship of these with the evolution of the disease, i.e., whether it evolves favorably or dies; and to be able to contribute with new knowledge to improve the timely diagnosis of the disease in primary health care. That is, at the patient's first appointment with the physician.

This study was conducted in the municipality of Mexicali, Baja California, Mexico; a region with a high incidence of the disease since the first reported case in 2009 (Foley et al., 2019). Mexicali has a population of 1,059,896 inhabitants, distributed in 1650 localities of which 19 are considered urban and 1,631 are rural; 10 out of every 100 inhabitants of the municipality live in the latter (COPLADE, 2018). The climate of this region is categorized as very dry semi-warm registering temperatures of up to 50° Celsius in the months of July and August (INEGI, 2018). High temperatures with low humidity are recorded during most of the year (May-November) which is favorable for the increase of the brown tick population (Dantas,2010; Parola et al., 2008).

Methodology

To carry out this analysis, we worked with data obtained from 2014 to 2018 from patients in the municipality of Mexicali, Mexico, documented by the Department of Jurisdictional Epidemiology of the Ministry of Health of the State of Baja California. These patients initially presented symptoms of Rickettsiosis and, after the corresponding tests, they were ruled as positive or negative. The municipality of Mexicali is where most cases of Rickettsiosis have been registered in the state.The information was collected from different sources such as: epidemiological studies carried out by health institutions to study the prevalence of Rickettsiosis in the municipality of Mexicali and records of confirmed cases of Rickettsiosis.

In the case of epidemiological studies, the information included: patient identification data, notifying health unit, epidemiological data, clinical picture presented in each case, evolution in the hospital, results of laboratory studies, treatment and observations. Each case file examined had the format for immediate notification of probable cases of Rickettsiosis, specifically of RMSF. This form contains: patient identification data, hospitalization, risk factors such as overcrowding, garbage dump, dirty yard, unsafe housing, dirt floor and noxious fauna found in the patient's home, possible sources of exposure, chronological description of the symptoms presented, habits, contact with noxious fauna, consumption of drugs and/or alcohol, other diseases, first contact with health services, diagnosis and treatment. In addition to these data, the epidemiological study of cases of vector-borne diseases carried out by health institutions, laboratory tests confirming Rickettsiosis as a case and the concentrate of activities carried out by the health brigades, 5 blocks were integrated around the domicile of the reported case.

Two data sets were obtained from these sources: the first contains data on cases reported as probable (unconfirmed) cases of Rickettsiosis, which contains 1593 cases (rows) and 84 variables (columns). Some irrelevant variables for this study were eliminated, such as the personal data of the patients, among others; leaving 42 variables. Of these, 4 correspond to patient data, 26 to symptoms presented and 12 to variables with hospitalization data and laboratory tests. The second set of data was obtained from the information extracted from the personal files, compiled by the epidemiology department, of confirmed cases of Rickettsiosis. This set contains 290 cases (rows) and 72 variables (columns) of which: 4 correspond to patient data, 32 to symptoms presented, 14 correspond to risk factors found, 22 to data such as diagnosis in primary care, hospitalization data and results of laboratory tests performed. Both data sets are in digital format with Excel format. We worked with both files transforming the qualitative data into numerical data of those variables that we would use for the first statistical analysis.

Data mining with Principal Component Analysis

The Principal Component Analysis (PCA) technique was used to study the structure of the information in search of numerical patterns that generate a differentiation between the data. The central concept of PCA is to reduce the dimensionality of a data set, which consists of a large number of interrelated variables, while preserving as much of the variation present in the data set as possible. This is achieved by transforming a new set of variables, called principal components (PC), uncorrelated and ordered in such a way that the former retain the largest variation present in all the original variables. Formally, PCA is defined as an orthogonal linear transformation, which transforms the data into a new coordinate system such that the largest variance of any projection of the data is in the first coordinate (called the first principal component), the second largest variance in the second coordinate, and so on. In theory, the PCA is the optimal transformation for a given data set, in terms of least squares. The procedure for obtaining the main components can be summarized as follows: given a vector X^T of n dimensions, $X = [x_1 x_2 \ldots x_n]^T$, of which its stock vectors, M, and covariances, C, are described by: $M = E(X) = [m_1 m_2 \ldots m_n]^T$ and $C = E[(X - M)(X - M)^T]$. Calculate eigenvalues $\lambda_1, \lambda_2, \ldots, \lambda_n$, and the eigenvectors $P_1, P_2, \ldots, P_n$ and sort them according to their magnitude $\lambda_1 \geq \lambda_2 \geq \cdots \geq \lambda_n$. Select d eigenvectors to represent the n variables, $d < n$. Then $P_1, P_2, \ldots, P_d$ are called principal components. For the data set of the cases reported as probable of Rickettsiosis, the variables *Sex*, *Age*, *Cycle*, *Laoratory_Results*, *Fever*, *Headache*, *Malaise*, *Myalgias*, *Arthralgia*, *Retro_ocularPain*, *Rash*, *Pruritus*, *Vomit*, *Nauseus*, *Chills*, *Photophobia*, *AbdominalPain*, *Diarrhea*, *Conjunctivitis*, *NasalCongestion*, *Cough*, *Pharyngitis*, *Rhinitis*, *Hepatomega*, *Splenomega*, *Adenomegal*, *Hemorrhage*, *Convulsions* and Weakness are discrete variables; *Hto*, *HB1*, *PLAQ1xM* and *LEU* that are laboratory tests performed in the hospital and are continuous variables. As a result, a shift was performed to center the data at zero, and a scaling was performed to have a unit variance. The tool used for the PCA analysis was R-Studio. To perform the PCA, records containing null data in the variables *Hto*, *HB1*, *PLAQ1xM* and *LEU* were eliminated; so, 245 records and 34 variables were analyzed.

Regression Analysis

The regression model was the second tool used in our analysis, which is very useful to establish the correlation between two or more variables, as well as for measuring the degree of association or mutual variation between them (Perez, 2008; Wayne, 2005; Wonnacott, 1997). Multiple regression models are mathematical methods for modeling the quantitative stochastic relationship between a variable of interest and a set of explanatory variables. In general, these models can be expressed as follows (Rosner, 2011):

$$Y_i = \beta_0 + \beta_1 X_{i1} + \beta_2 X_{i2} + \cdots + \beta_p X_{ip} + \varepsilon_i$$

Where:

Y_i: interest variable, dependent or returning,

$X_{i1}, X_{i2}, \dots, X_{ip}$: explicative variables, independent or regressive,
β_0: intersection or constant term,
$\beta_1, \beta_2, \dots, \beta_p$: parameters, measure the influence that the explanatory variables have on the return,
p : number of independent parameters to be considered,
ε : observation error due to uncontrolled variables,
i: 1,2, … , n : number of observations of the variables.

With these models it is possible to study the linear relationships between multiple variables and the effect they have on the dependent variable. They are estimated following the least squares criterion:

$$\hat{Y}_i = \hat{\beta}_0 + \hat{\beta}_1 X_{i1} + \hat{\beta}_2 X_{i2} + \cdots + \hat{\beta}_p X_{ip}$$

$$e_i = Y_i - \hat{Y}_i = Y_i - \left(\hat{\beta}_0 + \hat{\beta}_1 X_{i1} + \hat{\beta}_2 X_{i2} + \cdots + \hat{\beta}_p X_{ip}\right)$$

$$\min_{\substack{\beta \in n \\ i=1,\dots,n}} \sum_{i=1}^{n} e_i^2 = \left(Y_i - \hat{\beta}_0 - \hat{\beta}_1 X_{i1} - \hat{\beta}_2 X_{i2} - \dots - \hat{\beta}_p X_{ip}\right)^2$$

And the least squares estimators are obtained from the equation:

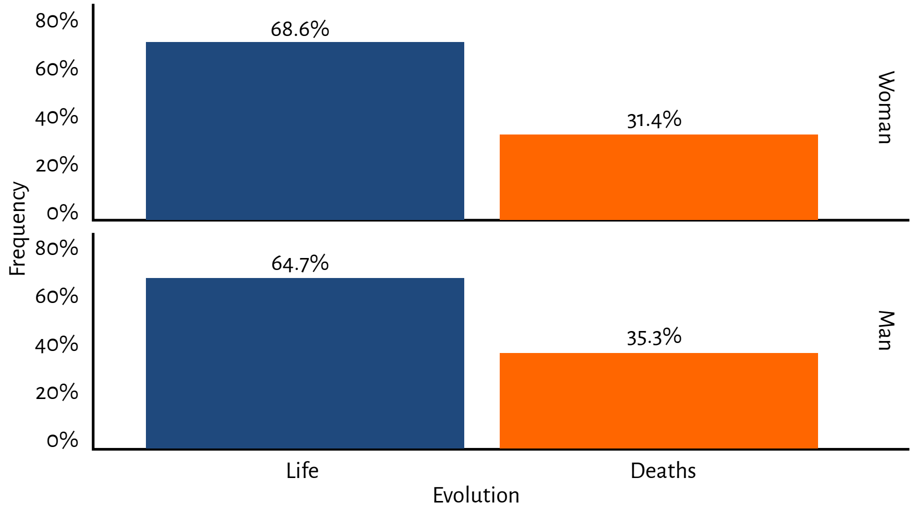
$$\hat{\beta} = (X^T X)^{-1} X^T Y$$

Results

Descriptive statistical analysis:

As a first step, a descriptive statistical analysis was carried out using R-Studio software as a tool. Of the set of 290 cases confirmed with Rickettsiosis, 150 (51.72%) were men and 140 (48.28%) women. Figure 1 shows the bar graph with the percentages of deceased and surviving patients of men and women. The red bars show the patients alive, of which 68.6% are women and 64.7% are men; and the blue bars show the deceased patients, of which 31.4% are women and 35.3% are men.

Figure 1. *Gender description of living and deceased patients.*



Source: *Own elaboration.*

A second examination was performed analyzing the variable place of the rash, which describes the place of the body where the rash began, a characteristic symptom in patients with Rickettsiosis. Table 1 shows the numerical classification that was assigned to each place of the body where the patient refers to the appearance of rash.

Table 1. *Numerical assignment for each place on the body where the patient refers the appearance of a rash.*

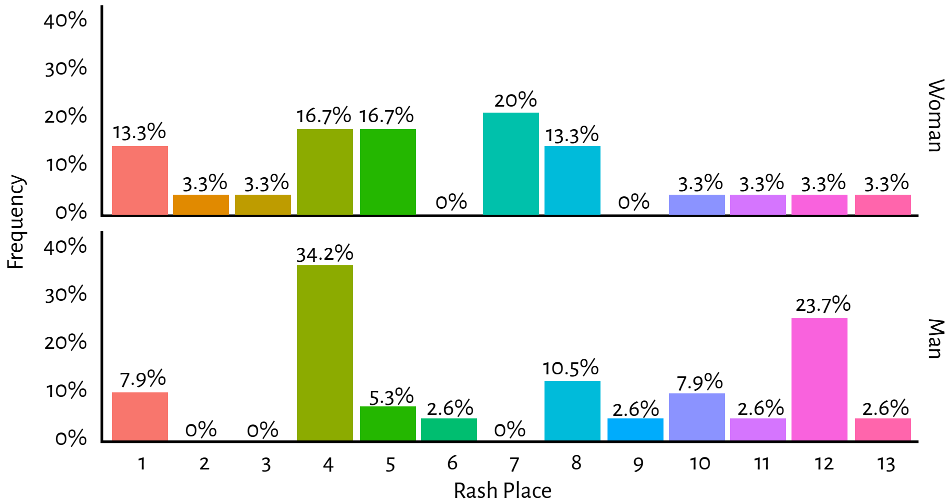
Rash_Place	
1= Abdomen	8= Upper and lower extremities
2= Abdomen and posterior chest	9= Upper extremities and abdomen
3= Abdomen, wrists and posterior chest	10= Upper extremities and chest
4= Body (no place specified)	11= Limbs and abdomen
5= Lower extremities	12= Chest
6= Lower extremities and Abdomen	13= Chest and y abdomen
7= Upper Extremities	

Source: *Own elaboration.*

Figure 2 shows the result of this analysis graphically, in which men and women were analyzed separately and it was observed that 20% of the women presented the upper extremities rash (7, according to table 1), 16.7% presented rash in the body without specifying place (4) as well as in lower extremities (5) 16.7%, on the other hand, 13.3%

presented rash in abdomen (1) and upper and lower extremities (8). In the case of men, 34.20% indicated that the rash began in the body (4, according to table 1); however, it is not specified in which part of the body the rash was presented. 23.7% indicated that the rash started in the chest (12, according to table 1). 10.5% in upper and lower extremities (8) and 7.9% reported having presented rash in abdomen (1) and upper extremities and chest (10).

Figure 2. *Percentages of appearance of rash in patients.*



Source: *Own elaboration.*

The following examination was performed with the symptoms reported by patients confirmed with Rickettsiosis chronologically, which coincided with the main clinical manifestations indicated in the literature (Casal et al., 2019; Klein et al., 2017). Of the 290 cases recorded in our data set, those that did not contain any symptoms were eliminated, leaving 126 cases. Many patients had no documented symptoms because during the years 2014 and 2015 the patient interview was not conducted. The variables cited in the literature were taken as indicators of Rickettsia, in addition to others found as constants in the interviewed patients, leaving 12 symptoms to be analyzed. To inspect the time of appearance of each symptom was performed in hours. Table 2 presents the results obtained.

Table 2. Descriptive statistics of the symptoms analyzed in this study, in patients with Rickettsiosis. Standard deviation (SD), Mean in hours (Mean).

Time in hours		Fever	Rash	Headache	Myalgia	Malaise	Arthralgias	Nauseous	Vomit	Stomach ache	Weakness	Diarrhoea	Confusion	Cough
Man	Mean	38.04	114.67	30.55	67.58	64.42	98.40	81.78	86.71	91.38	72.00	91.00	160.94	72.00
	SD	28.02	43.08	14.97	47.30	49.31	63.14	59.26	68.36	61.48	60.54	78.80	49.31	67.88
Woman	Mean	46.67	104.00	48.57	83.66	62.55	98.67	75.56	81.82	80.64	91.20	91.20	154.91	72.00
	SD	51.16	56.26	61.70	64.39	54.97	70.23	54.77	47.80	51.32	70.99	68.63	69.03	63.50
Live	Mean	39.88	99.43	39.86	77.02	60.28	99.43	74.25	86.25	90.16	90.46	72.00	146.40	66.00
	SD	40.12	50.85	41.01	59.15	49.51	72.09	52.21	65.05	63.09	74.77	68.38	68.38	53.22
Deaths	Mean	46.77	127.74	38.40	72.80	68.57	79.30	85.09	82.29	75.43	72.00	112.5	165.33	78.00
	SD	43.68	43.11	52.58	52.91	55.32	51.39	63.16	53.44	32.41	54.43	78.25	59.87	76.84

Source: *Own elaboration.*

Table 3 shows the mean time in hours of onset of symptoms, as well as the frequency with which symptoms occurred in the 126 cases of patients with rickettsiosis.

	Mean (Hours)	Standard Deviation (Hours)	Frequency	%
Rhinorrhea	36.0	17.0	2	1.6%
Headache	39.3	45.1	86	68.3%
Nasal congestion	40.0	12.0	9	7.1%
Fever	42.4	41.4	107	84.9%
Dysphagia	44.0	17.2	12	9.5%
Sleepiness	56.0	40.3	18	14.3%
Earache	56.0	55.4	3	2.4%
Pharyngeal pain	57.6	32.2	5	4.0%
Malaise	63.5	51.6	71	56.3%
Cough	72.0	61.5	8	6.3%
Myalgia	75.3	56.3	73	57.9%
Nauseous	78.7	56.6	54	42.9%
Anorexia	81.9	70.7	34	27.0%
Weakness	82.0	66.2	48	38.1%
Vomit	84.7	60.2	53	42.1%
Abdominal pain	86.1	56.4	51	40.5%
Photophobia	86.4	67.0	5	4.0%
Asthenia	90.0	76.0	12	9.5%
Diarrhoea	91.1	74.9	34	27.0%
Adynamia	96.0	74.7	14	11.1%
Arthralgias	98.5	66.0	57	45.2%
Rash	109.5	49.9	87	69.0%
Petechiae	126.7	64.7	18	14.3%
Prostration	133.5	56.8	16	12.7%
Pruritus	136.0	77.1	3	2.4%
Delirio	154.9	55.1	11	8.7%
Confusion	158.6	56.7	28	22.2%
Convulsions	163.8	51.8	17	13.5%
Stiff Neck	192.0	0.0	1	0.8%

Source: *Own elaboration.*

From the results in Table 3, we observe that in chronological order of appearance of the symptoms and by the frequency in which the symptoms occurred, 68.3% of the patients reported having had a headache around 39 hours after the symptoms started, 84.9% had a fever around 42 hours, 56.3% had general malaise around 63 hours, 57.9% had myalgia around 75 hours, 42.9% had nausea around 78 hours, 42.1% had vomiting around 84 hours, 40.5% presented abdominal pain around 86 hours, 45.2% presented arthralgias around 98 hours, 69% presented rash around 109 hours, it is worth mentioning that this symptom is the third symptom with higher frequency only after fever and headache according to the analyzed data.

Data mining with Principal Component Analysis

To visualize the structure of the data by means of information clusters, a Principal Components Analysis (PCA) was applied and graphs were generated contrasting the obtained components. A labeling of the points of the graph was made with different variables of the data set, in order to see if any of them is the one that generates this distribution. In most of the variables analyzed, it was not observed that any variable defined the distribution of the data.

Regression Analysis

To measure the relationship between the variable (live/death) with the variables sex, age, laboratoryresponse (if positive or negative to the IIF and PCR serological tests), symptoms, as well as the blood count data performed during hospitalization (*HTO, HB, platelets and leukocytes*). A linear regression analysis was performed, resulting in the variables *Platelets, Age, Hemorrhage and Convulsions* with a very high degree of statistical significance, *pvalue*<0.001(***); the variables abdominal pain, laboratory tests (IIF/PCR), *diarrhea* and *malaise* with a high degree of significance, 0.001<*pvalue*<0.01(**) . Similarly, the variables *Arthralgias*, *Vomit*, *Hepatomegaly*, *Retro-ocularPain*, *Icterice*, and *Myalgias* were statistically significant, 0.01<*valorp*<0.05(*). Table 4 shows the results obtained.

Table 4. Variables associated with the variable (Live/Defunction) according to their degree of significance. Source: Own elaboration.

