Handbook T-I

Computer Technology and Innovation

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ISBN: 978-607-8948-20-8
ECORFAN Publishing Label: 607-8948
HCTI Control Number: 2023-13
HCTI Classification (2023): 301223-0013

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ECORFAN Computer Technology and Innovation

Volume I

The Handbook will offer volumes of selected contributions from researchers who contribute to the scientific dissemination activity of the Tecnológico de Estudios Superiores de Jocotitlán in their areas of research in Social Sciences. In addition to having a total evaluation, in the hands of the directors of the Tecnológico de Estudios Superiores de Jocotitlán, the quality and timeliness of its chapters, each individual contribution was refereed to international standards (RESEARCH GATE, MENDELEY, GOOGLE SCHOLAR and REDIB), the Handbook thus proposes to the academic community, recent reports on new developments in the most interesting and promising areas of research in the Social Sciences.

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Handbooks

TecNM / Tecnológico de Estudios Superiores de Jocotitlán December, 2023

DOI: 10.35429/H.2023.13.1.122

Preface

López, Jimenez, Miranda and *Antonio*, developed artificial vision and image analysis methods and techniques for the detection of fruits and vegetables. Some of the developed systems allow the detection and selection of tomato fruits creating their personalized classification according to the physical characteristics of the fruit.

Gonzalez, Jimenez, Medina and *Blas*, seek to create a render farm that will allow low-income emerging production houses to implement this tool helping them to complete animation projects that contain complex compositions or require computational power to render these works.

Caballero, Muñoz and *Ramos*, show the application of techniques for string membership recognition to formal languages using context-free grammars, on the other hand, a software for sentiment recognition in a text has been developed.

Reyes presents a qualitative analysis of different Machine Learning algorithms, classified into supervised and unsupervised machine learning. A bibliographic review is established, where the information obtained allows evaluating the advantages and disadvantages of the algorithms.

López, Ponce, Maldonado and *Reyes* develop an assistant based on PLN (Natural Language Processing) focused on the Java programming language, with the characteristic of guiding the user on the use of this language from reliable and validated sources, through voice recognition and speech synthesis by the assistant, allowing communication between the software and the user through natural language.

Suarez seeks an alternative for obtaining the proportional constants, integrals and derivatives is through the application of evolutionary algorithms, which calculate these parameters to reduce the cooling time to a desired temperature.

Reyes, López and *Gil* present the identification of different species of mature corn cobs produced in the northern part of the State of Mexico, specifically white, yellow, black and pink cobs by using a Convolutional Neural Network associated to a classification algorithm.

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Content

Chapter 1 Selection methods and detection techniques applied to tomato fruits based on their physical characteristics

Capítulo 1 Métodos de selección y técnicas de detección aplicados a frutos de tomate en función de sus características físicas

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DOI: 10.35429/H.2023.13.1.13

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A. Reyes, E. López and B. Hernández (AA. VV.) Computer Technology and Innovation. Handbooks-TI-©ECORFAN-Mexico, Mexico City, 2023

Abstract

Tomatoes are a vegetable crop of great economic importance worldwide, in addition to being the subject of research to be able to have a higher quality of fruits for consumers. As with many of the crops in the world, the harvest of the tomato fruit is a task that requires a large amount of labor, causing an increase in the costs to be paid by the producer. In recent years, there has been a great and growing interest in automating agricultural processes such as harvesting. This has prompted the development of computer vision and image analysis methods and techniques for the detection of fruits and vegetables. For this reason, given that obtaining images is a very fast and non-invasive way to detect the fruits, these can be classified as both mature and immature or detect some other physical traits that may be useful for the grower of the crop. Some of the systems developed allow the detection and selection of tomato fruits by creating their personalized classification according to the physical characteristics of the fruit. There are a large number of environmental factors that are of importance for the full development of tomato fruits because they have a great influence on the speed of the biological processes of the tomato fruit. During the post-harvest, the care of the plants is as important as the care of the tomato fruit, good care generates a higher quality of the fruits.

Deep Learning, Neural Networks, Object Detection, Artificial Vision, Artificial Intelligence

Resumen

El tomate es un cultivo hortícola de gran importancia económica a nivel mundial, además de ser objeto de investigación para poder tener una mayor calidad de frutas para los consumidores. Al igual que ocurre con muchos de los cultivos en el mundo, la recolección del fruto del tomate es una tarea que requiere una gran cantidad de mano de obra, lo que provoca un aumento de los costos a pagar por el productor. En los últimos años, ha habido un gran y creciente interés por automatizar procesos agrícolas como la cosecha. Esto ha impulsado el desarrollo de métodos y técnicas de visión artificial y análisis de imágenes para la detección de frutas y verduras. Por este motivo, dado que la obtención de imágenes es una forma muy rápida y no invasiva de detectar los frutos, estos pueden clasificarse como maduros e inmaduros o detectar algunos otros rasgos físicos que pueden ser útiles para el cultivador del cultivo. Algunos de los sistemas desarrollados permiten la detección y selección de frutos de tomate creando su clasificación personalizada según las características físicas del fruto. Hay una gran cantidad de factores ambientales que son de importancia para el pleno desarrollo de los frutos del tomate porque tienen una gran influencia en la velocidad de los procesos biológicos del fruto del tomate. Durante la postcosecha, el cuidado de las plantas es tan importante como el cuidado del fruto del tomate, un buen cuidado genera una mayor calidad de los frutos.

Deep Learning, Redes Neuronales, Detección de Objetos, Visión Artificial, Inteligencia Artificial

1. Introduction

The tomato fruit is one of the most demanded around the world and one of the ones with the greatest economic value in Mexico, in addition to this, there is a great variety in terms of types of tomatoes, which also makes the demand even greater and with it, in the same way, its cultivation, production and marketing. That is why in this research a type of tomato called "Saladette" or also known as "Roma" is studied, since it is one of the most consumed tomatoes in Mexico, this because there is a great demand for the product and its great relevance and importance in the daily diet of society. both fresh consumption and preserves. Currently, automatic tomato recognition systems are little used by small farmers, however, they have limitations when selecting tomatoes since they use manual methods and with this they damage or damage the product; which may cause customers to be lost given the condition of the tomatoes offered.

According to Megha.P.Arakeri, Lakshmana, the task of sorting fruits is extremely vital for agriculture given that there is a huge demand for the best quality fruits in the market, however, as previously mentioned the sorting done by humans is not completely effective, so an automated sorting system not only speeds up the processing time, but also it also minimizes errors. The demand for tomato fruits is considerably large both nationally and internationally (Arakeri, M. P., 2016).

Taking into account the points previously stated, it is possible to understand more deeply the need and importance of creating and/or developing an automated system that provides a much more effective and efficient selection of fruits than by performing this process manually, the fruits will be directly less manipulated so the bruises on them will be considerably reduced and the consumer will receive higher quality products.

Now, in order to develop a system of this type, the physical variables of the tomato that are necessary during the development of the system are studied and analyzed, as well as the temperature of the environment, since according to the article by Wosene, *et al* (Tadesse, T. N., Ibrahim, A. M., & Abtew, W. G., 2015) It is mentioned that the most important environmental factor is temperature since it has a great influence on the speed of biological processes, which includes both the color and the softening of the tomato, however, during the post-harvest the most common type of damage that the fruits receive are bruises, so it is also sought to cover that need; A possible solution according to some authors such as Xiaochn is to use technology based on hyperspectral images which consist of collecting and processing information regarding the duration of the electromagnetic spectrum, is then, that these images divide the spectrum into several bands, which allows us to know if there is a malformation or something in bad condition with the tomato fruit. All objects leave unique fingerprints along the magnetic spectrum, allowing the identification of materials and components of the object in question.

For the classification and selection of the tomato, the visual characteristics of the tomato must be considered, one of them is the color that the fruit of the tomato acquires throughout its life. In tomatoes, the ripening process of the fruit involves dramatic changes in small organelles within the fruit cells called plastids, and it is these plastids that are responsible for giving the fruit its color. Phytochromes detect changes in the composition of light that filters through the flesh of the fruit. When the fruit is green due to the accumulation of chlorophyll, it retains the radiation corresponding to the red, but when the fruit and its seeds are developed, the fruit begins to lose chlorophyll, the amount of red in the light that is filtered and perceived by the phytochromes present in the tomato flesh increases, that is, the center of the fruit.

So, knowing the necessary physical characteristics it is key to create a classification with them, that is why it is recommended to make a classification based on the stages of ripening of the tomato, so there are 3 categories: unripe (when the tomato has a green color), light red (intermediate stage in the maturity of the fruit) and finally ripe (when the tomato acquires a red color), This is based on the article published in (Bello, T. B., Costa, A. G., Silva, T. R. D., Paes, J. L., & de Oliveira, M. V., 2020). However, the inclusion of techniques, algorithms and strategies based on artificial intelligence is essential for the development of this system, one of the techniques contemplated is artificial vision, artificial vision systems are based on digital sensors protected inside industrial cameras with optics specialized in acquiring images, so that the hardware and software can process, Analyze and measure different characteristics to make decisions.

Another technique or, rather, devices of great importance in this aspect are colorimetric sensors, which are of complete necessity when making a classification based on maturity levels, which, as is notorious, include or intervene changes in the color of the fruit. However, RGB images are also used for this, which refer to three colors: red, green and blue (Red, Green, Blue). Thus, by merging the studied physical characteristics of the fruit and even the tomato plant with the methods and strategies of artificial intelligence, it is possible to successfully culminate in the development of an automated tomato selection system, which will bring benefits to farmers by being able to offer a higher quality product.

2. Theoretical background

There is now a large amount of recent research examining factors that affect the physical structure of tomatoes throughout their life. Wosene *et al*. (Tadesse, T. N., Ibrahim, A. M., & Abtew, W. G., 2015), mention the most important environmental factor in the postharvest life of tomatoes, they propose that temperature has an enormous influence on the speed of biological processes, which includes tomato color and softening. The objective of the study they propose was to investigate the effect that tomatoes suffer from temperature variations during storage, the effects analyzed refer to the degradation and synthesis of the color of the tomato.

During the post-harvest, bruises are the most common type of damage that tomatoes receive, the study carried out by Xiaochn *et al*., indicates that it is very difficult to detect the damage by each one through human inspection because the changes presented in the fruit are less in the appearance of the fruit. They made use of hyperspectral imaging-based technology to detect those tomatoes bruised by fruit drop. The results they obtained showed that the bruised spectra were lower than those of healthy tomatoes, they eventually developed partial least squares discriminant analysis models to classify tomatoes with an overall accuracy of 90.03% and the data they simulated confirmed that hyperspectral technology can classify bruising damage in tomatoes (Sun, Y., Pessane, I., Pan, L., & Wang, X., 2021).

Some studies were based on specific study and testing. In Thaísa et. al., its objective was to evaluate the colorimetric and physicochemical variables of tomatoes, grouping them in tomato ripening stages. During their experiment they used 150 fruits and classified 3 stages of ripening (unripe, light red and ripe). The variables were evaluated using a method that makes use of images in RGB color model taken with a digital camera, in the case of the correlation between the colorimetric variables it was analyzed using Pearson's coefficient. In the end, they obtained that the colorimetric variables present a greater explanatory capacity of the maturation variation than the physicochemical variables, the colorimetric indices presented a higher performance in the maturation clustering with an accuracy of 0.98% (Bello, T. B., Costa, A. G., Silva, T. R. D., Paes, J. L., & de Oliveira, M. V., 2020).