Variables	P value of the variable CYCLE (Live/Death)	Significance Codes 0 '***' 0.001 '**' 0.01 '*' 0.05 '.'
Platelets 1 X M	2.71E-07	***
Age	7.90E-06	***
Hemorrhage	5.50E-05	***
Convulsions	0.000658	***
Abdominal pain	0.00528	**
Lab tests	0.00656	**
Diarrhoea	0.00674	**

Variables	P value of the variable CYCLE (Live/Death)	Significance Codes 0 '***' 0.001 '**' 0.01 '*' 0.05 '.'
Malaise	0.00696	**
Arthralgias	0.0273	*
Vomit	0.0285	*
Hepatomegaly	0.0352	*
Retro-ocular Pain	0.0363	*
Ictericia	0.0365	*
Myalgia	0.0465	*
Headache	0.0954	.
Cough	0.0956	.
Pruritus	0.0999	.

Similarly, to measure the relationship between the *laboratoryresponse* variable (Positive/Negative) with the variables of *sex*, *age*, *cycle*, (if the patient recovered or died), symptoms, as well as the blood count data performed during the hospitalization (*HTO, HB, platelets* and *leukocytes)* a linear regression analysis was performed, in which the *cycle* and *age* variables with very high degree of statistical significance were found *pvalue*<0.001(***); the *platelet* and *hemorrhage* variables resulted in a high degree of significance, 0.001<*pvalue*<0.01(**); and similarly the *diarrhea*, *chills* and *arthralgia* variables were statistically significant, 0.01<*pvalue*<0.05(*). Table 5 shows the results obtained.

Table 5. *Variables associated with the variable (Positive / Negative) for Rickettsiosis according to their degree of significance.*

Variables	P value of the variable LAB_RESPONSE (Positive / Negative)	Significance Codes
Cycle	5.46E-08	***
Age	0.00019	***
Platelets 1 X M	0.00402	**
Hemorrhage	0.00668	**
Diarrhoea	0.0289	*
Chills	0.0303	*
Arthralgias	0.0438	*

Continued...

Variables	P value of the variable LAB_ RESPONSE (Positive / Negative)	Significance Codes
Malaise	0.0594	.
Rash	0.0615	.
Nasal congestion	0.0928	.
Convulsions	0.0977	.

Source: *Own elaboration.*

Conclusions

Industry 4.0 seeks to benefit more than one sector of society with the implementation of concepts and technology that allow process improvement and reduction of errors, without losing the quality of the process. In this sense, the implementation of Industry 4.0 in the health sector in Mexico, would improve both primary care services in hospitals and access to clinical data information of patients between health institutions, as well as being able to have remote medical care in places of difficult access and to have a correct and timely diagnosis of diseases. This document presents a first analysis of the clinical information of 1,883 cases of patients who presented symptoms due to possible Rickettsiosis in the municipality of Mexicali, Baja California, Mexico. For the information analysis, descriptive statistics of patients with similar behavior in the period of 2014 to 2018 were computed. Results showed a fatality rate of 12.40% in women and 13.41% in men. Other analyses included the calculation of the percentage of patients who presented the symptom of exanthema in different parts of the body; inspection of 13 common symptoms of Rickettsiosis; and the computation of the average times of appearance of symptoms in patients. In a second analysis, data mining was performed using the Principals Components technique. The results did not show a clear influence of any variable on the distribution of the data. Finally, an association analysis using regression techniques on different variables of interest, with the result of the diagnosis by laboratory tests (whether the patient was positive or negative for Rickettsiosis) and the evolution of the infection (whether the patient died or survived), was carried out.Six variables were very highly associated (*platelets, age, bleeding, seizure, cycle and age*), six more highly associated (*abdominal pain, laboratory tests* (IIF/PCR), diarrhea, malaise, platelets and hemorrhage) and nine were normally associated (*arthralgias, vomit, hepatomegaly, retro-ocular pain, jaundice, myalgia, diarrhea, chills and arthralgia*). Finally, this study suggests a series of variables associated with both the acquisition of Rickettsiosis and death due to infection, which may, under a subsequent analysis, be declared as risk factors for acquisition and death by Rickettsiosis in the population of Baja California, this can be determined in future research, seeking to make a contribution to improve techniques to make a correct diagnosis in primary health care. Critical situation so far, since in the analyzed cases we found that the average time in which patients attended a health service is 3 days, however, only 23.17% of patients received a correct diagnosis, delaying this the start of antibiotic treatment (doxycycline), which potentializes severe irreversible damage to multiple organs. Improving the quality of medical care, the access to clinical patient information and diagnostic protocols for diseases such as Rickettsiosis, are aspects still pending in health institutions, therefore promoting the implementation of Industry 4.0 would generate new methods for the prevention, diagnosis and timely treatment of diseases, guaranteeing people a better quality of life.

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CHAPTER 16

Visiting an Urban Park in a Smart City: An Intelligent Systemic Approach Considering Visitors' Desires and Expectations

Diego Adiel Sandoval[1],
Aida-Yarira Reyes*[2], Alberto Ochoa-Zezzatti[2]

[1]*Tecnológico Nacional de México campus Instituto Tecnológico de Ciudad Juárez.*
[2]*Universidad Autónoma de Ciudad Juárez*
* *Corresponding author aida.reyes@aucj.mx*

Abstract. Public space is necessary to achieve wellbeing in cities. Urban parks in particular play a decisive role because they provide a connection between urban life and nature. Two case studies regarding the positive role of urban parks are presented in this chapter. The first case study regards a group of visitors driving under the influence looking for a safe port to avoid being the cause of an accident and stopping in a nearby park. The second case focuses on finding the best route for a visitor to avoid allergenic vegetation. In both cases, we adopted a technological approach using a mobile device, geo-referenced systems and biometric identification equipment to locate both the users and the best path to visit the park. We tested both systems at the "Hermanos Escobar" Central Park, located in Juarez, Mexico. The results show that a safe harbor for

intoxicated drivers is located near the west entrance. At this location, there is easy access to restrooms and it is a safe place to leave the car overnight. Furthermore, the park is an allergy-free space that is easily walkable, except for the east side of the park—where most of the allergenic species, such as *Morus nigra*, are concentrated. In this chapter, we present a general discussion of the advantages of both systems and the conclusions derived from this preliminary study.
Keywords: Urban green spaces, Smart Cities. Intelligent dispositive to decision support system.

Introduction and problem setting

Urban green spaces (UGS) play a crucial role in cities since they provide an extensive series of environmental, social and economic services. Urbanized areas are places where humanity has achieved economic, technologic and social progress; nonetheless, these areas lack natural environment. Moreover, persons who live in large cities face social disarticulation and farness. These phenomena are even more intense in cities experiencing urban sprawl (Rueda, 1997). The agglomeration of constructions and highways in cities promotes a monotone environment where mate colors predominate, mainly encompassed by grey and inert components. The heavy traffic intensifies stress at the time that incivilities and crime rapidly increase. The city script delineates in the mist of exposure to pollution and to a great variety of contaminants. No doubts cities lack of a naturalized profile that negatively affects the society as a whole.

Conversely, urban parks are perhaps the most refined form of public space, as they are not only common areas where many groups gather, either in harmony or in conflict, but also because they provide a wide variety of environmental, social, and economic services. Urban parks are essential elements of cities because they overcome the negative effect of urbanization. The literature repeatedly reports (see Córdova and Martínez-Soto, 2014) that when people gather in urban parks, social cohesion occurs and, at the same time, homogeneity is broken by the encounter of diverse groups coming from many backgrounds. In addition, urban parks aim to improve physical and mental health by promoting active and passive practices, such as exercise or contemplation. Although park services have no market value, i.e., their services are not for sale, these numerous social and environmental benefits enrich the economic value of urban parks in smart cities. Unveiling the value of these services is an excellent way to promote investment in maintenance and extra funding for the park.

Often, the design and planning of an urban park that aims to satisfy all user groups fails to do so. It is common that during the process—if there is any—the designer focuses on the configuration of the park itself, and not on the multiple ways in which visitors can use the park, thus, creating a gap between the visitor and the technical requirements set by the designer. In addition, many studies on park-use patterns reveal that visitors do not always have a clear idea of their intentions when visiting the park. That is, once visitors arrive at the park, their intentions for use may vary, performing activities different from those originally planned. Moreover, these studies show that it is not common for users to have no clear intentions when visiting the park or for their plans to arise from circumstantial factors (such as passing by the park and deciding to visit it). In either case, users may experience uncertainty about what activities they can perform, what adverse conditions the park may have, or simply what to expect -safety conditions- during the visit.

Background on park visiting and use

Three pathways need to be considered to study patterns of urban park use. The first pathway addresses the active use of parks, which is directly related to fitness and health. This pathway concerns the set of facilities that a park should have for exercise and active use, such as stretching, walking, or jogging. Active use of parks helps prevent metabolic diseases like diabetes and obesity. The second approach involves passive activities, such as meditation, sightseeing, rest, relaxation, or contemplation. These activities are related to the prevention of mental illnesses like depression and anxiety. Lastly, the third pathway refers to community use for cultural or educational purposes. These forms of use are important because they encourage social encounters, interaction and the exchange of experiences among heterogeneous groups. In terms of active use, urban parks are excellent for exercise and sports. The most common activities are jogging, walking, stretching, personal routines, exercise in the gym and group programs. To perform these activities, the park must have adequate facilities, which in turn require periodic maintenance. The facilities most frequently mentioned in the research are tracks, walking trails, jogging tracks, gymnasium, tennis courts, playgrounds, sandy grounds and other similar amenities (Guevara et al., 2014; Espejel et al., 2014). Other publications refer to the importance of pet walks (Peñalosa, 2018; Iojă, Rozylowicz, Pătroescu, Niţă, & Vânau, 2011) and cycling routes (G. Brown, Rhodes, & Dade, 2018).

Research on active park use shows that weekday-weekend scenarios are determinants of active use patterns (Bertram et al., 2017; Baran et al., 2012; Flores-Xolocotzi, González-Guillén, and de los Santos-Posadas, 2010; Ries et al., 2009). Thus, studies should differentiate between these two scenarios. Moreover, active use is contingent on a park's actual facilities (He, Yi, and Liu 2016), this suggests that the supply of active amenities should be aligned with those in demand (B. B. Lin, Fuller, Bush, Gaston, and

Shanahan, 2014). Focusing on demand is the right strategy to satisfy visitor desires (Mak and Jim, 2019).

Studies emphasize the relationship between physical activity and physical health. H. Liu, Li, Li, and Zhang (2017) examined how people spend time exercising in a set of parks in China. They found an association between self-perceived levels of energy, relaxation, mood and confidence, and time spent. The elderly also take advantage of exercising in parks (Duan, Wagner, Zhang, Wulff, & Brehm, 2018). The distance between butler developments and parks is a factor associated with better health and fitness, as well as mental well-being (Ekkel and de Vries, 2017; Akpinar, 2016).

Passive activities are crucial for mental health and parks are spaces where people can appreciate nature and scenery. Here, people find relaxation and rest, they also find contexts for contemplation, reading spots, flirting options, or even the way to let the mind fly around a non-particular subject (Perelman and Marconi, 2016; Razak, Othman, and Nazir, 2016; Guevara et al., 2014; Baran et al., 2012). Quiet areas, benches, and tables are essential to meet the needs of visitors seeking passive activities (Bertram et al., 2017; Baran et al., 2012). Finally, interaction between different groups of people in cultural or educational events is among the most valuable social features in a park. This includes educational gatherings, plunges, workshops, or neighborhood meetings (Peñalosa, 2018). If the park can host groups in kiosks, amphitheaters, dance halls, or auditoriums, then its value is enhanced, thus increasing the positive impact of these activities (Dickinson and Hobbs, 2017; Peters, 2010). The celebration of civic events, such as Independence Day, Labor Day or local holidays, enhance the sense of belonging and cultural and historical values (Amin, 2008; Segovia and Neira, 2005).

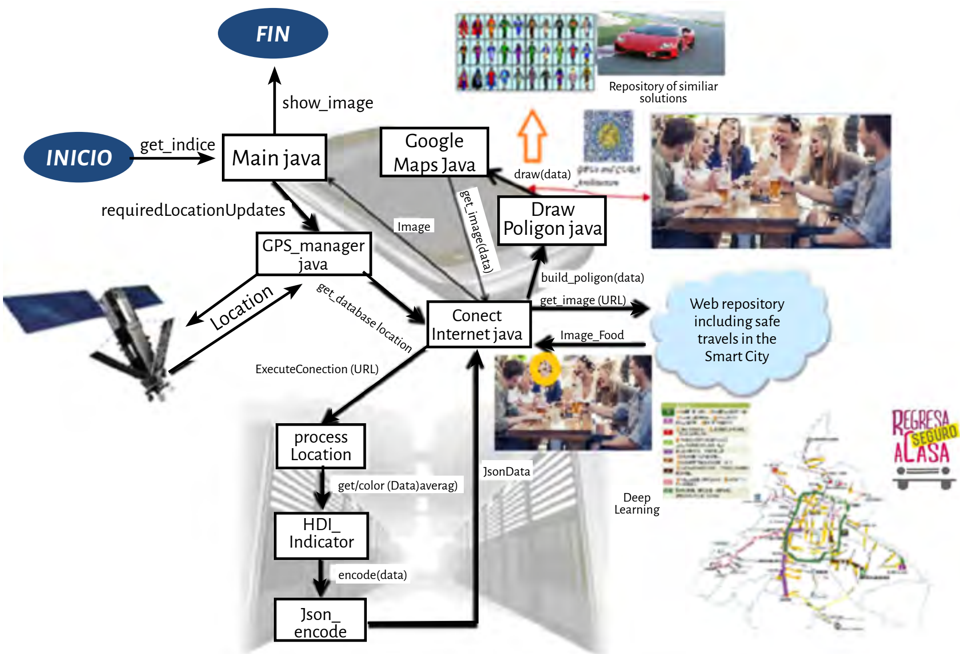
Method

Case 1: Safe Harbor for Intoxicated Drivers

To recommend activities to a specific user profile, we adopt the conceptual system depicted in Figure 1. In this case, we imagine a group of young or adult intoxicated drivers looking for a safe harbor in an urban park while waiting for a family member or friend to pick them up. As shown in Figure 1, the conceptual system initiates recognition of both the visitor's profile and the geo-referenced location and time at which the event occurs. A Java® interface manages this process through an interactive map that is easily accessible on a mobile device. Once in the park, visitors can enter their profile and their intention to visit. The system processes this input and provides an output with all the recommendations to find the best place to stay in the park.

The proposed system is a solution for a common problem in Smart Cities: drunk drivers. This interactive alternative, instead of endangering the integrity of the user and that of other drivers, scans the iris of each person in the group and determines who - if any - is capable of driving without being under the influence of alcohol. The configuration of the solution conveys an intricate network of interactions between various systems. A satellite locator determines where the group is at any given time. A database retrieves information from similar events and helps identify the patron to suggest a course of action. After determining the location and the patron, the system offers a solution, either by suggesting a safe route to the final destination or by providing a list of possible people to call for help. As a result, the system helps the smart city become a safer place, preventing deaths and losses from accidents due to intoxicated drivers. Although the setup needs further testing and probably more features, the current design, based on a high-resolution camera interacting with software adapted for various platforms, is an excellent starting point to scale up as the complexity of the phenomenon increases.

Figure 1. *Smart system configuration to find a safe harbor for an intoxicated DUI in an urban park in the Smart City.*



Source: *From Real-time video image processing through GPUs and CUDA and its future implementation in real problems in a Smart City, cited by Hernández et al., 2019, p. 47.*

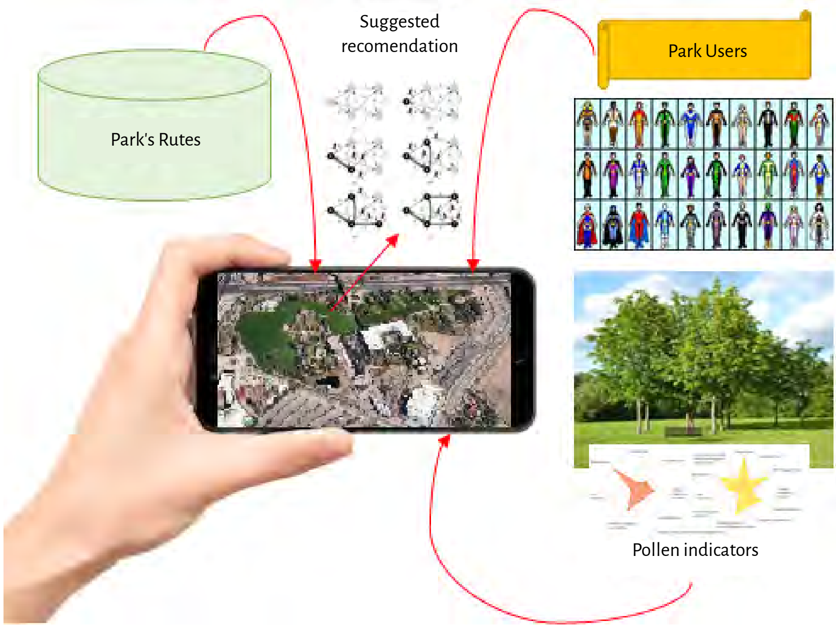
There are similar proposals to ours in other parts of Mexico. For example, in the region of Aguascalientes, known as "Altiplano Hidrocálido", the number of fatalities by drunk drivers is high and a program called "Safe Return Home" has already been implemented using similar technologies. Similar research proposes real-time image analysis is discussed in Hernandez, et al (2019).

Ciudad Juarez is one of the three cities in Mexico with the high rates of alcohol consumption among young people. Therefore, this research aims to present a proposal for continuous improvement to prevent traffic accidents associated with high speed and drunk driving in the city at night. This proposal includes an intelligent and safe alternative once the individual arrives at the urban park, so that he/she can alert his/her family and ask for help.

Case 2: Allergies caused by pollen propagation in urban parks

The Smart City ensures the health of society by anticipating adverse situations that bring danger to people. Allergies are one of the main concerns of park visitors. The system depicted in Figure 2 describes a configuration in which a mobile device displays an interactive map of an urban park showing the paths along which a visitor would encounter allergenic species. These species may affect visitors's health by triggering an allergic reaction.

Figure 2. Configuration of the intelligent system to avoid allergenic species during a visit to an urban park



Source: Own elaboration.

To do this, the system accesses a previously registered database that encompasses the different species of vegetation and the multiple routes that a visitor can follow. Then, an integrated and interactive geo-referencing-based application, which recognizes the visitor's location, advises him to take a recommended path where there are no allergenic trees. In addition, the application also describes allergenic species by their common and scientific name, as well as the period of the year when they pollinate. The touch resource on the screen zooms in and out as desired for additional useful information, such as average temperature and noise level in selected areas along the recommended route.

Results

In Figure 3 the line in blue shows the output generated by the system to find a safe harbor for intoxicated drivers who want to use the park as a place to leave the car while waiting to be picked up by someone else. Using this option would increase safety in the Smart City, reducing the incidence of accidents and fatalities. The exit area provided by the system is well lit and has 24-hour surveillance. In this way, the park acts not only as a public recreational space for environmental services, but also as an opportunity to allow intoxicated drivers to leave the car and avoid accidents. The area delimited by red lines represents the path to avoid if visitors do not want to encounter allergenic plant species. Allergy-related illnesses are aggravated during spring and autumn in Ciudad Juarez. Thus, by knowing which route to avoid, the intelligent system helps to improve the health of users. In this case, vegetation within the red lines is predominantly allergenic during spring (blackberry, whose pollen is highly allergenic).

Figure 3. *Output of both intelligent systems: a) safe port for intoxicated drivers (in blue) and avoiding allergenic species (in red) during a visit to Parque Central "Hermanos Escobar" in Juarez, México.*

Source: *Own elaboration.*

Preliminary conclusions

Urban parks promote health and social interaction, they are perhaps the most refined form of public spaces in urban settings (Campbell, McMillen, & Svendsen, 2019). The visitor experience should be the driving force in designing/planning the configuration of urban parks. That is, visitor desires and expectations should prompt the design and planning process of urban parks. In smart cities, technology greatly helps to improve the visitor experience of urban parks. This paper proposes a pair of system design structures to address two common problematic adversities in cities: drunk drivers and allergies. The first proposed system uses geo-referenced resources and biometric features to identify intoxicated people who cannot drive, thus preventing accidents and fatalities in smart cities. The second system aims to alert the visitor about allergenic plant species. This system anticipates allergy crises, which translates into improved health for park users. Although both systems are at a conceptual stage for now, they are fully feasible and applicable in a smart city. Moreover, the adoption of these approaches would improve the user experience in urban parks.

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CHAPTER 17

Case-Based Reasoning to Improve a Serious Game Associated with Borderline Syndrome

Ismael Rodriguez*[1], Alberto Ochoa-Zzzatti[2]

[1]*Jagiellonian University, Poland*

[2]*Doctorado en Tecnologia, Universidad Autónoma de Ciudad Juarez; Chihuahua, México.*

* *Correspondig Author: ismael.rodriguez@doctoral.uj.edu.pl*

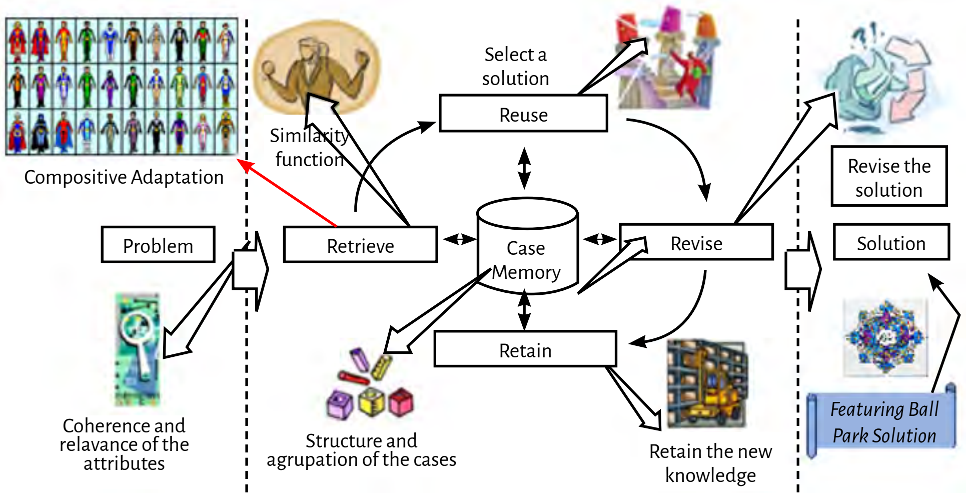
Abstract. The possibility of having a range of individuals with different skills facing different scenarios with high uncertainty of what can happen, as well as case-based reasoning, has been studied by several authors. In this research, the design of a group of strategies for a Serious Game associated to the use of a group of characters to represen a specific player where the user is the main character, also known as RPG (Role-Playing Game). In this game, two different virtual societies are modeled. The first one is called "civilians" and presents a social behavior resembling Borderline Syndrome and will always try to position itself close to the player as a means of protection, while the other will try to eliminate both the player and the civilians. The behavior of each society has been modeled by two different evolutionary techniques: the PSO technique and Cultural Algorithms

Keywords: Stratagems based on roll skills Serious Game, Artificial Societies, Case-based Reasoning, RPG, Particle Swarm Optimization.

Introduction

In this chapter we present a research related to an intelligent Serious Game where the user is the protagonist of a scene where there is a group of individuals controlled by the computer, "civilians", who have a profile associated with Borderline Syndrome. Borderline Personality Disorder (abbreviated as BPD), also called borderline, is defined by the DSM-IV (DSM-IV 301. 831) as "a personality disorder characterized primarily by emotional instability, extremely polarized and dichotomous thinking, impulsivity, and chaotic interpersonal relationships. The disorder typically involves marked and pervasive instability of mood, self-image and behavior, and sense of identity, which may lead to periods of dissociation." It is included in cluster B of personality disorders, the so-called "dramatic-emotional" disorders and is the most frequent personality disorder. On the other hand, there is another group of individuals referred to as "enemies" and their function is to annihilate civilians. The main character (the user) will have the function of being a protective leader for the civilians, who, in turn, will have to move through different scenarios where he is the leader while the enemies try to take them down to attack and annihilate our main character (Gal, 2007). This scenario denotes a rich field for implementation and experimentation using Artificial Intelligence techniques. For example, civilians will have to follow the leader using case-based reasoning for their movements while enemies will use stratagems as part of their negotiation using Particle Swarm Optimization to decide the steps that lead them to wreck everything, including the rival society in the game. Previous research was able to compare the convergence speed of PSO and associated cultural models in first degree cultural algorithms, for which a similar game was used from the point of view of the environment and the fight between the two groups controlling the locations, in the research, it was found that PSO achieved adequate convergence to establish the right stratagems to win, while the social behavior patterns help to find the models associated with the effect of certain types of massive attacks to capture and destroy the members of the opposing group (Ochoa, 2008). We propose an Intelligent Model that uses Compositional Adaptation over Case-Based Reasoning to change the different skills when advancing in the game, in this model we include a Ball Park Solution Evaluation Module to determine the quality of the solution over time, as shown in Figure 1.

Figure 1- Cycle of CBR emphases on Compositive Adaptation.



Source: Own elaboration with respect to review literature.

Strategy Serious Games

A game is essentially an imaginary universe related to a specific social phenomenon (Gal, 2007). Strategy Serious Games are a vast field of experimentation, implementation and development of Artificial Intelligence techniques because it is possible to analyze many ideas related to social behavior in warfare. An Intelligent Game using stratagems based on Evolutionary Computation no matter what the specific task of the AI involving Cultural Algorithms(Reynolds, 1979), (Reynolds, 1996), (Ziad, 2006) , (Reynolds, 2008), such as killing the player (e.g. monsters in a first-person shooter), receiving extra information to advance in a global war (e.g. Vega Conflict), defeating the player in war (e.g., strategic AI in a real-time strategy game), or learning to perform tasks on behalf of the player (e.g., the creature in Black & White). The AI is always acting, entertaining, scaring, and surprising the player. The fundamental goal of AI is to create an experience for the player. Measures of effectiveness used in traditional AI research, such as time required to perform a task, number of errors, etc., are insufficient to guide the work of game AI. Game AI must not only accomplish tasks within the game world, but do so with style (Mateas, 200).

Application domain related with the Intelligent Serious Game

Since Serious Game has two constraints, it is multirestrictive since the user will have to save as many civilians and eliminate all adversaries in the scenario but the enemies will have to eliminate all civilians and their leader. If the enemies eliminate all the civilians the game ends and the user will lose the game. On the other hand, if the user is eliminated before all the civilians, then the game will end, and the user will also have been defeated.

The rules of the game are as follows.

First the user selects the game parameters: Number of civilians. Number of Enemies, Enemy Vision Rank, Player is assigned as the main character, Time of the mission duration. The game starts when the civilians and enemies and the user are randomly placed inside the scene. Enemies start looking for civilians in the scene, if a civilian is spotted and eliminated by the enemy then the enemy will know the leader's position with respect to himself for the rest of the game. If the leader is spotted by an enemy, the enemy will seek to contact his closest allies and negotiate to ambush the leader. From this point on, the leader's position will be known for the rest of the game even if the leader moves out of the enemies' range of vision. If an enemy who has one or more civilians in sight one and is called by another who has seen the leader, (Ziad, 2006) then he will have to negotiate whether to eliminate the civilians or the leader. Player and civilian rules: The player can move freely throughout the scenario and has a full range of vision. He can eliminate enemies at any distance. An Intelligent Serious Game using Evolutionary Computation based stratagems like the one proposed by us, considers different abilities of each character and associates them with a different planet (real scenario) and determines the armor abilities under this character type as shown in Figure 2.

Figure 2. *It is possible to optimize the armor suit of the leader by using case-based reasoning and a catalog of various skills and represent it as a specific planet according to a different atmosphere and an armor suit.*

The user must rescue as many civilians as possible. Civilians know the position of the leader and must follow him to decrease the probability of being taken down by an enemy. The goal of the game is reached when the player has eliminated all enemies, and thus the player wins. The player must manage to get a minimum number of civilians to the rescue ship located in the maze, and then even if the player has not eliminated the enemies, the player wins. However, the player loses if all civilians are taken down and if the player is eliminated by the enemies.

Enemy Role using PSO

The particle swarm optimization (PSO) algorithm is inspired by the movement of a flock of birds or a school of fish (Kennedy, 1995). A member of the flock is called a "particle". In PSO, the source of diversity, called variation, comes from two sources. One is the difference between the current position of the xt particle and the global best GBest (best solution found by the flock), and the other is the difference between the current position of the xt particle and its best historical value PBest (best solution found by the particle). Although the variation provides diversity, it can only be maintained for a limited number of generations because convergence of the flock to the best is necessary to refine the solution (Ochoa, 2008). The velocity equation combines the local information of the particle with the global information of the flock, as follows:

$$vt{+}1 = w * vt + \Phi 1 * (P_{Best} - xt) + \Phi 2 * (G_{Best} - xt) \quad (1)$$

$$xt{+}1 = xt + vt{+}1 \quad (2)$$

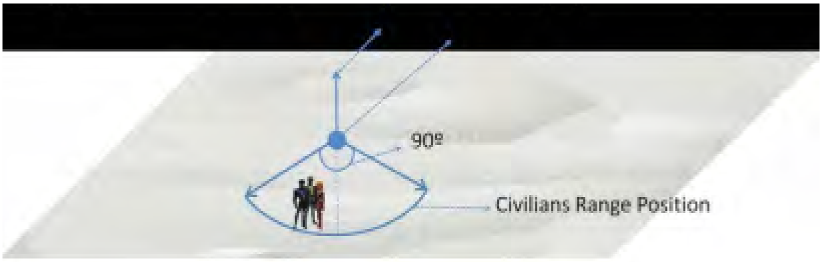
where v_t is the velocity vector, w is the inertia factor, Φ_1 and Φ_2 are the acceleration coefficients. The second term is called the cognitive component, while the last term is called the social component (Ochoa, 2008).

PSO was used given that the player's purpose is to rescue a group of civilians while the civilians must cluster around the player's position. Therefore, the player's position will always be considered the best location and is where the civilians "should converge in the first instance". However, since PSO requires a model that tells each individual how to move (commonly referred to as the Objective Function), we have chosen to use the equation of the Euclidean distance between two points which is given by the following equation:

$$D = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2} \quad (3)$$

Where a point will be the position of the player and another one will correspond to the position of each civilian according to different movements during the game, as is possible view in Figure 3.

Figure 3: *Rank of positioning between the communities of agents (civil) and the player.*



Source: *Own elaboration with respect to review literature.*

The next point to consider is the modification of the position of the civilians when they converge with the player with the previous formula of the distance. If this position is not modified, the civilians try to converge on our position being provoked a graphic collision. To be able to resist this, we must add a control function, so that it allows us to place the civilians in a radius very close to the position of the game:

In order to obtain the previous modification of the position of the civilians when they converge with the player, the following equations were used (4) y (5):

$$\left\{\left[(y - y_p) - (x - x_p)\right] \tan\left(\frac{\theta}{2}\right)\right\} < 0 \qquad (4)$$

$$\left\{\left[(y - y_p) + (x - x_p)\right] \tan\left(\frac{\theta}{2}\right)\right\} < 0 \qquad (5)$$

Where:

x and y are each civilian's position on the plane. x_p and y_p are the player's current position on the plane.

θ is the angle where an arc are described to place the civilians. This cold is taken as a constant with a value of 90º.

Player Role using Case-based Reasoning

In recent years, CBR has experienced rapid growth since its emergence in the United States. What seemed only interesting for a very small research area, has become a subject of wide interest, multidisciplinary and with great commercial interests. Although

Case-Based Reasoning is yet another problem-solving paradigm, it is precisely the differences with the other approaches to artificial intelligence that make it so special. Instead of relying solely on general knowledge of the problem domain or making associations along with relationships between problem descriptions and conclusions, this paradigm is able to use specific knowledge from previous experiences, i.e., specific problem situations (cases). A new problem is determined after a similar attack case is found and reused in the new problem situation.

Furthermore, an approach to incremental and sustained learning experiences that are saved with every solved problem, generating new ways to solve future problems at any moment (Wender S., Watson I. D., 2014). Having seen few notions before, we could venture to give the first definition for Case-Based Reasoning: Solving a new problem by recalling a previous similar situation and reusing information and knowledge (Stefan and Watson, 2014).While the paradigm as an artificial intelligence technique is novel, Case-Based Reasoning has been well known among psychologists for many years. A physician examining a new patient recalls a case from a few weeks ago with significant similarity of symptoms and decides to assume that it is the same disease and proposes the same treatment since it was effective on the previous occasion. With this example, we can see how we remember a previous case to apply it to a new problem. In CBR terminology, we can define a case as a situational problem.Thus, a previously experienced situation, which has been captured and learned so that it can be reused to solve future problems, is called a previous case. Thus, a new case or an unsolved case is nothing more than the description of a new problem to be solved (where "solving" can be from justifying or criticizing a proposed solution, to interpreting the problem, generating a set of possible solutions or generating expectations from the observed data) (Ontañon, 2012). Case-Based Reasoning suggests a model of thinking that incorporates the aforementioned aspects of problem solving, understanding and learning and integrates all the processes of mere memory.In short, these are the premises underlying the model: Reference to past cases is interesting and useful to try to re-organize-situations. Reference to similar situations is often necessary to deal with the complexity of a new situation. Since problem descriptions are often incomplete, it is a necessary stage of understanding or interpretation. This stage can be considered to be both a prerequisite and a part of the reasoning cycle since understanding improves as reasoning progresses. However, any form of reasoning requires that the situation is made in sufficient detail and clarity and that the appropriate vocabulary is displayed to recognize the reasoning knowledge needed (either generally known or cases) to reason from. Practice shows that no event occurs exactly as a new case. Therefore, it is usual to have to adapt the last solution to fit the new situation. Learning is a natural consequence of reasoning. If a new procedure is encountered in the course of solving a complex problem and the application is positive, then the new procedure is learned to solve new types of situations. Revision of the proposed solution and analysis of the revision are two necessary parts of completing the reasoning/learning cycle. This overhaul analysis (usually performed by an external human agent) can lead to repair of the fault.

These assumptions suggest that the quality of a case-based reasoning depends on:

1) Experience
2) The ability to understand new situations based on past experiences
3) Adaptability.
4) Ability to assess and repair.
5) Ability to integrate new experiences in their memory.

Intelligent games using stratagems are usually associated with variable combinations of populations. During the last phase, a new population is reproduced using a basic set of evolutionary operators. The similarity model allows to locate each society with respect to the others. The profiles of each society are stored and used to calculate the rank among the remaining societies using their specific technological and cultural characteristics (to search for their similarities) and to also specify the boundaries of the clusters (Societies with similar preferences), as shown in Equation 6.

$$\frac{\sum_{i=1}^{n} w_i \times sim(f_i^I, f_i^R)}{\sum_{i=1}^{n} w_i} \tag{6}$$

where:

w_i is the weight of importance of an attribute.

sim is the similarity function.

f_i^I y f_i^R are the values of the attribute i in the entrance cluster (I) and in the recover cluster (R).

Results

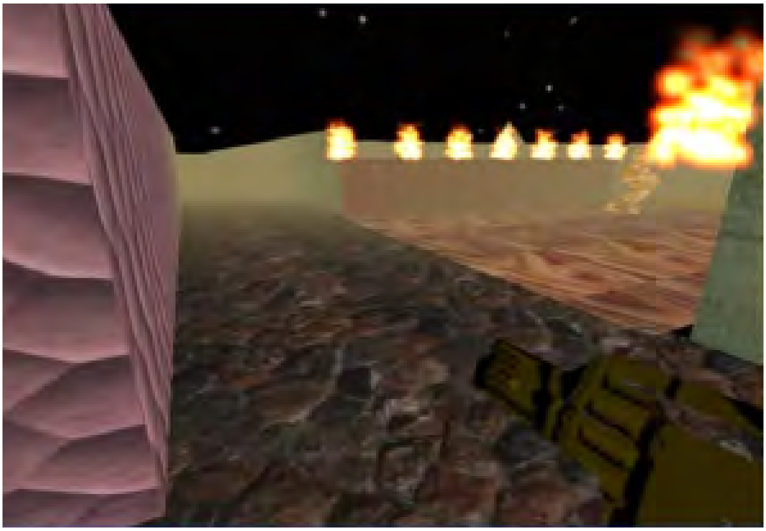
The Serious Game is used under a model associated to RPG, Figure 4 shows how the main character is in a variable environment with respect to its height position. The terrain where the survival and search of both societies takes place is constituted by mountains and irregular surfaces; this results in an irregular and highly interesting terrain for the realization of search algorithms that make use of compute evolve compute.