Halil *et al*., make use of deep learning in order to obtain the anomalies that occur in the tomato plant. They intended to use an algorithm based on deep learning to detect plant diseases by means of a robot, this robot allows the monitoring of tomato leaves by taking photographs and making an exhaustive analysis of the photographs taken (Durmuş, H., Güneş, E. O., & Kırcı, M., 2017).

Dayana *et al*. also developed a robot (LEGO-Mindstorms NTX 2.0) whose purpose was to recreate a scenario where pests that affect the growth and structure of tomato fruits can be detected. The solution was to implement a color sensor and an infrared sensor for color detection on the pests, the software they used allows to determine the color of the pest in real time from the images of leaves, obtaining very encouraging results, although statistical data of the results are not specified (Ariza, D. V., Palacio, A. M., Aragón, I. P., Logreira, E. A., Pulido, C. M., & Mckinley, J. R., 2017).

On the other hand, Xiukang Wang and Yingying Xing, conducted an evaluation on the management of water and nutrients applied to fertilizers, which are the factors that most affect crop growth and productivity. In recent years, tomatoes have quickly become one of the most popular products in the world, and tomatoes are marketed to consumers as a health food that can help reduce the risk of contracting certain human diseases and developing many forms of cancer. However, when there is a shortage of water, it is very likely that fertilizers will be used, which affects the alterations of the product in question, causing physical and chemical changes in the fruit (Wang, X., & Xing, Y., 2017).

Murtaza *et al*. also investigated the effects on tomato fruits by applying the effect of plasma-activated liquid, i.e. plasma-activated water (PAW) in order to reduce pesticide residues applied to tomato fruits. The results revealed that by applying this effect, fungicide residues were reduced by between 79.43% and 85.3%, avoiding alterations in tomato structure (Ali, M., Cheng, J. H., & Sun, D. W., 2021).

Hilje and Stansly mention the evolution of a methodology for the evaluation of trap crops for the management of Bemisia tabaco. The whitefly Bemisia tabaci is a pest of tropical and subtropical regions that affects the status of tomatoes and other crops such as tobacco, beans and eggplant. This method demonstrates prevention in pest situations, especially for the tomato plant (Hilje, L., & Stansly, P., 2017).

2.2. Fruit sorting systems

Currently, many of the systems are based on factors such as color, which is a physical and sensory phenomenon, captured by the human perception of the light reflected by an object and is affected by the observer, the illuminant, the optical geometry, the area, background, surface, brightness and temperature. These properties function as indicators of degradation in tomato fruits to determine those that are in poor condition or in the process of ripening.

The quality of the tomato can be judged by its visual characteristics, this being one of the main starting points for its classification because from its brightness and color it can be determined in which stage of ripeness the tomato is, this characteristic has been studied by the researcher Saber e*t al*., by using artificial vision and soft computing approaches for automation and improvement of processing time (Iraji, M. S., 2019) while Dussan *et al*., make an observation about the differences that exist when using digital cameras as color instruments vs. the use of sensors and the ease of data acquisition (Dussán-Sarria, S., Garzón-García, A. M., & Melo-Sevilla, R. E., 2020).

In Sun *et al*., he performs the evaluation of the brightness of the surface of apples where he performs the extraction of color parameters from areas of high light and detection or classification of the SVM model. This sorting method had 96.7% accuracy results, showing good operational results in terms of sorting accuracy rates and calculation speed for tomato quality processing (Sun, K., Li, Y., Peng, J., Tu, K., & Pan, L., 2017). The proposed method achieved a sensitivity of 83.2%, a specificity of 96.50%, and a mean g of 89.40% with accuracy of 95.5%. On the other hand, Liu *et al*., detail a new way for the automatic detection of fruits using the YOLO-Tomato model based on YOLO v3 that, among its main advantages, facilitates the reuse of functions and helps to learn a more compact and accurate model. It uses a circular bounding box to locate the tomato, matching it to the shape of the tomato. The results obtained under mild occlusion were an identification rate of 94.58%, demonstrating that it can be applied to picking robots for tomato detection (Liu, G., Nouaze, J. C., Touko Mbouembe, P. L., & Kim, J. H., 2020).

In all cases, it can be observed that the model or system developed is made from a certain range of colors or values where the environmental conditions change notoriously according to the area where the system is implemented, one of the conflicts being the level of illumination and that the sensors have a limited range of colors. In turn, K. Schmitt, *et al*., mentions that colorimetric sensors based on color-changing dyes offer a convenient approach to quantitative gas measurement. An integrated mobile colorimetric sensor can be particularly useful for occasional gas measurements, such as informal air quality checks for odors. In these situations, the main requirement is high availability, ease of use and high specificity towards a single chemical compound, combined with cost-effective production (Schmitt, K., Tarantik, K., Pannek, C., Benito-Altamirano, I., Casals, O., Fabrega, C., ... & Prades, J. D., 2017).

On the other hand, Bif Leonardo, *et al*., investigates the potential use of low-cost, short-range terrestrial RGB imaging sensors for fruits. Traditional digital image processing in approaches such as RGB color space conversion were applied in several terrestrial RGB images to highlight the information presented in the original dataset (Biffi, L. J., Mitishita, E. A., Liesenberg, V., Centeno, J. A. S., Schimalski, M. B., & Rufato, L., 2021). Afterwards, binarization and segmentation of optimal images were carried out, once these processes were carried out, parameters were chosen to detect the fruits efficiently. Megha.P.Arakeri and Lakshmana, mention that the task of sorting fruits is vital in agriculture because there is a high demand for high-quality fruits in the market. There is a high demand for tomatoes both locally and abroad (Arakeri, M. P., 2016).