Figure 4: Player shooting to an enemy.

Source: Own elaboration with respect to review literature.

The civilian agents handled by the Particle Swarm Optimization converge to the point marked by Figure 2 of the trajectory of the three-dimensional vector that the player is leaving as a signal so that it is possible to continue solving function 3 which is used as an objective to complete the cognitive and social components of this technique. Due to the irregularities of the terrain shown in Figure 3, some particles or civil agents could not converge in a single case, while others cannot converge due to the appearance of civil agents that interfere the iterative process not allowing to always count with a constant population and the continuous changes of Gbest in the same algorithm. The agents that manage to find the player's position to be protected by him depend on the player's ability as a strategist to win the game. Figure 5 shows a change of the player's weapon and a section of the maze where the player is looking for civilian agents. One of the special features of Serious Game is that it allows a fog effect to be made throughout the environment to complicate the player's objective, and the back of an enemy agent searching for the main player or any civilian agent.

Figure 5: Immersed player in a labyrinth in search of enemies.



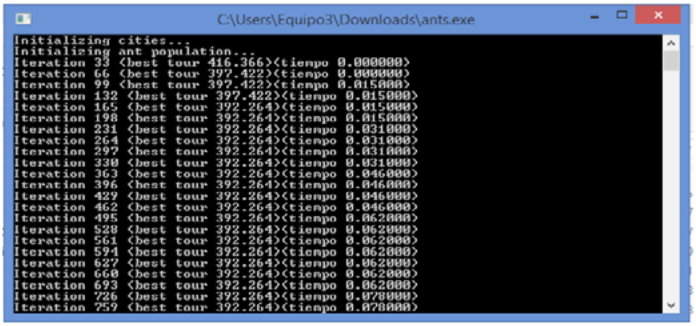
Source: Own elaboration with respect to review literature.

Enemy agents are controlled by Particle Swarm Optimization for optimizing visible trajectories in their view range. In addition, they make use of negotiation to decide how to attack civilians or the main player, i.e. if an enemy agent sees the main player he does not go towards him before negotiating with other agents of the enemy society. The irregularities of the terrain mean that the decisions made by the agents do not conclude in the objective of not attacking exclusively the main player since 40% of the time they were crowded by the maze or the mountains. One of the main aspects to evaluate is adaptation, which implies a comparison with the CBR and the rapid level of convergence that has the PSO's. It is important to emphasize that the generations advance determines the PSO crucial strategies and stratagems and determines CBR predictive models of how to defend against these attacks (Weber and Mateas, 2009).

Design of Experiments (DOE) with the improved components of PSO Algorithm

Tables 1, 2, 3, 4 and 5 thus characterize each of the results obtained by simulating our application developed in C # language as shown in Figure 6 and the results with the various analysis of the components in PSO and the number of branches of the scenarios to be simulated using instances each subject (artificial particles) and the results generated by it, this allows us to understand the scope of the algorithm and optimization with respect to random values, as discussed in (Yan et al., 2018)(Yan et al., 2019)(Yan et al., 2019).

Figure 6. *Implementation of PSO algorithm in C language.*



Source: *Own elaboration with respect to review literature.*

Results of the program execution supported by PSO

In order to evaluate our algorithm, we propose a model related with different instances, as shown in the next tables: 100 possible scenarios; 60% of search–space dimension; cognitive parameter = 1 and fitness function, optimization problem = 0.9.

Table 1. *Results with respect to the variables, 60% of search–space dimension; cognitive parameter = 1 and fitness function, optimization problem = 0.9*

Number of executions	Iteration	Results	Time
1	5400	723.344	14.661
2	7800	729.6	22.211
3	3800	724.39	10.884
4	7700	714.143	22.046
5	3500	740.23	10.036
6	8100	735.666	22.898
7	4600	710.712	13.226
8	6700	723.899	19.059
9	5600	706.738	16.068
10	8300	705.188	23.559

Source: *Own elaboration with data of our research.*

Table 2. *Results with respect to the variables: 70% of search–space dimension; cognitive parameter = 1 and fitness function, optimization problem = 0.95*

Number of executions	Iteration	Results	Time
1	7300	707.537	20.481
2	5000	720.195	14.280
3	5300	709.106	15.309
4	3000	727.979	8.674
5	5900	731.879	16.925
6	8400	710.110	23.845
7	6500	712.104	18.571
8	3500	699.435	10.317
9	5300	713.539	15.304
10	9200	736.2	26.033

Source: *Own elaboration with data of our research.*

Table 3. *Results with respect to the variables: 75% of search–space dimension; cognitive parameter = 5 and fitness function, optimization problem = 0.80*

Number of executions	Iteration	Results	Time
1	1300	694.446	6.215
2	1500	697.577	6.277
3	1500	699.487	4.070
4	1100	697.473	2.922
5	7100	695.644	19.139
6	700	692.687	1.875
7	2500	700.745	7.497
8	8700	696.378	23.222
9	1000	699.487	2.755
10	3500	697.577	9.447

Source: *Own elaboration with data of our research.*

Table 4. *Results with respect to the variables: 80% of search–space dimension; cognitive parameter = 5 and fitness function, optimization problem = 0.85*

Number of executions	Iteration	Results	Time
1	700	696.06	2.159
2	2500	694.446	6.602
3	300	697.043	0.842
4	900	694.446	2.549
5	300	694.263	2.505
6	3900	691.669	10.415
7	9200	693.829	24.091
8	600	694.446	1.657
9	1000	694.06	2.772
10	4000	695.381	10.750

Source: *Own elaboration with data of our research.*

Finally we organize the most relevant values associated with the optimization of our proposed Algorithm as in shown in Table 5.

Table 5. *Result the experiments with variation in search–space dimension; cognitive parameter and fitness function, optimization problem.*

%Search–space dimension	Cognitive parameter	Fitness function, optimization problem	Iteration	Results	Time
60	1	0.9	3500	699.435	10.317
60	1	0.95	8300	705.188	23.559
60	5	0.9	1300	694.446	6.215
60	5	0.95	3900	691.669	10.415
80	1	0.9	5400	691.133	15.357
80	1	0.95	2500	716.813	7.325
80	5	0.9	9700	693.54	25.57
80	5	0.95	500	690.521	1.369
100	1	0.9	2700	713.234	23.453
100	1	0.95	9500	693.822	26.644
100	5	0.9	600	694.446	4.477
100	5	0.95	1100	689.605	5.397

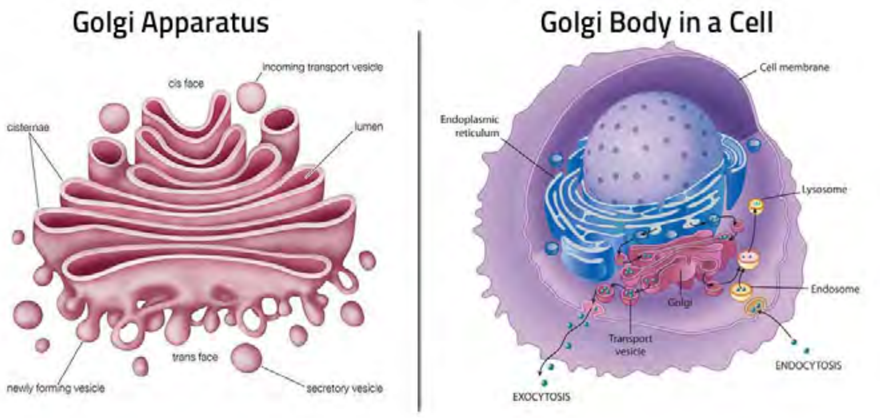
Source: *Own elaboration with data of our research.*

It was observed that the best result was obtained with 100% of the particles represented by the agents. A similar result was obtained with 80% of the agents compared to the experiment. With this it is concluded that the resources of both results are optimized and that it is possible to improve the visualization problems with specific scenarios and the PSO algorithm performs better in complex problems. In this research, the possibility of improving a real scenario with many agents was discussed. Using the PSO it is possible to verify the above. It is relevant to show graphically the expected demand reactively covers various situations associated with a scenario to specific components associated with the personality of the agents.

Conclusions and further research

This research has shown that the application of evolve compute techniques in 3D strategy Serious Games is a viable option since it offers non-monotonous benefits in the development of combat operations that agents can take, thus providing a more realistic simulation of environments than those achieved with heuristic techniques. This research will be extended by constructing a new virtual environment and making use of a neural network previously refined by the Particle Swarm Optimization used in this work for the control of enemy agents. Once the main player has won, he will have the opportunity to access a second phase where he will face a higher level society, now, as the neural network used in this second phase will already have prior knowledge of the techniques used by the player to reach that stage. In addition, the use of a hybrid model that includes Bayesian Networks is likely to improve the resilience of civilians according to the use of Case-Based Reasoning. Therefore, it is expected to contribute in being able to make intelligent Serious Games with a human-perceivable sense of reality, facilitating those patients to be treated in conjunction with commonly prescribed drugs, such as lamotrigine, decreasing adverse side effects and increasing their quality of life. In our future research, we will try to analyze the Golgi apparatus of patients to determine anxiety when playing this video game, as shown in Figure 7.

Figure 7.- *Visualization of a Golgi Apparatus.*



Source: *Own elaboration with respect to review literature.*

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CHAPTER 18

Ambient Intelligence in the Timely Detection of Color Vision Beficiency by Nursing

María Concepción de Luna-López*[1], Rosalba Robles-Ortega[2], Luis Ernesto Cervera-Gómez[1], Alberto Ochoa-Zezzatti[2], Juana Trejo-Franco[2], Luis Flores-Padilla[2], Michel Amador-Ruiz[1], Carlos Gerardo Urenda-Campos[1] and Francisco Javier Luevano-de la Rosa[1]

[1]*El Colegio de Chihuahua, Calle. Partido Días 4723, esquina con anillo envolvente del PRONAF Colonia Progresista 32310 Ci udad Juárez, Chihuahua, México.*
[2]*Universidad Autónoma de Ciudad Juárez. Ciudad Juárez, Chihuahua, México.*
**Corresponding author. Email: conyx06@gmail.com*

Abstract: The objective of this chapter is to provide reflections on how the nurse detects through a software detects deficiencies in color vision in children in the state of Chihuahua, Mexico. Bringing technology to marginalized places allows strengthening the activities that the nursing professional performs by detecting in a timely manner a public health problem that benefits the child population if it is diagnosed in time and thus, improve the educational performance of the student. A decisive aspect for the timely diagnosis is to determine the actions to follow for the children of Chihuahua and to specify who should use special lenses for this purpose.

Keywords: environmental intelligence, nursing, usability of the test, color discrimination and color perception.

Introduction

Vision Science understands that vision is a multisensory, perceptual and kinesthetic process and/or with the ability to process information from the environment, obtain meaning and understand what is seen through the visual system". The retina is the structural organ of vision with a photosensitive membrane, which contains photoreceptors: the cones that are responsible for day vision (photopic vision) and the rods responsible for night vision (scotopic vision). (Vicario, C.U. 1999) (Fransoy & Augé M., 2013). The trichromatic theory argues that the retina contains three types of particles which select and produce color effects and color discrimination results from the mixture of product colors. The three receptors mainly respond to red, yellow and blue light. The theory of the opposite color deriving from the subjectivity of color and the understanding of color vision was achieved when it was discovered that visual perception is processed in a series of zones (Chaparro Morales, I. 2018).

The visual process requires aspects that together will achieve visual perception (see table 1).

Table 1: *Interdisciplinary aspects.*

· Anatomy: Structure and organization of the eye and the visual pathway. · Physiology: Function of the eye and visual system. · Physics: Biophysics of image formation and photoreception · Microbiology: Eye pathology caused by microorganisms.	· Optometry: Functionality of the visual system in relation to the environment. · Pathology: Visual dysfunctions due to congenital pathological causes. · Psychology: Psychological mechanisms of visual perception. · Chemistry: Photochemistry of vision and chemical messages in the system.

Source: *own based on the neurobiology of vision book (Vicario, C. U. 1999).*

This visual disorder arises from the deficiency or absence of presenting proper photopigments that are embedded in the multiple sheathed membranes of the cone outer segments, and each photopigment consists of a protein residue attached to the retina. These photopigments are composed of cones that are activated by daylight and are responsible for the perception of the primary colors: blue, green and red. The rods are activated in the dark, perceiving colors in low light, such as black, white and grayscales. Our communication is based on the language of symbols, so color vision is of utmost importance (Hernández Santos, L. R. et al. 2019) (Mota, M. M. et al. 2019). Likewise, it is important to address visual problems from an early age. ICT should be considered as useful tools in the health field because timely and continuous attention to existing health problems has been guaranteed (Arandojo Morales, A. I., 2016). At this point, the nursing professional with the knowledge of digital tools strengthens the first level of care, by having the skills to use the digital resource and timely detect vision problems, which is considered a remarkable example of how ambient intelligence has achieved a great impact on health and society issues.

Impact of Ambient Intelligence

This technology, in an intelligent environment is a convergence of computers, biometric and wireless sensors, intelligent agents and emotional machines will endow our everyday home and work environment with intelligence and amplify our cognitive capabilities. In our immediate future, intelligence will permeate the environment and become an ambient presence. The convergence of computers embedded in everyday objects, wireless communications between them, next-generation interfaces, biometric sensors, intelligent agents, personalization systems, emotional machines, broadband, will shape the Ambient Intelligence that will surround us and amplify our cognitive capabilities. The devices that will make up this new environment will learn from people's needs and anticipate them. They will create an intelligent environment, at our disposal. Ambient intelligence will be invisible, customizable, adaptive and anticipatory of ourselves, person-centered. Emotional Computers, Nanotechnology, Artificial Life, Virtual Immersion Systems, Wireless, Biometrics, Personalization Systems, Intelligent Agents, Electronic Paper, Active Bioclimatics, hundreds of microcomputers embedded in clothes, in furniture, in elements of the environment are some of the technologies that will make up Ambient Intelligence. Ambient Intelligence is a concept that implies a new technological future scenario (Montebello, M. 2019).

Intelligent Interfaces

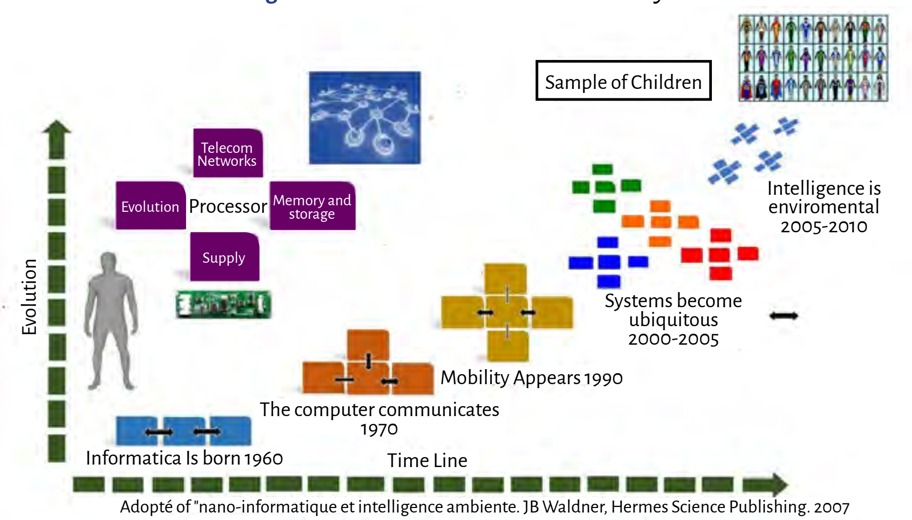
Smart interfaces allow the user to communicate with the devices in the smart environment in a simple way (Weitz, D. et al. 2016). The main goal of these interfaces is to hide the complexity of the system from the user and show only its functionalities. In this way, the user can get the service he needs without worrying about the inner workings of the intelligent environment. The interfaces used in intelligent environments must have the following properties:

- Multimodal communication: Interfaces must be able to communicate with the user in several ways: written messages, images, voice, gestures. This multimodal communication allows a more natural and richer interaction than currently exists in PCs (based on the use of keyboards, mice and screens).

- Context sensitivity: Interfaces must not only transmit data internal to the system, but must also see its environment. The system is not passive, but constantly collects information from the user to offer the most appropriate services (Teixeira, M. S. et al. 2019).

The way services are presented to the user is significant. Therefore, the development of intelligent interfaces is a key aspect for the success of the vision proposed by Ambient Intelligence (Nalepa, G. J. et al. 2019).The relationship between Intelligent Interfaces and natural language processing through grammars can help to communicate the Ambient Intelligence user with the interfaces in a simple way. Multimodal communication can be realized through a complete grammar, we can recognize any kind of sentence uttered by users with a level of complexity in which we can recognize task execution times, gender, number, interfaces involved. Moreover, by means of a Bayesian network system we can draw conclusions with a degree of probability produced by the uncertainty of some agents for which we cannot obtain concrete data. To obtain the rest of the data of the environment it is only necessary to have counters of the different data of the desired environment (see figure 1).).

Figure 1. *Time line associated with our study.*



Source: *Prepared by the authors*

Characteristics of the Ambient Intelligence Environment

Ambient Intelligence environments can be implemented in different domestic scenarios, in mobile spaces (car, train, plane), in public environments (offices, stores, hospitals) and even in small private spaces (smart clothes), thus serving the user in any scenario in which he/she carries out his/her activity. An environment can be described as intelligent when, in a non-intrusive way, the different technologies complement each other to provide users with the services and benefits that are demanded or can be expected to be demanded, in as many areas as are specific to those users. Thus, an intelligent environment will have a technological framework that, surrounding those who inhabit it, will be able to do and relate naturally with those users through multimodal interfaces. It will recognize users and their circumstances and act accordingly. That is, it must be sensitive to the presence of people. Have predictive behavior based on knowledge of the habit environment (Gomes, L. et al. 2019).

Nursing as a discipline, intervenes in the prevention, detection and treatment of multiple eye diseases so it can make a timely diagnosis in visual issues that require comprehensive care. With the knowledge and application of technological resources, it is more feasible to perform interventions from the first level of care, especially at an age between 6 and 12 years old school age, since it is a stage in which, if visual problems are detected in a timely manner, it favors the improvement of the student's academic performance and academic future. (Luegas Contreras, A.et al. 2014) (Cotter, S. A. et al., 2015).

The objective of this research is to analyze how the nurse shows the usability of a digital tool, that determines in a timely manner whether or not the person performing the test has problems in color discrimination, determining whether there is a visual problem and it is necessary to refer the patient to a specialist.

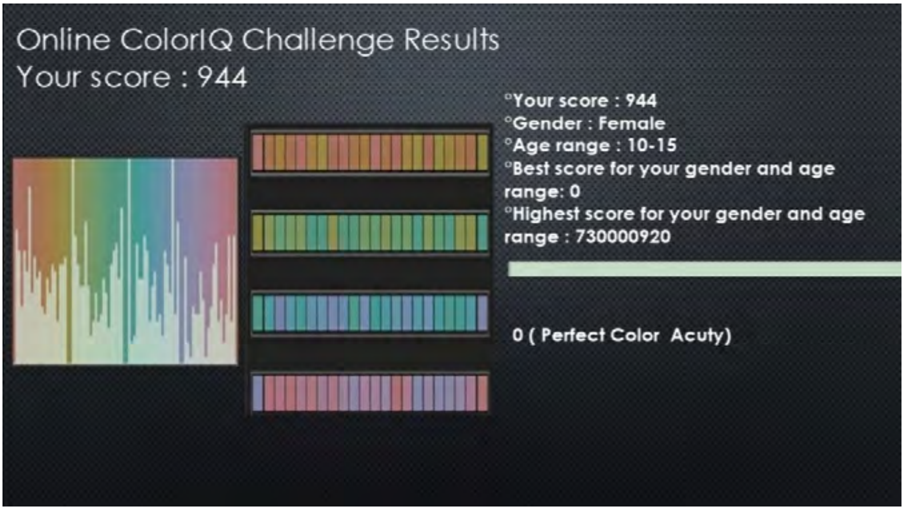
Methodology

Procedures and techniques

The Munsell Hue Test software is designed with 4 rows containing different shades of similar colors and each row has 20 frames. Each color shade at the end of a row is fixed in position to serve as an anchor and every tone square can be adjusted as the observer sees fit. The final arrangement of the squares represents the ability of the visual system to discern color differences. The Musell Hue test has been described as a laboratory device for color analysis (Farnsworth, D. 1943). Faults within the observer's visual system that are found in the test can be caused by two main factors: the number of cases in which the color squares are out of place or the level of displacement of a square (i.e. the distance between the place where the square should be placed to unify the shades and the place where it was actually placed). The closer the software value is to 0, the better the color discrimination; the closer it is to 1, the poorer the color discrimination. For the study we considered a sample of 20 elementary school children from different regions of the state of Chihuahua, Mexico. The procedure was explained with simple indications, and there was an adequate space for the test: a desk, chair, computer with internet network, comfortable and with natural light.

Figure 2 shows how technology allows for greater accessibility and the possibility of timely detection of a public health problem, such as color vision deficiency.

Figure 2. *Online ColorIQ Challenge Results*



Source: *Prepared by the authors with the imagine taken of software.*

When opening the application, the first thing displayed is a description of the application and the objective of the test. This description indicates that each color bar is to be ordered, the objective of the test and the instructions to be followed in the application. Once the test scoring button is clicked, the test starts, the image is presented and it is enabled so that with the mouse each box can be slid and ordered by shades starting with the color of the margin. At the end the program compares the results with others with similar demographic information by gender and age range, where a value of 0 is perfect color acuity and 99 is low color acuity. The closer the color acuity is to 0, the better the color vision. It is expected that, with this, the nursing professional will be able to identify the largest population in vulnerable groups with color vision problems with the technological resource.

Discussion of results

Results

20 people participated in the study was 20, whom ages ranged from 6 to 12 years, 11 men and 9 women.

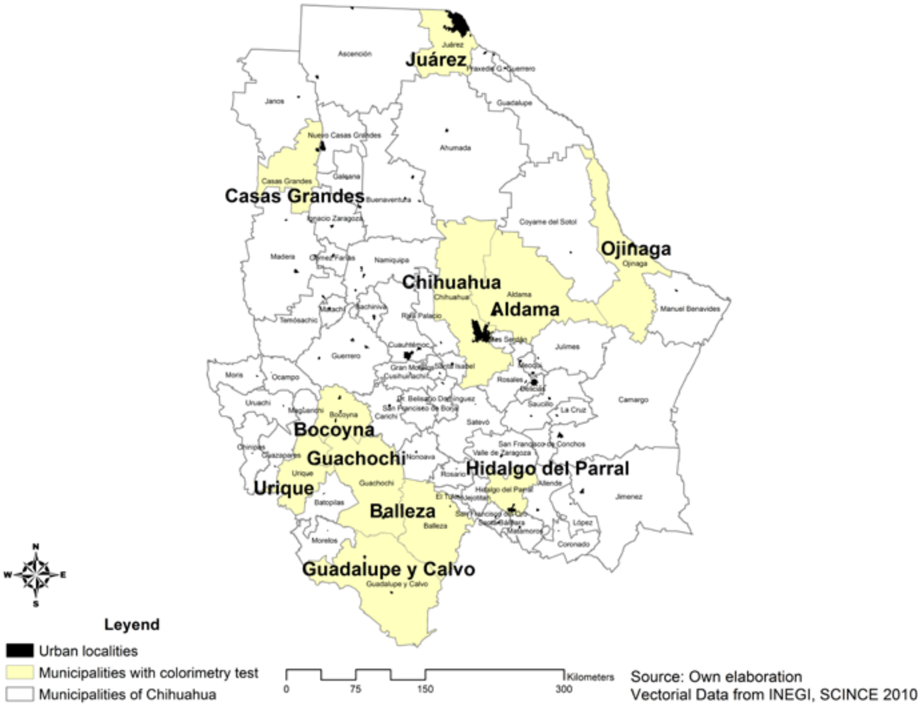
Table 2 shows the composition of the group examined and Figure 3 shows the distribution of the group by municipality in the State of Chihuahua.

Table 2. *Group under review*

Age in years	Female	Male	Total
6	1	0	1
7	0	2	2
8	0	1	1
9	4	3	7
10	2	2	4
11	1	2	3
12	1	1	2
Total	9	11	20

Source: *Prepared by the authors with data from the participants.*

Figure 3. Colorimetry test applied to students of grammar school level at Municipalities of Chihuahua (2020).



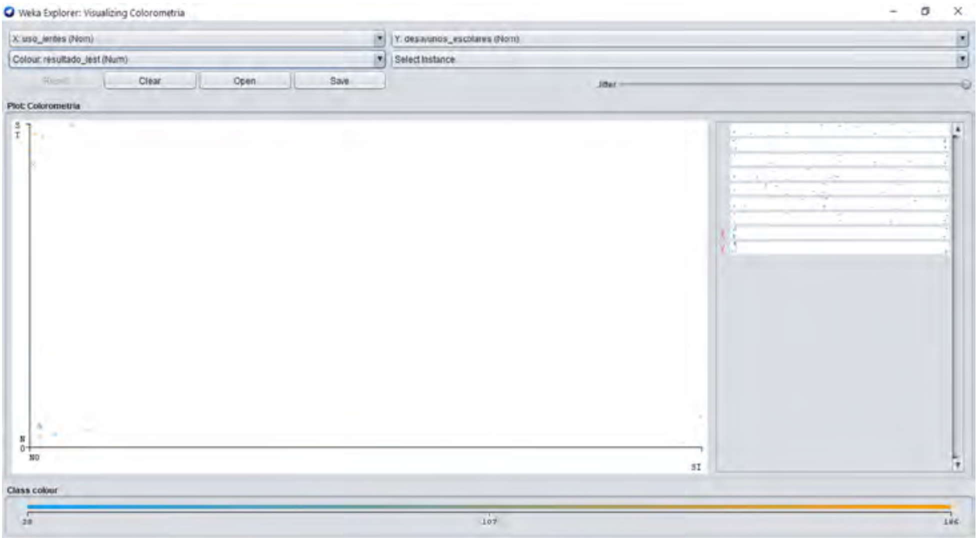
Source: Prepared by the authors with data from the participants.

The municipalities in the State of Chihuahua, Mexico where the tests were applied are: Ciudad Juarez, Casas Grandes, Chihuahua, Aldama, Ojinaga, Bocoyna, Urique, Guachochi, Hidalgo del Parral, Balleza, Urique, Guadalupe y Calvo (see figure 3).

With the Waikato Environment for Knowledge Analysis (WEKA) program, the data was grouped by finding an association between the lenses wearing, school breakfasts and test result attributes (see figure 4).

The first result is relevant, as expected, the test result is directly proportional in the selected attributes. Figure 4 shows the relationship between the selected attributes and the best test result. Making mention that the closer this is to 0, the better color discrimination.

Figure 4. *Weka Explorer*



Source: *Prepared by the authors with data from the participants.*

X: Lenses Wearing
Y: School breakfasts
Class: Test Result

As we can see in the illustration, the blue color represents the best color perception in the group of children who do not wear glasses and who do not receive school breakfasts at school. Another important aspect is that most of the children have difficulties in color perception even if they wear glasses and school breakfasts are provided by full-time schools (Figure 4).

The Munsell Hue test makes it possible to reliably measure and characterize the effectiveness of color discrimination in both healthy individuals and those with impaired color vision. The results of the test show that the older the age of the children, the greater the care they take in performing the test. This may be due to a greater understanding when it comes to explaining the importance of the study. Girls on average take longer, referring to school breakfasts the values are lower and it occurs in the unprotected population and it is where breakfasts are included in the school schedule, besides children do not eat well at home. The results of the test reflect that it is a problem in infrared colors more than in ultraviolet, that is to say, it is important that 20 children see better during the day than at night.

Table 3. *Survey Data*

FOLIO	SEX	AGE	TIME IN SECONDS	TEST RESULTS	SCHOOL GRADE	USE OF LENSES	SCHOOL BREAKFAST
1	W	11	252	28	6	NO	NO
2	M	12	306	94	5	NO	YES
3	M	10	369	67	5	NO	YES
4	W	10	483	88	5	NO	YES
5	W	9	720	186	4	NO	NO
6	W	6	720	152	2	YES	NO
7	M	9	615	52	4	NO	NO
8	W	12	329	60	6	NO	NO
9	M	7	450	140	2	YES	NO
10	M	8	420	95	3	NO	NO
11	W	9	480	181	4	NO	YES
12	M	11	360	171	6	NO	YES
12	W	10	540	163	5	NO	NO
14	M	11	60	128	6	NO	NO
15	W	9	780	66	3	NO	NO
16	M	9	900	55	3	NO	NO
17	W	9	660	75	3	YES	NO
18	M	7	1260	90	1	NO	NO
19	M	10	360	40	6	YES	NO
20	M	9	492	151	4	NO	NO

Source: *Own elaboration with data obtained from the survey.*

Conclusions and recommendations

With the technological resource and the usability of the software, it was possible to evaluate the perception of color in schoolchildren. The software was liked by the students since it is easy to use and visually engaging. It was detected that the older the student, the shorter the response time and the greater the ability to use the computer. The use of technological tools for timely diagnosis is feasible because more objective evaluations are obtained. Due to the characteristics and high reliability exposed in the test available in the Munsell Hue, the use of the test is recommended as a diagnostic tool for future studies in the evaluation of color in all children in regions where accessibility to technology is more difficult. The investigations reviewed have used different tests that have similarities, but can be complementary so that the nursing professional can detect color vision deficiencies in a timely manner. Color vision perception is a public health problem and affects a large population, especially children, who are more vulnerable. Therefore, it is important to prevent, detect and treat this problem in a timely manner to reduce the consequences of this problem in their daily life and schooling. The role of the nursing staff in the detection is through the use of new complementary and timely technologies with excellent usability, which facilitates reading with this type of technological applications as one of the diagnostic tests of low cost and access to all types of population. It is of utmost importance to implement strategies that address the early detection of eye problems, while highlighting the importance of the sense of vision as part of the ability of individuals to interact, communicate and learn, which is why a decrease in vision has an impact on the proper development of children. It is also significant to consider that environmental intelligence in the field of health and education are references to continue generating research and demonstrate that disciplines can be united for the good of the population.

Future research

The use of Artificial Intelligence focused on the continuous improvement of specific applications for the timely diagnosis of hereditary diseases or diseases associated with the environment to achieve a paradigm shift for the children of Chihuahua and allow in this case to distinguish objects by day and see dangers at night, something common in rural areas of the state. (This is sentence does not propose any future research)

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CHAPTER 19

Industry 4.0 Sustainability in Manufacturing Enterprice and Impact on Poverty Mitigation in Ciudad Juarez

Carlos Gerardo Urenda Campos*[1], Cely Celene Ronquillo Chávez[2], Michel Amador Ruiz[1], María Concepción de Luna López [1], Armando Esquinca Moreno[3], José Luis Ibave Gonzalez[3]

[1] El Colegio de Chihuahua, Calle. Partido Días 4723, esquina con anillo envolvente del PRONAF colonia Progresista 32310 Ciudad Juárez, Chihuahua, México.

[2] Universidad Autónoma de Ciudad Juárez

[3] Universidad Autónoma de Chihuahua

**Corresponding author: curenda@alumnos.colech.edu.mx*

Abstract. Based on the economic constraints faced by the production workers in the manufacturing industry, it can be stated that poverty and this industry are closely related. Even though the manufacturing industry provides jobs for several number of locals in Ciudad Juarez, these people tend to live in the most marginalized areas of the city.
Keywords: Sustainable Development Goals, Poverty measurements and analysis, Human development indez, Geospatial analysis of the poverty.

Introduction

The Sustainable Development Goals offer a set of objectives that give a system for (federal and local) governments to work in a standard manner. People, planet, prosperity, peace and association maintain the reasonable connection between the monetary, social and biological framework. Practical improvement investigates 17 significant difficulties associated with diverse features that focus on ending destitution by allowing all individuals that suffer hunger to be paid above the need line so that they can afford food for every meal. This guarantees wholesome living by giving sanitary measures to battle COVID-19, HIV/AIDS and other destructive sicknesses. Offices for comprehensive and profound learning with the assistance of quick advances in innovation achieve gender equality by employing women. Solar and wind based-power is used to diminish water contamination and water squandering. Manageable financial development and gainful work provides a respectable working level to employees. Industrialization, sustainable advancement and framework decrease in disparity in remuneration and abundance, as well as those dependent on age, sex, handicap, nationality, race, origin or social standing, make urban communities and human settlements bearable. It additionally aids in combating environmental change, controlling and supporting seas and marine assets, expanding the sustainability of the biological system and biodiversity, building comprehensive social harmony and aiding in the advancement of worldwide associations. The ten advances of Industry 4.0 sensors are: drones, miniature mechanical technology, virtual and expanded reality, added substance production, information examination, network protection, distributed computing, and innovation of things (IoT) give a proficient answer to the difficulties of sustainable turn.

For decades, the federal government has implemented social programs to serve low-income families, although the results have been minimal or nonexistent. A significant amount of economic resources are allocated to combat poverty at the national level and the effects they have had in reducing poverty in Mexico are few. Therefore, it is important to analyze these public policies implemented by the federal government in the last 30 years and investigate why the programs are not meeting the objectives established in the reduction of multidimensional poverty in the different states of the country. These programs have considered priority attention zones, which are areas or regions predominantly rural or urban-whose population registers poverty indexes, marginalization indicating the existence of marked insufficiencies and backwardness in the exercise of social development rights. Their determination is guided by the results criteria defined by the National Council for Social Development Policy and must, at all times, promote the quantitative and qualitative effectiveness of the executors of social policy (Art.29 General Law of Social Development, Congress of the Union, 2018).

In the decree declaring the Priority Attention Zones for 2019 in Ciudad Juarez Chihuahua, 111 zones were determined in this locality, in which social programs to combat poverty will be focused in these Basic Geostatistical Areas with an acronymus (AGEB). This study will focus in this border area (Cámara et al., 2019). The Social Development Law establishes that on an annual basis the federal executive will review the priority attention zones, taking as a reference the evaluations of results of poverty measurement studies, issued by the National Council for the Evaluation of Social Development Policy CONEVAL (Art.30 General Law of Social Development,2018).

Figue 1. *Priority Care Areas, Ciudad Juárez, Chihuahua, 2010.*

Source: *: Author's elaboration with information CONEVAL estimation based on the 2010 population and housing census*

Figure 2. Priority Care Areas 2019

Source: Author's elaboration with information official Journal of the Federation (2018)

Justification

The United Nations General Assembly, at its meeting held in September 2015 in New York, established 17 goals in the 2030 agenda for sustainable development. This proposal was signed and agreed by 193 member states of this assembly, including Mexico, in which goal number 1, called the end of poverty, points out five goals to be achieved in this fifteen year period (United Nations/ECLAC, 2016). The most relevant goals are to eradicate extreme poverty in its entirety, reduce poverty statistics for men, women and children by fifty percent and ensure that people living in this situation have equal rights to economic resources and basic services (United Nations/ECLAC, 2016). Therefore, it is important to analyze the reasons why policies in Mexico, focused on combating this problem over a period of 30 years, have reduced the population living in poverty by a minimal percentage. Analyzing similar programs in other countries with similar characteristics to Mexico, such as emerging economies and the largest in Latin America, such as Brazil, where these programs with similar characteristics have had a relevant impact in this area (Celso Garrido, n.d.) is essential to solve the problem.

The Brazil case study

The Bolsa Familia program in Brazil is a conditional cash transfer program implemented in 2003 by the Ministry of Social Development and Fight against Hunger, which benefits families with incomes below 154 Brazilian reals, equivalent to about 808.5 Mexican pesos per month. An achievement that improved the regulation of beneficiary payments, in 2011 the program was consolidated, as well as the beneficiaries' commitments (Hellmann, 2015). For each municipality an estimate of families in poverty was established and through a census and demographic research it was determined that the priority families were those belonging to an indigenous ethnicity, with members freed from slave labor and families in a situation of child labor (Hellmann, 2015). And through a detailed breakdown of the characteristics of families in poverty, it was possible to significantly reduce poverty rates in Brazil over a period of 10 years, from 9.7% to 4.3% at the national level (Mariana Ceratti, 2014).

Figure 3

Source: *Author's elaboration*

Development

The importance of the design and implementation of national public policies to combat poverty is of the utmost significance for their impact and proper functioning. It is necessary to examine what criteria the CONEVAL (National Council for the Evaluation of Social Development Policy) to determine the Priority Attention Zones, since as shown in Figure 1.1 and 1.2 in a period of nine years there have been minimal updates, which could be taken into consideration because in the southeast and northeast of the city there are areas where low-income families live that often cannot access these programs because the area where they live is not considered a priority attention zone, given that their streets have roads and urban services.