The fruit of the tomato is very delicate and, therefore, needs a lot of care. The proposed quality assessment method consists of two phases: hardware and software development. The hardware is developed to capture the image of the tomato and move the fruit to the appropriate containers without manual intervention. The software is developed using image processing techniques to analyze the fruit for defects and ripeness. According to Manya Alfonso, *et al*., Deep Learning-based methods emerged as the cutting-edge techniques in many image segmentation and classification problems, and are very promising in challenging domains such as agriculture, where they can deal with the great variability in data better than classical computer vision (Afonso, M., Fonteijn, H., Fiorentin, F. S., Lensink, D., Mooij, M., Faber, N., ... & Wehrens, R., 2020).

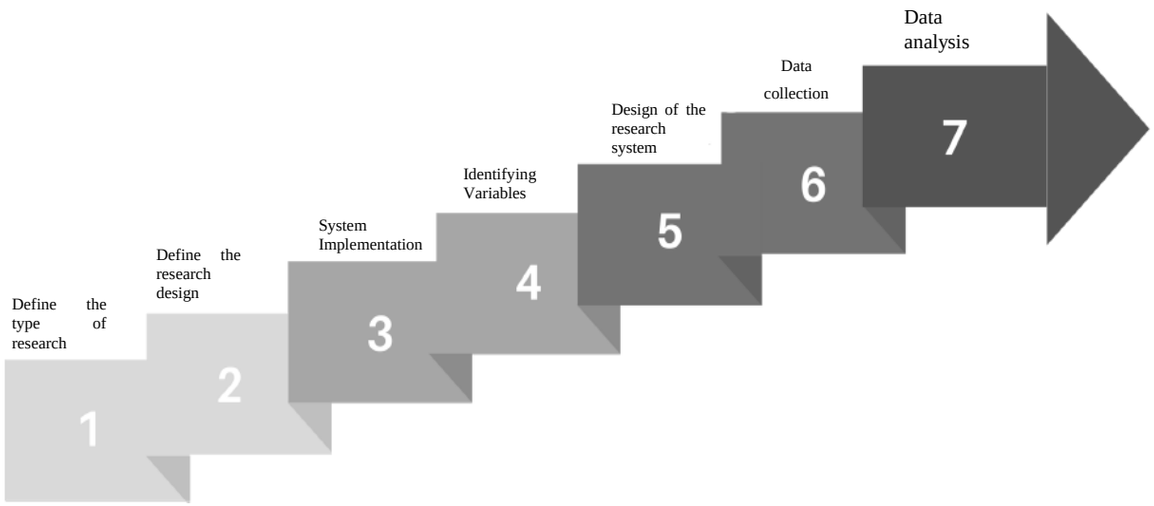
The study carried out by Juan Víctor Eduardo Ramos Diaz had the objective of determining the effectiveness of the algorithm integrated with artificial intelligence supported by a robotic hand in the recognition of tomato ripeness and four phases of development were applied (understanding of the business, development of the robotic hand solution, obtaining data and development of the neural network solution) in order to recognize the maturity of the fruit.

For the results of the maturity recognition network, the prediction of probabilistic category and 4 independent numerical variables (humidity, temperature, luminosity and color) and a dependent category variable (maturity recognition) were used, we worked with a data that contained 161 records divided into two groups, one of 80 for training and testing. the other 81 records for prediction (Ramos Díaz, J. V. E., 2020).

3. Methodology

The proposed methodology for the research is Search Learning, which describes the research process that has as its main objective to develop a system of classification and detection of tomatoes, discarding physical anomalies. The research describes techniques and processes applied to the classification of tomatoes, as well as the use of tools that allow the study of physical anomalies that this fruit may present (See Figure 1).

Figure 1 Search Learning Methodology



Source: Authors' Own Creation

3.1. Define the type of research

The type of research is practical, since based on the processes applied in the research, a solution will be given to a specific problem, in this case, a system will be developed that allows classifying and detecting physical anomalies in the tomato fruit making use of current technologies such as Machine Learning and the implementation of some devices such as colour.

3.2. Define the research design

The research is based on the comparison of the physical or color properties of the tomato, which allows us to identify its state of maturity in unripe, ripe and rotten. The influencing factors that make it difficult to identify the state of the fruit are the quality of the environment, within this are the level of luminosity, humidity, temperature and the state of the soil.

3.3. System implementation

The classification system will be implemented in a fixed place, this place will be the place of study for the plant and the fruit, which will allow the corresponding field tests to be carried out.

3.4. Identification of Variables

The variables involved in the study are:

- Environment variable: Humidity, temperature, luminosity and color.
- Intervening variable: Tomato classification algorithm.
- Dependent variable: Identification of tomato status (ripeness).

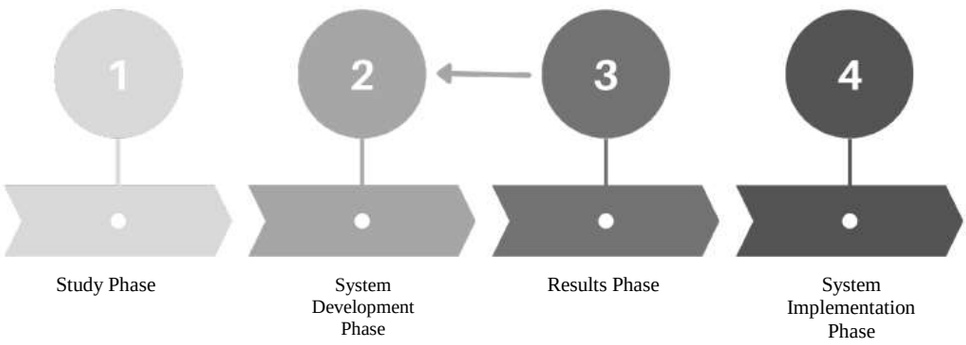
3.5. Data collection

Population and sample: The tomato population to be studied will be taken from the greenhouse dedicated to the cultivation of tomatoes. For the samples, groups of tomatoes in various conditions and states will be selected to obtain detailed information that will help generate an evaluation and classification according to their condition.