Luis F. Aguilar (2010, 31) states: "public policy is understood as a specific plan of action, a limited plan, aimed at achieving objectives related to the solution of specific problems and the improvement of social life situations, each of which is different and has its own circumstances". In this logic, public policies "do not constitute a utopia or a political project for society, but a concrete response to specific problems" (Merino, 2013,179). The specificity that distinguishes the policy approach, however, can generate a problem of myopia: focusing carefully on each public policy without reviewing the whole, or believing that this set of public policies is automatically harmonious and complementary. It can be a mistake to assume that, by having well-designed and implemented policies, one has a set of coherent public policies, whose results complement or reinforce each other and that, as a whole, now solve the major problems of a country (CEJUO, 2016).

It is imperative to carry out a coordination between municipality, state and federation that can give certainty to the detection of poverty polygons that are not considered in the federal declaration for updating, or that these policies are not determinant for access to social programs, which although it is important to determine the areas of priority attention, are these policies to prioritize investment in urban infrastructure such as paving, lighting, drainage, drinking water.

Figure 4

Source: *Author's elaboration*

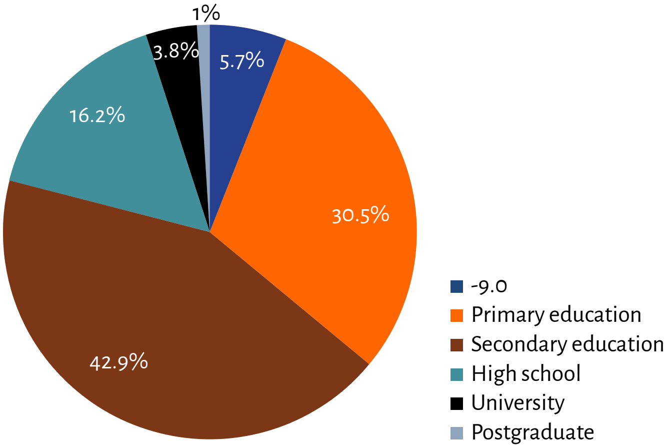
Source: *Author's elaboration*

Source: *Author's elaboration*

The Riveras del Bravo neighborhood is one of the areas with the highest index of marginalization in Ciudad Juarez, but because it is not considered in the declaration of Priority Attention Zones, it is excluded from the application of federal programs to combat poverty and the families living in this area are left unprotected. In order to conduct the analysis, an evaluation instrument for these social programs was piloted and applied in three poverty polygons established in the Priority Attention Zones, as established in the decree of declaration of ZAPs 2019 issued by the Chamber of Deputies, and a polygon outside these zones, in which 105 questionnaires were randomly applied to households within these zones, 4828, 8106 and 5084 , also included the Riveras del Bravo neighborhood, which is not considered as a ZAP in this declaration.

When analyzing the data in SPSS, it was detected that the characteristics of these four polygons are very similar, 5.7% of this population has no studies, 42.9% of the respondents have secondary education, 30.5% have only primary education, that is, 79.1% have basic education or no studies, 16.2% have high school studies, 3.8% have university studies and 1% have postgraduate studies.

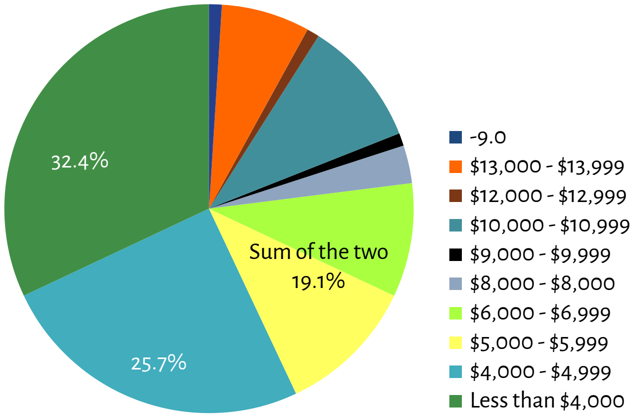
Figure 5. *What is your highest level of education?*



Source: *Author's elaboration*

The incomes per family are closely related in these areas. 32.4% of the population surveyed has an income of less than 4,000 thousand pesos per month, 25.7% earns less than 5,000 pesos monthly and 19.1% less than 7,000 pesos, the remaining 23% varies between 8,000 and 13,999 thousand pesos per month divided into 6 categories, i.e. 58.1% has an income of less than 5,000 pesos.

Figure 6. *What is your monthly income?*



Source: *Author's elaboration*

The families surveyed in the pilot are made up as follows: 14.3% are more groups made of five people, 29.5% have five members per home, 17.1% by four members, 18.1% by three members. That is, 79% of the homes surveyed are made up of more than three people, if we multiply this data by the minimum welfare line that CONEVAL stipulates at 1,338.36 pesos per month per person from the food basket, plus 1,375.80 from the non-food basket. State the final result necessary to cover the basic needs associated with a family.

Figure 7. *Urban Food Basket at Price*

Urban Food Basket at Prices		feb-20			
Group	Name	Consumtion	Price x kg/l	Daily Cost	Monthly Cost
		1,592.5		$ 44.63	$ 1,338.86
Corn	Corn tortilla	155.4	14.0	$ 2.18	$ 65.30
Wheat	Pasta for soup	5.6	28.6	$ 0.16	$ 4.85
	White bread	26.0	29.4	$ 0.76	$ 22.93
	Candy bread	34.1	53.3	$ 1.82	$ 54.59
	Sandwich bread hamburgers	5.6	47.9	$ 0.27	$ 8.01
Rice	Rice grain	9.2	17.7	$ 0.16	$ 4.90
Other cereals	Corn,Wheat,rice,oatmeal	3.6	59.3	$ 0.21	$ 6.45
Beef and veal steak	Bistec: watery,cuete,pigeon,leg	21.1	128.9	$ 2.72	$ 81.51
	Ground beef	13.9	111.2	$ 1.55	$ 46.35
Pork beef	Rib and chop	20.3	72.3	$ 1.47	$ 43.97
Processed Meats	Chorizo an sausage	3.1	85.5	$ 0.27	$ 8.03
	ham	4.1	84.3	$ 0.35	$ 10.37
Chicken	Leg, thigh and breast on the bone	15.8	53.1	$ 0.84	$ 25.10
	Leg, thigh and breast whitout bone	4.5	73.5	$ 0.33	$ 10.01
	Chickenwhole	17.1	48.1	$ 0.82	$ 24.65
Fresh fish	Whole fish	3.4	58.8	$ 0.20	$ 6.03
Milk	Cow milk, pasteurized,whole,ligth	203.8	14.5	$ 2.96	$ 88.67
Cheese	fresh	4.8	69.4	$ 0.34	$ 10.08
Other milk products	Yogurt	6.7	32.4	$ 0.22	$ 6.49
Eggs	Chicken	33.4	27.9	$ 0.93	$ 27.90
Oils	Vegetable oil	10.9	23.3	$ 0.25	$ 7.60
Raw or tuber	Potatoes	44.6	12.0	$ 0.57	$ 17.10

Monthly value per person of the urban food basket

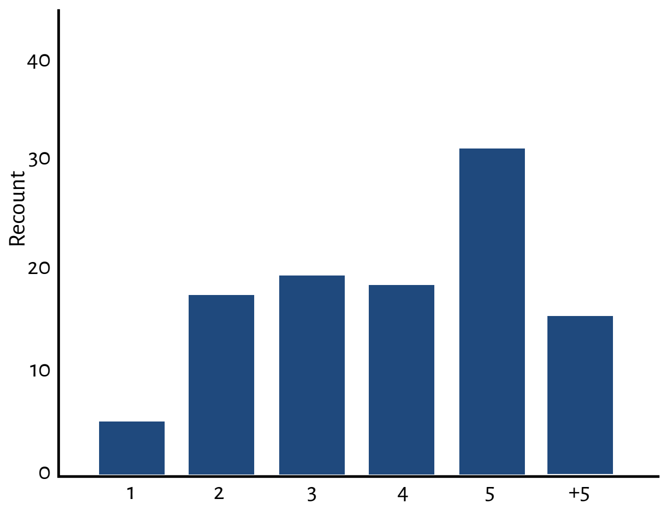
Source: CONEVAL

Figure 8. *Monthly value per person of the welf line associated with an average family.*

Montly value per person of the Welfare Line (food basket plus non-food basket)	feb-20			
	Urban Basket		Rural Basket	
Food plus non-food baskets (Welfare Line)	**$**	**2,714.66**	**$**	**1,755.57**
Grup				
Food Basket (Minimum Wlfare Line)	**$**	**1,338.86**	**$**	**959.72**
Non-Food Basket	**$**	**1,375.80**	**$**	**795.85**
Public Transportation	$	223.27	$	136.09
Cleaning and care of tjc house	$	72.24	$	65.98
Personal care	$	127.46	$	81.08
Education,Culture and recreation	$	266.45	$	101.50
Communications an vehicle services	$	57.26	$	15.37
Housing an conservation services	$	209.24	$	118.36
Clothing, footwear and accesories	$	171.01	$	111.77
Glssware, linens an household utensils	$	19.37	$	14.93
Health care	$	176.85	$	121.10
Household goods and home maintenance	$	22.96	$	13.72
	$	5.81	$	2.04
Other expenses	$	23.88	$	13.89

Source: CONEVAL

Figure 9. *How many people live in the house?*



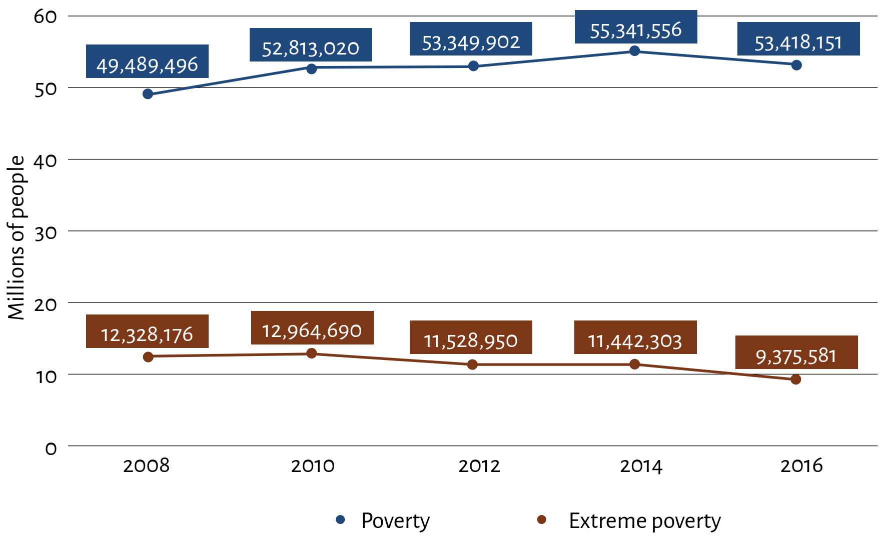
Source: *Author's elaboration.*

Conclusions

The basic welfare line for households made up of five people would be 13,573.3 pesos per month and for families of four 10,858.64 according to the CONEVAL, that is, 60.9% of the surveyed households require between 10,858.64 and 13,573.3 pesos per month to meet their food and non-food needs and as we could analyze in Fig.1.2 82% of the surveyed population has an income of less than 10,000 pesos, therefore they could not satisfy the basic food and non-food basket. These families live in clearly identified poverty polygons and three of them have been determined as priority attention zones by the Welfare Secretariat, therefore they should be receiving support from some social program to help them solve their poverty situation. Nevertheless, with the sample taken, it could be observed that this is not the case; out of 105 households surveyed, 90 do not receive any governmental support, only 15 families are benefited by some federal government program, that is, 85.7% of the households**.**

These programs have historically been used by governments to create political structures to attract votes for the different local state and federal elections, and this could be one of the main reasons why these programs have not been able to reduce poverty statistics in Mexico since the benefits do not always reach those who need them most, but rather those who actively participate in the proselytism of the electoral campaigns of the party in power. The billions of pesos destined to these social programs can be a very profitable capital for the creation of partisan structures, in this way, the resources destined to these programs become very attractive to support economically or in kind the people who participate in these political structures, Regardless of whether they comply with the socioeconomic studies or the location of the houses outside the Priority Attention Zones, which makes it impossible for people who really need these resources for the education of their children or to access the basic food basket to achieve it, and therefore the little or no impact on poverty indicators, as we can see in the following figure.

Figure 10. Number of people living in poverty in Mexico, 2008-2016



Source: *Coneval estimates based on MCS-ENIGH 2010,2012, 2014 and MCS-ENIGH 2016.*

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CHAPTER 20

Elements of the Tap and Sociodemographic Variables that Influence the Entrepreneurial Intention of University Students: A Statistical Analysis

Michel Amador Ruiz[1],Karla Erika Donjuan Callejo[2], Sarahí Sánchez León[3], Carlos Gerardo Urenda Campos[1], María Concepción de Luna López[1], Alberto Ochoa Ortiz Zezzatti[4] y Gisela Medrano Hermosillo[5]

[1] El Colegio de Chihuahua, [2] Universidad Popular Autónoma de Puebla, [3] Universidad Autónoma de Quintana Roo, [4] Universidad Autónoma de Ciudad Juárez, [5] Universidad Pedagógica Nacional

**Corresponding author. Email: mruiz@alumnos.colech.edu.mx*

Abstract. This chapter presents a multivariate analysis of the Entrepreneurial Intention (EI) in a sample of university students from the Autonomous University of Chihuahua, Mexico, specifically in the Faculty of Political and Social Sciences at its Juarez and Chihuahua campuses, applying the Entrepreneurial Intention Questionnaire (EIQ). This questionnaire, developed and validated in Spain (Rueda, Moriano, & Liñán, 2015) and in Colombia (Laguia, Moriano, Molero, & Gámez, 2017) is framed within the Theory of Planned Action (TPA) (Ajzen I., 1991). The TPA is currently the most widely used model to predict entrepreneurial intentions. With a sample of 20 university students per campus, it can be seen that the TPA has a high reliability and predictive validity on entrepreneurial intention. Having reliable and validated measurement scales in different cultural contexts allows an easier comparison between different organizations. A better knowledge of the psychosocial background (attitudes towards entrepreneurship, subjective norm and entrepreneurial self-efficacy) that lead university students to become entrepreneurs can contribute to a more adequate design of the entrepreneurial training programs that are being promoted in many universities and from other types of institutions. Nevertheless, it is observed that there is no vision towards entrepreneurship related to Industry 4.0 in university students outside the training fields of technology and engineering.

Keywords: entrepreneurship; attitude; subjective norm; entrepreneurial self-efficacy; theory of planned action (TAP); industry 4.0, entrepreneurial intention.

Background

Entrepreneurship is considered a phenomenon of great importance for the development of the economy and fundamental for encouraging business innovation (Ubierna Gómez, 2014). With the current crisis, entrepreneurship is one of the solutions that allow the creation of value, more efficient companies and economic and social development (Vivel Búa, Fernandez Lopez, & Rodeiro Pazos, 2011). Within this perspective, according to the National Survey on Productivity and Competitiveness of Micro, Small and Medium Enterprises (ENAPROCE 2018) in our country, in 2018, there were a total of 4 million 057 thousand 719 micro enterprises, with a market share equivalent to 97.3 percent. In addition, there were 111,958 Small and Medium Enterprises (SMEs), with a market share of 2.7%. In total, in Mexico there is 4,169,677 Micro, Small and Medium Enterprises (MSMEs) classified in the manufacturing, trade and non-financial private services sectors.

Entrepreneurship plays a fundamental role in the emergence and exploitation of the Fourth Industrial Revolution (Industry 4.0), which is characterized by the increased digitalization and interconnection of products, value chains and business models. In this new environment, competitiveness no longer depends solely on the optimization of in-house resources, but also on the capacity for innovation in the value chain between organizations and the technologies, products, services and systems of partners. (Serrano Santoyo & Lopez Hernandez, 2020). In the entrepreneurship research, there has been different models and explanatory theories over time. The models of entrepreneurial intention are quite complete models that arise from the limitations to the models of personality characteristics (Robinson, Stimpson, Huefner, & Hunt, 1991), (Shane & Venkataraman, 2000) and combine factors that other models address separately. In the entrepreneurship research, there has been different models and explanatory theories over time. The models of entrepreneurial intention are complete models that arise from the limitations to the models of personality characteristics (Robinson, Stimpson, Huefner & Hunt, 1991), (Shame & Venkataraman, 2000) and combine factor that other models addres separately, these factors can be personal, values, attitudes, motivations, and social factors such as social support, subjective norm, perception of opportunities and/or perception of resources.

Planned behavior is the direct result of an individual's intentions, in turn, intentions are formed and remain until opportunity and time are given. Under these conditions, the subject moves from intention to action (Ajzen & Fishbein, 2005). Thus, entrepreneurial behavior can be considered planned behavior and within this context arises the studies conducted in countries such as Spain (Jaen, Moriano & Liñán, 2013; Liñán, Urbano & Guerrero, 2011; Mariano 2005), United States (Autio, Keeley, Klofsten, Parker & Hay, 2001) and in Colombia (Laguia , Moriano , Molero , & Gámez , 2017) that highlight the importance and robustness of the Theory of Planned Action (TPA) construct as a way of predicting entrepreneurial intent, not only in individual psychological factors, but also by social factors (Krueger, Reilly and Carsrud, 2000). Entrepreneurial intentions, in turn, are a crucial antecedent to entrepreneurial behavior (Lee, Wong, Foo, & Leung, 2011).

The TPA model is open to the inclusion of other variables that may allow a greater explanatory capacity (Ajzen, 1991). In this context, recent studies show the direct or indirect influence of values on the intention to undertake (de Groot and Steg, 2010; Jaén et al., 2013; Liñán and Chen, 2009; Mariano, 2005; Mariano, Trejo and Palací, 2001) and of gender (Díaz-García and Jiménez-Moreno, 2010; Díaz García, 2012; Gupta, Turban, Wasti and Sikdar, 2009; Langowitz and Minniti, 2007; Marlow and Patton, 2005). Since the study of TPA is of great interest (Autio et al., 2001; Kolvereid, 1996; Mariano et al., 2012), in Ciudad Juarez, it is essential to carry out studies that allow progress in the understanding of this phenomenon, taking into account sociodemographic variables that can influence the entrepreneurial intention of university students.