3.6. Design of the research system

The methodology used is divided into 4 subphases (See Figure 2).

Figure 2 Phases of research system design



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Study Phase

In this first phase, a one-week field study will be carried out in which data will be obtained on the state of the tomato in various conditions so that later, taking into account these conditions, these data will be obtained conditions, can be implemented in the next phase, which is the development of the classification system.

System Development Phase

In phase 2, the classification system will be developed to detect the physical anomalies of the tomato. To this end, an algorithm will be developed to classify the state of the tomato according to the information it receives from the sensor and thus be able to classify it. To program the sensor, the Arduino board will be used.

Results Obtaining Phase

In phase 3, the results obtained in one week of the operation of the system will be taken into account in order to detect failures, possible improvements or, in case of satisfying the classification needs, to be able to approve it. If this is not the case, you have to go back to the previous phase to verify which procedure was done wrong and to be able to improve it.

System Implementation Phase

In phase 4, the system will be implemented in the greenhouse once it has already met the acceptance level and the error rate is minimal.

3.7. Data analysis

At the end of the collection of results, tables will be generated that show the results of the field study and in this way classify the data to generate graphs that allow representing the percentage of predictions to obtain the failure and error rate of the system.

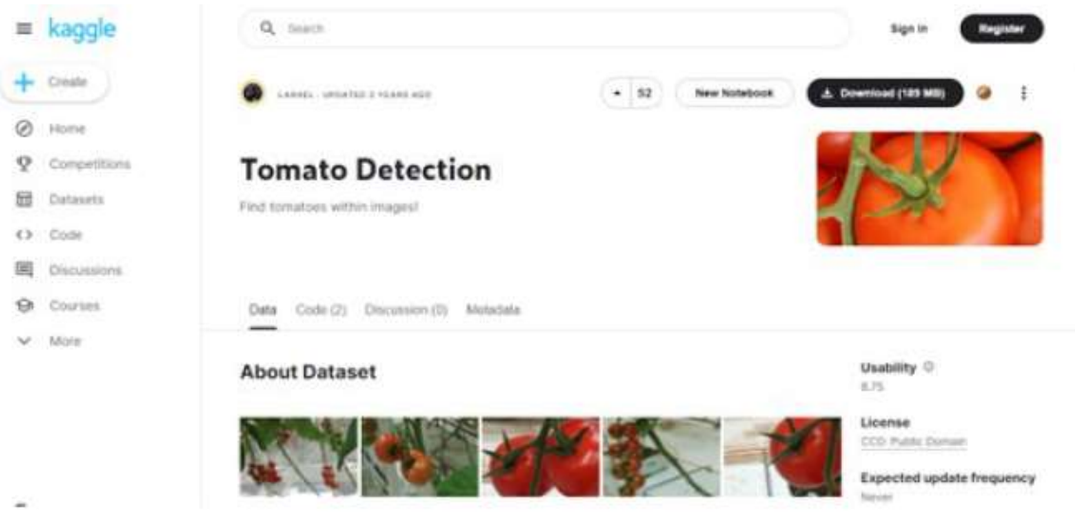
4. Development

4.1. Downloading the Dataset

The development begins from phase 6 of the methodology, this phase is called Data collection and is based on the implementation of the dataset to create the model that addresses the problem raised in the research and is also capable of detecting objects based on the parameters of the tomato fruit such as its color.

To acquire the dataset, the Kaggle web platform was used, since it has a fairly large Data Science community in which users publish their dataset to contribute to the community belonging to it. The dataset that was used is called Tomato Detection, which was published by user @LARXEL. This dataset has 895 images of tomatoes licensed to use. To visualize the interface, see Figure 3 which shows the name of the dataset, as well as the user and some images belonging to it.

Figure 3 Dataset Tomato Detection



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4.2. Training tools

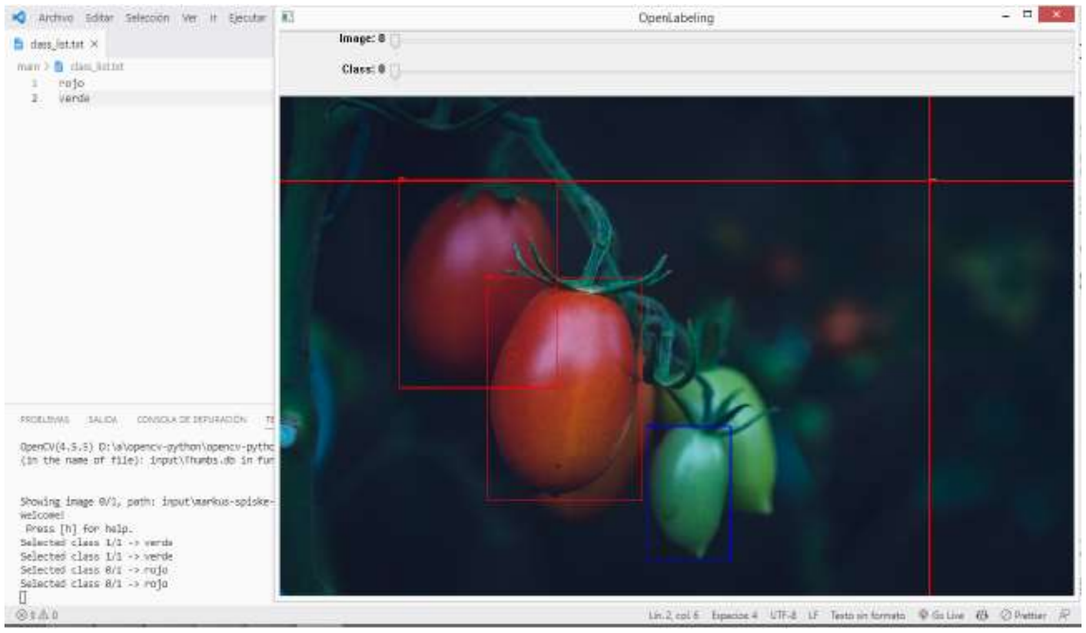
Three tools were used to train the model: Python. TensorFlow. Google Colab.

Python was used as a programming language, as it is widely used within Artificial Intelligence and can be used with TensorFlow. On the other hand, TensorFlow was also used to create the machine learning model, as this tool is based on the Keras API standard for neural network training. Last but not least, Google Colab was used, which allows you to run and program in Python from the web browser and use GPU and CPU of a cloud computer for free without the need to install anything extra.

4.3. Image Tagging

For the creation of the model, the images obtained from the dataset of the Kaggle platform were labeled. This labeling was necessary because it is based on this labeling that the images are classified to be assigned to the corresponding model layer. The labeling contains the class name and the outline box of the fruit, as shown in Figure 4.

Figure 4 Image Tagging



Source: Authors' Own Creation

4.4. Model training

For the training of the model, Mobilenet V2 SSD was used, which is a family of neural networks, which is designed for the detection and execution of deep networks in mobile devices, providing security and privacy to the user who uses it.

4.5. Learning Transfer

To train the model, the learning transfer technique is used, which seeks to use the architecture of an already created model and change only the first layer, which receives the class to be classified and then be able to make use of all the hidden layers. Figure 5 shows the training of the model, in this one you can see a path, this path has the PIPELINE CONFIG PATH parameter which indicates the path of the configuration file; MODEL DIR is the storage location of the training model; NUM TRAIN STEPS is the total number of training steps; SAMPLE 1 OF N EVAL EXAMPLES is the sampling frequency of the sample during the verification process, if it is 1, it means that all samples will be checked, usually set to 1. After the script file is generated, execution is initiated via sh train VOC.sh.

Figure 5 Learning Transfer

Source: Authors' Own Creation

4.6. Model exported to TensorFlow Lite

The model was exported to a TensorFLow Lite file from a normal TensorFlow model, it was done this way, since this is a lightweight file type (FlatBuffer format) that allows mobile devices to run them. In addition, the Python API was used, which facilitates the conversion of models to optimize them. Figure 5 shows the lines of code that were used to generate the .tflite file.

Figure 6 Exported model

Source: Authors' Own Creation

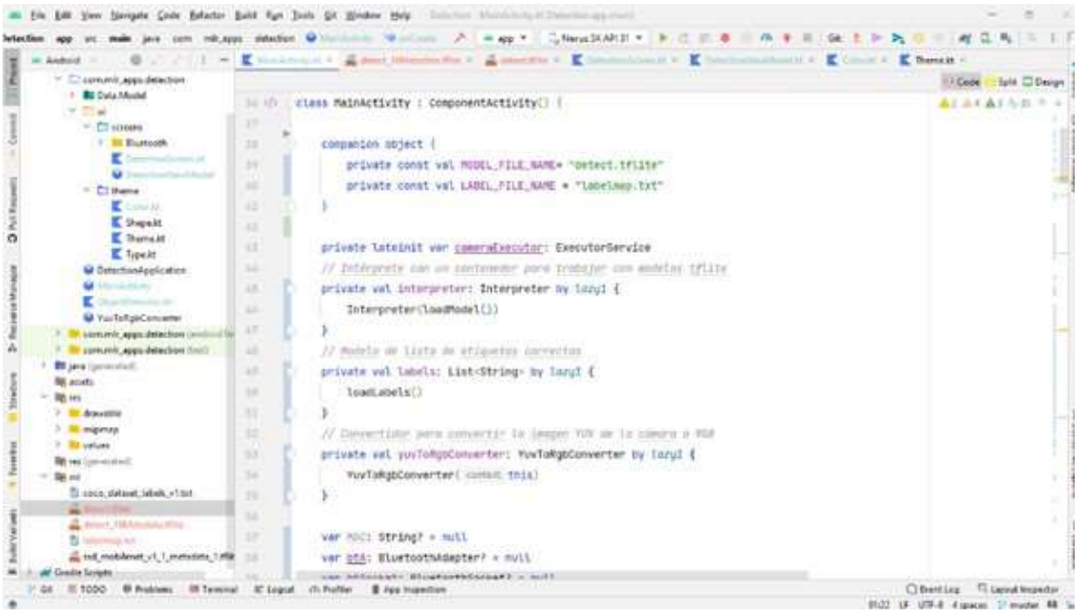
4.7. Programming tools

For the implementation of the model within the mobile device (cell phone), some tools were used, including: Kotlin TensorFlow Lite C++ Kotlin was used as the programming language to generate the mobile application that will allow the implementation of the model generated with TensorFlow Lite. We chose to use this language because it allows us to develop applications on the Android operating system and also allows us to develop graphical interfaces. In addition to this tool, TensorFlow Lite was also used, which allows machine learning models to be implemented on mobile devices and microcontrollers, this tool was used in the model previously generated with TensorFlow to later convert it into a compressed FlatBuffer file and thus generate the final file with .tflite extension, once compressed the model is loaded on the mobile device. Finally, the C++ programming language was also used to program and execute code in Arduino, the latter is in charge of controlling the tomato sorting mechanism physically.