The Entrepreneurial Intention

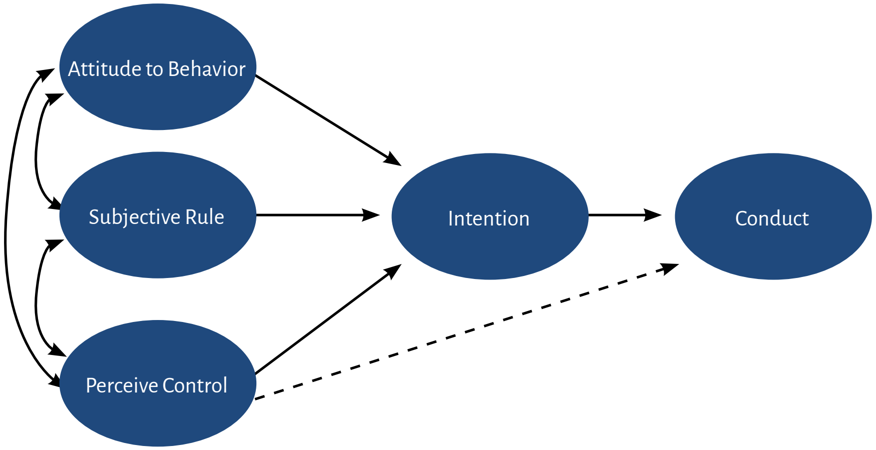
The connection between cognition and action has been addressed through the study of attitudes, behaviors and the role of intention in this relationship (Bagozzi, Baumgartner & Yi, 1989). In the literature on attitudes, some authors refer to their direct influence on behavior (Foxall, 1984); other authors argue that attitudes only influence behavior through their impact on intentions (Bettman, 1986, cited in Bagozzi et al., 1989). Various psychological models address the attitude-intention-behavior relationship (Ajzen and Fishbein, 1980; Triandis, 1979) and argue that intentions are the best indicator of behavior in its purpose of carrying out an action. Even though intention is a key component in preparing the mind, we cannot establish a linear relationship between intention and action. Triandis (1979) defines intentions as a kind of command or instruction that people give themselves to behave in a way they consider appropriate, thus constituting the decisions made to perform certain particular actions. Intentions can be inferred from people's responses in the form of: "I intend to do..." or "I plan to do..." or "I will do...". In psychological terms, intentional behavior integrates both the direction of the decision and its intensity (Sheeran, 2002). Ajzen and Fishbein (2005) also refer to intentions as the behaviors that people can execute under voluntary control: "A person forms an intention to perform a certain behavior, this intention remains a disposition until, at the appropriate time and opportunity, the attempt is made to translate the intention into action" (Ajzen and Fishbein, 2005, p. 199).

In the case of the study of the entrepreneurial phenomenon, individuals who act as entrepreneur's manifest behaviors and attitudes that are generally formed by motivations (Gray, Foster and Howard, 2006). Krueger (2007) states that behind the entrepreneurial action there are the entrepreneurial intentions. Given that entrepreneurial intentions are conceived as a link between the entrepreneur as an individual and the context within which an initiative is created (Bird and Jelinek, 1988), the study of intentions constitutes one of the most viable precursors of the entrepreneurial behavior that results in the creation of new businesses (Liñán, Rodríguez-Cohard and Rueda-Cantuche, 2011; Prodan and Drnovék, 2010). The study of entrepreneurial behavior was initially associated with the personality of the subject (Baum, Frese, Baron & Katz, 2007). Nonetheless, due to the inconsistent result, numerous criticisms arose (Gartner, 1989; Keh, Foo & Lim, 2002). In this sense, Liñán (2004) refers that models of entrepreneurship based on personality traits or demographic factors are less robust and have less predictive power than those based on entrepreneurial intention. Finally, recent models refer to the that entrepreneurial intent depends on the combination of personal factors (e.g. values, attitudes, motivations, personality traits) and on social factors (social support, subjective norm, perception of opportunities, perception of resources). Krueger et al. (2000) point out that the models of Entrepreneurial Intention function as solid, generalizable models that constitute a robust theoretical framework for analyzing and predicting entrepreneurial intention from an integrative perspective of the person and his/her environment.

The Theory of Planned Action

The models of Entrepreneurial Intention arise from the limitations and criticism of the models of personality traits of entrepreneurs (Robinson et al., 1991; Shane and Venkataraman, 2000; Shaver and Scott, 1991). Unlike personality traits, the development of entrepreneurial intention depends on a combination of personal factors, such as values, attitudes, motivations and personality traits, and social factors, such as social support, subjective norms, perception of opportunities and perception of resources. The TPA constitutes a revision of the Theory of Reasoned Action and includes a new conditioning in the intention, in which the perception of the individual about his or her capacity to produce a result is reflected (Ajzen, 1991). In both theories, intention is assumed as the immediate antecedent of behavior, since, by achieving a sufficient degree of real control over behavior, people are expected to carry out their intentions when the opportunity arises (Fishbein and Ajzen, 2010). According to TPA, intention is a function of attitude towards behaviour, subjective norm and perceived control. (Figure 1).

Figure 1. *Representation of the TAP.Adapted from "The theory of planned behavior".*



Source: *I. Ajzen, 1991, Organizational Behavior and Human Decision Processes, 50, p.182.*

Method

Participants

In this exercise, two samples were selected from 20 university students (men and women) between 18 and 29 years old, from the Faculty of Political and Social Sciences of the Autonomous University of Chihuahua in its Juarez and Chihuahua campuses, corresponding to the academic programs of Communication Sciences, Public Administration and International Relations. For the analysis, the following elements were taken into account: the intention of the professional path to be followed and those statements that were considered to have the greatest impact on each element of the TPA model (attitude, subjective norm, self-efficacy) in relation to the sociodemographic variables such as age, sex, socioeconomic group to which they belong (self-perception), if within their family circle there are entrepreneurs or businessmen, to see the relationship between the selected variables and the answers in the instrument.

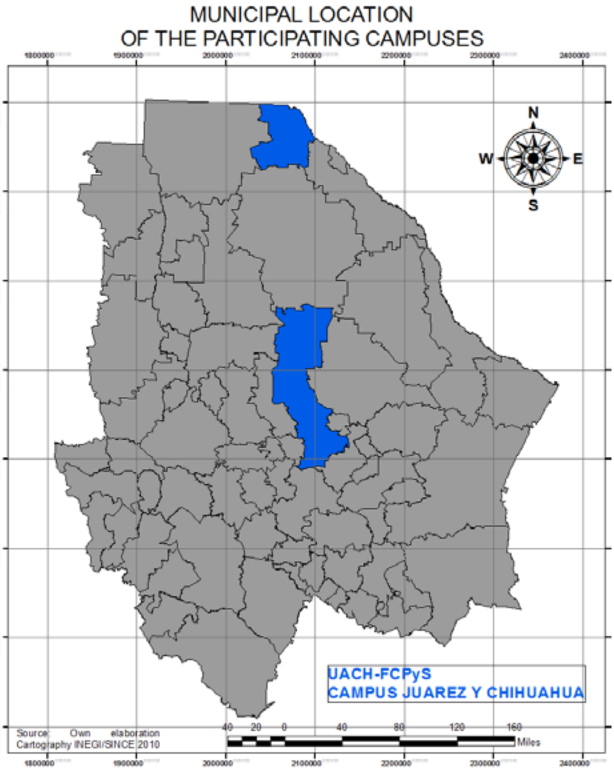
Instrument

This chapter was prepared within the framework of the TPA (attitude, subjective norm and self-efficacy) and the collection of data was gathered through the Entrepreneurial Intention Questionnaire (Rueda, Moriano, & Liñán, 2015). The items have a Likert-type measurement format ranging from 1 to 7 divided into three statements for each element of the TPA: not at all interested, moderately interested, totally interested; totally unlikely, moderately probable, totally probable; not at all desirable, moderately desirable, totally desirable; totally ineffective, moderately effective, totally effective; not at all agreed, moderately agreed, totally agreed; not at all important, moderately important, very important and not at all, moderately and totally, where numbers 1 and 2 correspond to the first statement, 3, 4 and 5 to the second and 6 and 7 to the third statement respectively. Below are the results of the analysis of the selected CIE items.

Procedure

A simple random sampling was carried out in the Faculty of Political and Social Sciences in both campuses (see Image 1) during the month of February, within the data requested in the EIQ, demographic data were requested (personal, professional and of academic formation). The questionnaire was applied in class hours and under supervision to solve possible doubts with the questionnaire.

Image 1: *Municipal Location of Participating Campuses.*



Source: *Own elaboration with data from INEGI/SINCE 2010.*

Results of the statistical analysis

Among the attitude towards entrepreneurial behavior items such as "Creating a new business (being an entrepreneur) would mean for you…" and "To what extent are desirable for you in your general life…" one item was selected for each response group: "Being creative and innovative" and "Being independent (your own boss)". Both items on a Likert scale of 1 to 7, where 1 is "Totally unlikely" and 7 "Very likely", as well as 1 "Not at all desirable" and 7 "Very desirable" respectively. We can observe that 87.5% of the students responded that to be an entrepreneur it is "Totally probable" (TP) that they must be creative and innovative, while only 5% responded that it is totally improbable (TI) (Table 1). While for the second item 87% of the students responded that it is "Totally desirable"

(TD) to be independent (own boss) and 12.5% responded that it is "Moderately desirable" (MD) (Table 2).

Table 1. *Creating a new company (being an entrepreneur) would mean for you...* be creative and innovative.

		Frequency	Percentage	Valid percentage	Cumulative percentage
Valid	3 TI	1	2.5%	2.5	2.5
	4 MP	1	2.5%	2.5	5.0
	5 MP	3	7.5%	7.5	12.5
	6 TP	11	27.5%	27.5	40.0
	7 TP	24	60.0%	60.0	100.0
	Total	40	100.0%	100.0	

Source: *Prepared by the authors with SPSS.*

Table 2. *"To what extent are they desirable for you in your general life...?" Being independent (your own boss).*

		Frequency	Percentage	Valid percentage	Cumulative percentage
Valid	4 MD	1	2.5%	2.5	2.5
	5 MD	4	10.0%	10.0	12.5
	6 TD	17	42.5%	42.5	55.0
	7 TD	18	45.0%	45.0	100.0
	Total	40	100.0%	100.0	

Source: *Prepared by the authors with SPSS.*

For the subjective standard which is composed of two groups, the first corresponds to "Think now about your family and closest friends. To what extent would they agree with you deciding to start and maintain your own business?". The second: "How would you rate the opinion of these people in this regard? I consider that..." one item per group was selected; that of my direct family (parents and siblings). Likewise, it is on a Likert scale of 1 to 7, where 1 is "Not at all in agreemen"t and 7 is "Totally in agreement" and 1 "Not at all important" and 7 "Totally important". It can be observed that the perception they have of their direct family circle, 85% of the students responded that the opinion of their direct family would "Totally Agree" (TA) while only 2.5% responded that they would "Not Agree" at all (NA) (Table 3). As for the second item, which values the opinion of this family circle, 82.5% of the students responded that it is (VI) while 17.5% responded that it is moderately important (MI) (Table 4).

Table 3. *To what extent would you agree if you decided to start and maintain your own business? My direct family (parents and siblings).*

		Frequency	Percentage	Valid percentage	Cumulative percentage
Valid	2 NA	1	2.5%	2.5	2.5
	4 MA	3	7.5%	7.5	10.0
	5 MA	2	5.0%	5.0	15.0
	6 TA	6	15.0%	15.0	30.0
	7 TA	28	70.0%	70.0	100.0
	Total	40	100.0%	100.0	

Source: *Prepared by the authors with SPSS.*

Table 4. *"How do you assess the opinion of these people in this regard? I consider it..." My immediate family (parents and siblings).*

		Frequency	Percentage	Valid percentage	Cumulative percentage
Valid	3 MI	2	5.0%	5.0	5.0
	4 MI	3	7.5%	7.5	12.5
	5 MI	2	5.0%	5.0	17.5
	6 MYI	6	15.0%	15.0	32.5
	7 MYI	27	67.5%	67.5	100.0
	Total	40	100.0%	100.0	

Source: *Prepared by the authors with SPSS.*

Entrepreneurial self-efficacy consists of a group of 6 items and refers to the sentence: "Indicate to what extent would you be able to effectively perform the following tasks: ...", two items were selected for this purpose. "Recognize opportunities in the market for new products and/or services" and "Create and operate a new business", both on a Likert scale of 1 to 7 where 1 is "Totally Ineffective" and 7 is "Totally Effective". Regarding item 1, 60% of the students responded totally effective (TE), 37.5% responded moderately effective (ME) and only 2.5% responded totally ineffective (TIE) when asked about the possibility of recognizing opportunities in the market for new products and services (Table 5). For item 2, 55% of the students responded feeling very effective (VE) while 45% responded feeling moderately effective when asked about Creating and running a new business (Table 6).

Table 5. *"Indicate to what extent you would be able to effectively perform the following tasks: ..." Recognize market opportunities for new products or services.*

		Frequency	Percentage	Valid percentage	Cumulative percentage
Valid	2 (TIE)	1	2.5%	2.5	2.5
	3 (ME)	3	7.5%	7.5	10.0
	4 (ME)	6	15.0%	15.0	25.0
	5 (ME)	6	15.0%	15.0	40.0
	6 (TE)	13	32.5%	32.5	72.5
	7 (TE)	11	27.5%	27.5	100.0
	Total	40	100.0%	100.0	

Source: *Prepared by the authors with SPSS.*

Table 6. *"Indicate to what extent you would be able to effectively perform the following tasks: ...". Creating and operating a new company.*

		Frequency	Percentage	Valid percentage	Cumulative percentage
Valid	3 (ME)	3	7.5%	7.5	7.5
	4 (ME)	5	12.5%	12.5	20.0
	5 (ME)	10	25.0%	25.0	45.0
	6 (TE)	11	27.5%	27.5	72.5
	7 (TE)	11	27.5%	27.5	100.0
	Total	40	100.0%	100.0	

Source: *Prepared by the authors with SPSS.*

For the analysis of entrepreneurial intention, a group of 6 items was selected referring to: "Please indicate your level of intention regarding the following statements" and for this two items were selected. "It is very likely that I will create a business someday" and "I am determined to create a business in the future", both on a Likert scale of 1 to 7 where 1 is "Not at all" and 7 is "Totally". For item one, it was observed that 60% of the students answered totally (T) and only 2.5% answered Nothing (N) in relation to the intention (Table 7); for item 2 it was observed that 52.5% of the students answered "Totally" (T) and 47.5% answered moderately (M) (Table 8).

Table 7. *"Please indicate your level of intent regarding the following statements…" There's a good chance I'll get to start a company one day.*

		Frequency	Percentage	Valid percentage	Cumulative percentage
Valid	2 (N)	1	2.5%	2.5	2.5
	4 (M)	6	15.0%	15.0	17.5
	5 (M)	9	22.5%	22.5	40.0
	6 (T)	10	25.0%	25.0	65.0
	7 (T)	14	35.0%	35.0	100.0
	Total	40	100.0%	100.0	

Source: *Prepared by the authors with SPSS.*

Table 8. *"Please indicate your level of intent regarding the following statements…" I'm determined to create a company in the future.*

		Frequency	Percentage	Valid percentage	Cumulative percentage
Valid	3 (M)	6	15.0%	15.0	15.0
	4 (M)	6	15.0%	15.0	30.0
	5 (M)	7	17.5%	17.5	47.5
	6 (T)	10	25.0%	25.0	72.5
	7 (T)	11	27.5%	27.5	100.0
	Total	40	100.0%	100.0	

Source: *Prepared by the authors with SPSS.*

In addition, a question was selected, "If you finally decided to create your own business, would you do it mainly for?", where the options were: For lack of a better employment alternative or for taking advantage of a business opportunity. This question also used a Likert scale from 1 to 7, where from 1 to 3 was considered the lack of a better employment alternative, from 5 to 7 the taking advantage of a business opportunity, while 4 was taken as the midpoint between both options. As indicated in Table 9, it was observed that 82.5% of the university students would do it to take advantage of the business opportunity (ON) while 7.5% would do it for an employment alternative, while only 4% were in a neutral position between both considerations.

Table 9. *"If he finally decided to start his own company, he would do it mainly for:" For lack of a better job alternative (BJA) or taking advantage of a business opportunity (BO).*

		Frequency	Percentage	Valid percentage	Cumulative percentage
Valid	1(ALM)	2	5.0%	5.0	5.0
	2 (ALM)	1	2.5%	2.5	7.5
	4	4	10.0%	10.0	17.5
	5 (ON)	7	17.5%	17.5	35.0
	6 (ON)	7	17.5%	17.5	52.5
	7 (ON)	19	47.5%	47.5	100.0
	Total	40	100.0%	100.0	

Source: *Prepared by the authors with SPSS.*

As a complement to the present analysis, a cross-analysis of variables was carried out in relation to the selected EIQ items to see how they influence the entrepreneurial intention of university students. Gender was taken into consideration in relation to the idea of being independent (their own boss). In this analysis it was observed that no matter the sex, 42.5% of the males and 45% of the females stated that it was totally desirable in their lives to be independent or to be their own boss, which together represents 87.5% of the total selected sample. The item is on a Likert scale from 1 to 7, where 3 to 5 is moderately desirable (MD), 6 and 7 is totally desirable (TD) (Table 10).

Table 10. *"To what extent are they desirable for you in your life in general... to be independent (your own boss)".*

4(MD)		Being independent (your own boss)				Total
		5(MD)	6(TD)	7(TD)		
SEX	1 Male	0	2	7 (17.5)	10 (25%)	19
	2 Female	1	2	10 (25%)	8 (20%)	21
Total		1	4	17	18	40

Source: *Prepared by the authors with SPSS.*

Similarly, gender was taken as a reference in relation to being creative and innovative, in this analysis it could be observed that regardless of gender, 42.5% of men and 45% of women stated as Totally probable that "Creating a business (being an entrepreneur) for you would mean..." being creative and innovative, which represents 87.5% in total. The item is on a Likert scale of 1 to 7, where 3 to 5 is moderately desirable (MD), 6 and 7 is totally desirable (TD) (Table 11).