4.8. Mobile App Development

The mobile application was programmed in the Kotlin programming language, figure 7 shows a snippet of the application's code, in this snippet you can see the use of the detect.tflite file that contains the model generated in TensorFlow as well as the file that has the labeling information of the images in the dataset. In addition to this, you can also see the lines of code to make use of the camera of the mobile device so that the tflite model can be used to be able to convert the YUV images into RGB from the input of the same through the camera.

Figure 7 Application Development

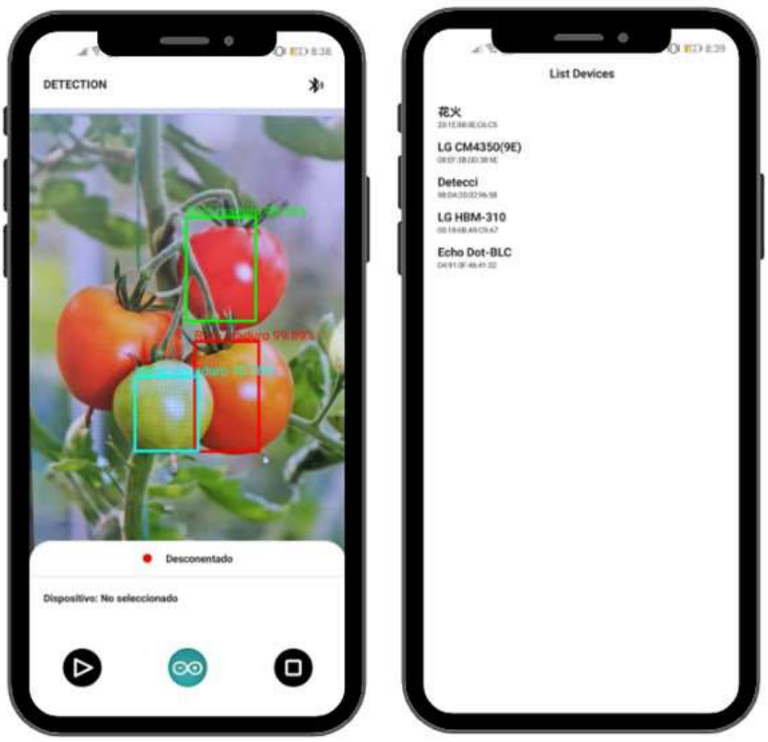


Source: Authors' Own Creation

4.9. Graphical Interface View

The view of the graphical interface is shown in figure 8, this interface has a display which shows the data input that the camera and frames the tomatoes according to the layers of the model, in addition to this it also has 4 buttons, the buttons at the bottom are buttons that allow you to start and pause the system as well as connect to the Arduino, The button at the top right allows you to open the interface to select the Bluetooth device you want to connect to so that the connection to the Arduino can be made.

Figure 8 Graphical Application Interface



Source: Authors' Own Creation

5. Results

The searches carried out to detect physical anomalies in tomato vegetables, taking as their main characteristic the color of the fruit, is one of the methods that has taken great interest to be optimized at the local level, since farmers do not have enough resources to have the new technologies for the harvesting and classification of these fruits. Therefore, the study of techniques based on artificial vision suggests an optimal way to carry out the analysis of the images of the fruit, however, it suggests having solid knowledge to be able to implement this technique. On the other hand, the use of neural networks and probabilistic studies to determine the level of maturity of the tomato begins to represent an effective way to determine if there are defects in the fruit without making use of an image analysis but of the fruit. Finally, the use of image processing with Open Cv and Matlab also suggests a more economical way with a less steep learning curve than the other techniques.

Conclusions

The review of research articles referring to tomato detection and classification systems taking into account the physical anomalies of the fruit, it is concluded that currently the tomato fruit plays a fundamental role in the food industry, since it is frequently used in homes for the preparation of food and some by-products such as tomato sauce. ketchup, tomato paste, etc.

For the production of the fruit, some aspects are taken into account such as the physical changes that occur in the environment where it develops, one of these aspects is the temperature of the environment, since the tomato has climacteric characteristics, that is, it can continue to ripen, even if it has already been cut and for this reason tomatoes that have already been cut are more sensitive to low temperatures.

Both manual and mechanical processes are used for the treatment and classification of the fruit. For the manual classification processes, the work of trained personnel is used for the manipulation and identification of the state of the fruit, in this way the staff classifies it into ripe, rotten and cooking state.

The quality of the fruit is greatly influenced by the way in which it is handled and the ability of the workers to identify the physical defects that it may have. The disadvantage of manual sorting is that after a while it ceases to be efficient due to the wear and tear generated by the workers. On the other hand, mechanical sorting is more efficient in terms of work and time, since, as there is no physical wear and tear on the part of the workers, the sorting can increase, but the disadvantage of this process is that it is not accurate, since the algorithms developed to identify the physical state of the fruit have some limitations depending on the physical conditions of the environment, such as the level of light. humidity and the quality of hardware used.