Table 11. *"Setting up a company (being an entrepreneur) for you would mean..." Be creative and innovative ". Sex.*

3 (MP)		Being creative and innovative					Total
		4 (MP)	5 (MP)	6 (TP)	7 (TP)		
SEX	1 Male	0	0	2	5 (12.5%)	12 (30%)	19
	2 Female	1	1	1	6 (15%)	12 (30%)	21
Total			1	3	11	24	40

Source: *Prepared by the authors with SPSS.*

An evaluation was made of the 5 levels of status proposed: 1 low, 2 medium low, 3 medium, 4 medium high and 5 high, in an attempt to determine the socioeconomic status to which they say they belong and the extent to which they feel capable of effectively creating and operating a new business. As well as the item "Creating and operating a new business".

The analysis showed that 62.5% of the sample considers themselves middle class (MC), with 40% of this status responding that they would be totally effective (TE) and 22.5% responding that they would be moderately effective (ME). 17.5% considered themselves to be of lower-middle status (LM), with 12.5% responding that they would be moderately effective (ME) and 5% totally effective (TE). While those perceived as upper-middle class (LM) correspond to 20% where 10% responded feeling totally effective (TE) and likewise 10% felt moderately effective (ME). (Table 12)

Table 12. *"Indicate to what extent you would be able to effectively perform the following tasks: ... Create and operate a new company" Status.*

3 (ME)		Creating and operating a new company					Total
		4 (ME)	5 (ME)	6 (TE)	7 (TE)		
Status	2 (LM)	2 (5%)	0	3 (7.5%)	0	2 (5%)	7
	3 (MC)	0	3 (7.5%)	6 (15%)	9 (22.5%)	7 (17.5%)	25
	4 (UM)	1 (2.5%)	2 (5%)	1 (2.5%)	2 (5%)	2 (5%)	8
Total		3	5	10	11	11	40

Source: *Prepared by the authors with SPSS.*

Conclusions

This investigation was elaborated with the purpose of knowing the entrepreneurial intention of university students, particularly of the Political and Social Sciences Faculty of the Autonomous University of Chihuahua, selecting specific assertions or items of the Entrepreneurship Intention Questionnaire, an instrument developed in Spain that demonstrates adequate social characteristics and that predicts, at a certain point, the entrepreneurial capacity of young university students, under the framework of the Theory of Planned Action (TPA).

Nine items were selected from those that make up the total of the instrument where we observe the relationship that the answers obtained by the students in the different statements have, in the same way, two crossed tables were made where sex (gender) was taken as an element in relation to the intention to be independent (your own boss) and to be creative and innovative, and a crossed table to relate the item: to create and start up a new company in relation to the socioeconomic status in which they perceive themselves.

What could be observed is that students show a high degree of entrepreneurial intention, especially when certain variables influence the decision making process; the opinion of their close relatives (parents and siblings), the socio-economic status in which they perceive themselves, the entrepreneurial attitude, the use of a business opportunity as well as the lack of a better job alternative are the ones that have more weight in relation to the intention of entrepreneurship by university students. Nonetheless, a peculiar inclination towards entrepreneurship of traditional companies and not towards industry 4.0 was observed, although the instrument was applied in a social-humanist institution, in the current times it is imperative that HEIs include in their educational programs, entrepreneurial education with a tendency to venture into industry 4.0 and artificial intelligence, because not only HEIs with programs that develop technology will be the only ones to be immersed in the technological advances of today's globalized and constantly changing world.

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CHAPTER 21

Blurred Image: Traveling Photographers. The Story of a Profession that Passed Away

Francisco Javier Luévano-de la Rosa*[1], María Concepción de Luna-López[1], Carlos Alberto Ochoa-Ortiz[2]

[1] *El Colegio de Chihuahua, Calle Partido Díaz 4723, Esquina con Anillo envolvente del PRONAF Colonia Progresista 32310 Ciudad Juárez, Chihuahua, México.*

[2] *Universidad Autónoma de Ciudad Juárez*

* *Corresponding author Email: fluevano@alumnos.colech.edu.mx*

Black and white are the colors of the photograph.
For me they symbolize the alternatives of hope
and despair to which humanity is subjected forever.
Robert Frank

Abstract. This article describes the founding of the photographic studios in the town of old Paso del Norte, Chihuahua, in 1870. Once the photographic studios increased and cameras became more compact, they began to be more accessible. Many trades derived from photographic practice such as news correspondents and itinerant photographers. The traveling photographers maintained a large clientele from the 1940s until the late 1970s, when the camera frenzy became commercialized and the photographers' business became secondary. The study and analysis of these documentary sources has become a required subject for sociologists, anthropologists and historians.

Keywords: Traveling photography, history of photography, ancient trades, and historic center.

Introduction

The abandonment that downtown has suffered for decades, as well as the disappearance of the economic boom, the permanent deterioration of a society that lacks cultural roots have resulted in the disappearance of different professions such as printing, tailoring, stonecutting, among others that for many years contributed in giving Ciudad Juarez, Chihuahua visual representation abroad. A significant amount of professions diminished to give way to new sources of work. Nonetheless, various lines of work have been slowly decreasing for several years although they have yet to vanish completely. Some of this professions are: sign makers, watchmakers, photographers, ice cream sellers and newspaper spokespersons. Emilio Gutiérrez de Alba, journalist whose work centers on the oral memory of the citizens of Ciudad Juarez, has shared Jesús Soto Pérez's (Don Chuy)—the oldest spokesman in Ciudad Juarez—testimony in an interview:

Don Chuy vividly remembered his early years as a newspaper and magazine salesman. He narrowed his eyes as a resource to pull out the memories of those times, more than three quarters of a century ago, [...] At that time a little train arrived at this border, not like the ones we see now, long, kilometers long. No, that one had four or five cars and their little machine, but it brought people from all over the center and south, fleeing the revolutionary movement, because there were outbreaks of the revolution everywhere, do you understand me? I was born in the year 1912, in Guanaceví, Durango state. He was from a family of three children: Jesus, Mary and Joseph. I was the oldest and was about nine years old when our parents brought us to this border. I was a humble child, from a huarache. And arriving here had to work to help support the family. One day I was walking on September 16, on the sidewalk in front of the now Café La Nueva Central. And then I saw several children and young people running away carrying newspapers under their arms. They were newspaper vendors who, I learned, came from Mexico City. It called my attention. I like that. And I started selling newspapers.

Through oral testimonies and the search for old photographs, it has been possible to reconstruct an important number of daily activities that took place in the historic center and in the surrounding streets (from where?) and that for years were present in the collective imagination of the inhabitants of the border (Flores Simental. 1994). The main streets of the city became ideal settings for the practice of itinerant photography. The photographic studios from which traveling photographers emerged had been very busy attending a high demand of costumers. Nonetheless, it was impossible for such an activity to remain static in a delimited space such as the photographic studio, so by positioning himself outdoors, "the artist of the lens" had the possibility of meeting the new demands of a different clientele. These photographers gave the public space a new image, the tripods were attractive to tourists and the printing of the photographs was also very economical if the novelty of the work was taken into account. The images that photographers captured, were at a very low cost.

The photographer would stand in a strategic location where the tide of people was constantly passing by and take a picture as soon as the lens approached from the front. Once the photograph was taken, the photographer would approach the potential customer and hand him a ticket with the address of the establishment where he could go pick up his photo.There were several establishments that offered this service, all in the historic center of the city, so picking up the photograph was accessible. (Solares. 1998). In addition, all the important activities took place in downtown, which was where the main businesses were located. The funeral parlors, the yerberías, the ebanisterías, the peleterías and the busy public baths gave a vitality to commerce since by their nature there was a constant swarm of people who frequented each of these establishments. Since most of the activities took place downtown, photographers had many potential customers at their disposal. The merchants provided relevant information for the historical construction of the photographic studios, since in addition to being present in their establishments, they also made use of photography. (Gutiérrez de Alba. 2002).

During the 1940's, cabarets, restaurants, cantinas and nightclubs offered shows, food service and liquor sales at night. There were masters of ceremonies who were in charge of welcoming the diners, presenting the show, giving various announcements and when the stipulated time arrived they would dismiss the clientele, outside the establishment there were promoters who attracted the crowd. Inside, there were waiters, bartenders, cigar sellers, cooks, women who took care of the dressing room, employees who took care of the bathrooms, service or maintenance personnel, the manager of the establishment and on many occasions a photographer who, without being an employee of the establishment, appeared on several occasions to portray the couples who enjoyed the show, since very often among the guests they had the opportunity to meet prominent figures from politics, sports or show business. (Gutiérrez de Alba. 2011). However, a photographer was always present. One of the most outstanding photographers of the time was Gilberto Flores Saenz who, according to the data collected, made Cabaret

Cucamonga his principal place of business and took hundreds of pictures of the city's nightlife, leaving for posterity a graphic page on the history of nightclubs on this border.

Photography in downtown Ciudad Juárez

The Historic City Center and the streets that surround it were established during the XVII century when a rustic Franciscan construction was erected in the high part of a plateau near the benefits of a plentiful and uncontrollable river that overflowed its waters in times of rain. In the surroundings of this building a group of houses, lots and irrigation ditches were built, which due to their dynamism soon attracted the attention of new settlers from different regions. From then on, the commercial space was delimited and the old streets became home to establishments and businesses run by artisans who carried out a wide variety of trades and by small merchants who offered a wide range of products. Thus, among these commercial spaces, the first photographic studios on the border opened up, possibly beginning in 1880 (Chueca Goitia. 1997).

To speak of photography in Ciudad Juárez is to go back to the end of the 19th century, when foreign photographers arrived in this locality for many different reasons, leaving hundreds of archives with beautiful samples taken in the historic center and its surroundings at the end of their lives. A large number of these photographs correspond to the rustic Guadalupe Mission, an emblematic and central building of the old Paso del Norte that today and perhaps unintentionally, by compiling these images have given rise to a series of changes, modifications, annexes and alterations in both the façade and its surroundings. (Santiago. 2004). Some of these photographers settled in the place and photography went from being a hallmark of the wealthy classes to become a common practice for the entire population, no matter how humble. The photographic studios began to receive more and more work, and as the clientele increased, so did the demand. Every frontiersman wanted a photograph, especially one that showed the fortune of being united in perpetuity. Photographs of weddings, church vows and liturgical activities filled the walls of every home. It was common to be photographed in military and police uniforms or for some city council appointment, in short, everything that represented pride or approval for the citizen.

Image 1: *Overview of the Guadalupe Mission and its main avenue and some commercial establishments.*

Source: *Chronicles of the last century. Ciudad Juárez, its life and its people. Universidad Autónoma de Ciudad Juárez (Flores, S. R. 2013).*

According to the information provided by Jorge Romero, owner of Modelo Studio, he assures that this commercial establishment is "more than a hundred years old" because the initiative was made possible by the efforts of his aunt who moved to this border from the capital of Chihuahua in order to set up an establishment that could offer the community "something artistic" very possibly at the end of the last century when she managed to bring from the United States a modern pedestal camera with which she inaugurated her establishment on the old 5 de Mayo Street (today Juarez Avenue). Later, they relocated to Comercio Street, right in front of the current cafeteria La Nueva Central, where after a while they managed to open a new branch next to the cathedral in a building that still preserves its original façade, which is the one that prevails to this day. (Gutiérrez de Alba. 2011).

The photographic studios became so popular that later it was necessary to include other members of the family as the workload did not cease due to the large number of assignments. Other photographic establishments appeared as the employees or members of these families gradually separated and when others appeared instead of coming from different places thanks to the incursion of the railroad by 1911, during the taking of Ciudad Juarez, a good number of correspondent photographers from the North American newspapers made their appearance with cameras in hand: James Hare, Fred Feldman, WF Stuart, Melville Jean Herskovits, Otis Aultman, Homer Scott, David W. Hoffman and G. Martin, among others, are considered pioneers of hand-held cameras in downtown Ciudad Juarez, since during the war clashes at the beginning of the revolution they took on the task of photographically recording the advance of the insurgents through the main streets of the city until culminating in the old Mission of Guadalupe and adjacent buildings.1

Imagen 2. *Revolutionary Roque Gonzalez Garza leading a column of horsemen in Ciudad Juarez during May 1911.*

Source: *frame by frame collection, 2005.*

Image 3: *Photography of James Hare taken in Ciudad Juárez on the banks of the Rio Grande. The scene corresponds to the ceremony of May 5, 1911 with Main revolutionary leaders.*

Source: *frame by frame collection, 2005.*

During the Mexican Revolution, border cities were in full development. Ciudad Juárez, Piedras Negras and Ojinaga had the advantages of sharing the proximity to the United States. With respect to Ciudad Juarez and El Paso, Texas, there was a commercial and labor dynamism that allowed the mobility of the border between both cities. In El Paso, Texas, there were already several photographic studios and highly qualified personnel to operate the cameras, chemicals and sophisticated developing equipment. Before the battle of Ciudad Juárez, a group of photographers traveled from El Paso, Texas, to make several samples in the insurgents' camp and then moved to the streets of the city, thus recording the war from its beginning. Other photographic studios began to operate in both cities and the practice became more common.

Once the warfare ended in the early 1920s, the reconstruction of the city began, where collapsed adobe farms gave way to the occupation of photographic studios in the main streets: Del Comercio, Del Porvenir, Railroad, From Tithe and May 5. Each photographic establishment had its own living room or studio with decorations and curtains, a white background, a tapestry landscape that also served as a background, and an adjoining workshop where the development was carried out. In this way, this practice became popular until the inclusion of a considerable percentage of the population that requested this service more frequently.

The Itinerant Photographer in Downtown

In the late 19th and early 20th centuries, people used photographic studios as a sign of economic solvency, as it was a new and somewhat expensive practice. Later, the printing of postcard photographs occupied the shop windows as a means of advertising shows and entertainment. The service attracted all kinds of artists (musicians and dancers), including bullfighters, who were the ones who could afford the service. Thus, the first photographic works were aimed at an economically stable clientele. However, with the itinerant photographer there was a transformation in terms of the clientele. The owners of some commercial establishments decided to put certain employees in charge of them so that, tripod in hand, they would set up in squares, parks and outside commercial establishments to offer photographs to anyone who wanted to use this modality, regardless of social status or any other requirement.

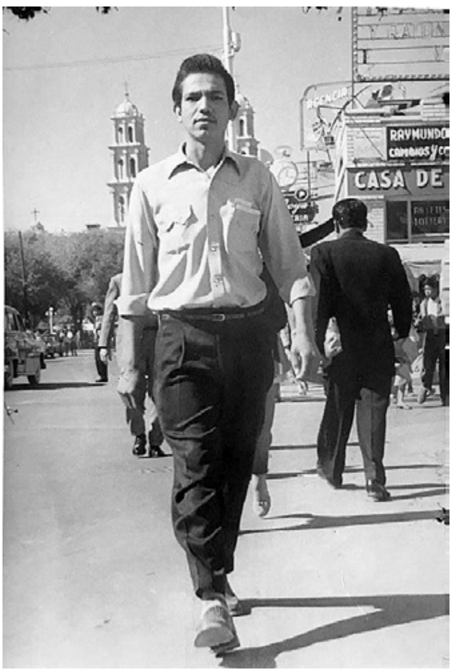

Image 4. *Photograph of Mr. Gilberto Rodríguez López (1954) taken between 16 de Septiembre and Ugarte streets, right at the corner of the "Club San Luis" where one of the main traveling photographers used to stand to capture passers-by, leaving the iconic towers as the background of the Cathedral.*
Source: *Photograph owned by Mr. Gabriel Rodríguez Zamora.*

Image 5. *Very common postcard photographs showing men and women in different activities (beginning of last century). Mexican woman using a metate to grind corn.*
Source: *frame by frame collection, 2005.*

The business was a family activity in which all the members were in charge of running the studio, as well as having assistants who, having acquired seniority and experience, could handle the cameras in the photographic studio, take charge of a photo session or even handle expensive chemical products such as bromide, blueprints, compounds for sepia photography, and work on the adjustments for the different sizes and characteristics of the different papers. The elaboration of photography was evolving and perfecting in its quality and development until it reached such an optimal level that today many of them are considered true works of art. (Dubois. 1994).

Image 6. *Typical photograph of a horse that is very popular for children. These horses, perfectly made of wood, were strategically positioned on Juárez Avenue on the two sidewalks and had hats, sarapes and cheeks to make the "souvenir" more attractive. African American boy on a rocking horse.*

Source: *Photograph provided by Mr. Juan de Dios Olivas.*

The influence that each photographer had on his work allowed a public eager for modernity to aspire to become the protagonist of a work of art. Photographers would also attend personally to the homes of all those who requested the service and capture images of their daily life. In this way, the itinerant photographer exploited a new strategy to offer his services, as he also received from the photographic studio a percentage of the services he performed there. Family photographs became popular in later years. (Favela. 1994).

Each photographer that was installed in a strategic point of the city was accompanied by posters or paintings that simulated landscapes, horses for children and Mexican props like *sombreros* and *sarapes* for adults. Some photographers, seeing that the business was thriving, decided to get their own cameras and become independent of the photographic studios by setting up their own sets and props.

The lens and its environment, an analysis of the spatial context

Photography became a more common practice in the 1940s. An important group of photographers then made their appearance in the streets of the city: Modelo, Baquier, Leonardo, Vega, Mejía, Rodarte, Angel, among others. Images of everyday life were often taken and are now an invaluable support as a printed document for research. (Costa. 1991). Photographers were not aware of the historic relevance of their photographs but some important Mexican festivities such as December 12, the feast of the Lady of Guadalupe, the Cinco de Mayo and the the revolution parades can be studied because of their photographs. As we delve into the study of these images, it throws us moments or historical episodes that allow us to understand the social life so decisive within the space of work and leisure. (Flores Simental. 2013).

Conclusions and the end of a trade

The sober and enduring architecture has evidently undergone various changes throughput time. The photographic review has helped historians reconstruct empty spaces and reconstruct missing information from old establishments. This has also helped with the examination of the architectural styles, the materials used in the buildings, thus providing a more reliable and tangible picture of the heritage of the historic center. (Munizaga. 1999). With the arrival on the market of increasingly sophisticated photographic cameras, the profession of itinerant photographer was displaced. All types of camera models came to saturate most of the homes at the Mexican-USA border. Over time, cameras have improved image resolution and have been incorporated into mobile devices. The photographic prefession is still present in research works that allow us to analyze in depth the generational changes of a society that transforms and reconstructs itself constantly. Modernity arrived displacing any hint of antiquity in new practices such as selfie photography and the design and correction programs included in the telephone equipment itself.

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