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Chapter 2 Design and construction of a render farm

Capítulo 2 Diseño y construcción de una granja de render

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DOI: 10.35429/H.2023.13.14.24

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Abstract

In the animation industry there are different techniques that allow the creation of audiovisual content such as 3D, 2D, Stop Motion animation, etc. In the case of 3D animation, this consists of a process where everything is made of digitally encompassing the creation of characters, settings, objects and the animation itself. In the first stage of a 3D production, it is not required to use highly capable computing equipment until the final stage known as post-production. At this stage, all the elements that will make up the animation are brought together so that it can be approved and distributed on digital platforms. When trying to unite all the elements that make up the animation, they go through a process called rendering that allows us to obtain photo-realistic images and which in turn gives us the final product of the finished animation, for this stage it is no longer possible work with home computing equipment since even the most powerful computers on the market present problems or difficulties when rendering this type of projects. Faced with this problem, many studios and companies resort to the use of so-called “Rendering Farms” or “Clusters”, which consist of the parallel connection of several computing devices, thus achieving that they work as one, allowing greater power and efficiency when it comes to rendering perform tasks that require a lot of processing. Knowing this, the goal of this work is to create a render farm that allows emerging production houses with low resources to implement this tool, helping them complete animation projects that contain complex compositions or that require computing power to render these works.

Rendering, Cluster, Parallel, Platforms, Efficiency, Compositions

Resumen

Dentro de la industria de la animación existen diferentes técnicas que permiten la creación de contenidos audiovisuales como la animación 3D, 2D, Stop Motion Animation, etc. En el caso de la animación 3D, se trata de un proceso en el que todo se hace de forma digital, abarcando la creación de personajes, configuraciones, objetos y la propia animación. En la primera etapa de una producción 3D, no es necesario utilizar equipos informáticos de alta capacidad hasta la etapa final conocida como postproducción. En esta etapa se reúnen todos los elementos que conformarán la animación para que pueda ser aprobada y distribuida en plataformas digitales. Al tratar de unir todos los elementos que componen la animación pasan por un proceso llamado renderizado que nos permite obtener imágenes fotorrealistas y que a su vez nos da el producto final de la animación terminada, para esta etapa ya no es posible trabajar con equipos informáticos domésticos ya que incluso los ordenadores más potentes del mercado presentan problemas o dificultades a la hora de llevar a cabo este tipo de proyectos. Ante esta problemática, muchos estudios y empresas recurren al uso de las denominadas "Granjas de Renderizado" o "Clusters", que consisten en la conexión en paralelo de varios dispositivos informáticos, haciendo así que funcionen como uno solo, permitiendo una mayor potencia y eficiencia a la hora de realizar tareas de renderizado que requieren mucho procesamiento. Sabiendo esto, el objetivo de este trabajo es crear una granja de render que permita a las casas productoras emergentes de bajos ingresos implementar esta herramienta ayudándoles a completar proyectos de animación que contengan composiciones complejas o que requieran potencia de cómputo para renderizar estas obras.

Renderizado, Clúster, Paralelo, Plataforma, Eficiencia, Composiciones

1. Introduction

When an animated project is about to be completed, the chapters or the final short film must go through the rendering process, where photorealistic compositions demand enormous amounts of computing power and the costs of the components are excessively high, so the aim is to collect the necessary information to be able to put together an economical and functional render farm.

Within the digital animation industry, mainly in emerging production houses with low budgets, it is necessary to implement render tools to help them produce quality audiovisual material in a short time, this with the intention of being able to provide the requested works in a timely manner with the highest detail in terms of image and composition. Therefore, it is necessary to search for information about all the hardware and software that is required to be able to assemble the equipment.

In this case, there are four different ways to set up render farms:

- By GPU (Graphic Processing Unit)
- By CPU (Central Processing Unit)
- Hybrid (GPU & CPU Usage)
- By Servers

Each alternative fulfills the same function as long as the assembly is optimal. Aspects such as the number of components and that each piece of equipment has the same characteristics in terms of hardware and software must be considered (Jaros *et al*., 2019).

One of the alternatives that can be implemented for the elaboration of such a farm is to use a hybrid model which consists of computers that have high-performance GPUs and CPUs, which will help the implementation and operation of the render farm.

The present research is divided into several segments of which we will start with the structure of a render farm, its construction and finally its operation.

A comparison will be made between the individual team and the farm using the same project to check the effectiveness of the farm. According to the results obtained, an analysis will be made to verify if it is really viable to use a rendering farm in the animation industry, mainly with emerging production houses.

2. Structure of a render farm

2.1. Structure and function in general

A render farm is made up of different machines connected in parallel via network cables. The main machine that controls the entire farm is known as "*Master*", it is responsible for managing all the tasks and processes that correspond to each machine.

The machines that are in charge of doing all the computational work are known as "*Slaves, Slaves,* or simply *Nodes*", these are in charge of receiving the tasks granted by the Master.

The connection between machines is made through network cables connected to a *Network Switch,* this device is responsible for distributing the data and information that is sent from the master node to the slaves and vice versa simultaneously.

Internally, you can count on various software that allows you to manage the nodes as well as allow you to configure and execute a 3-D scene that is about to be rendered. The software will depend a lot on the render engine to be used since there are several options that are up to the user.

2.2. Hardware

For optimal operation, each node must meet the same specifications, so they must have the same model of processor, GPU and other components that make them up.

In our case, we used a hybrid model that works with CPU and GPU at the same time. These devices have the same specifications and components.

Listed below are the main components of the nodes implemented for the elaboration of our render farm:

- GPU: NVIDIA GeForce RTX 2070 SUPER
- CPU: Intel Core i7-10700K leaves 3.80 GHz at 8 cores
- 32GB DDR4 RAM
- 500 GB SSD
- Dell 1KD4V OptiPlex XE SFF Motherboard

In the same way, the components to establish the connection between nodes are the following:

- 5-Port Gigabit Network Switch with 1000 Mbps Transfer Rate
- CAT6 Network Cables (These allow a data transfer speed of up to 1000 Mbps)

All nodes, including the Master, have these components so that the farm can work optimally.

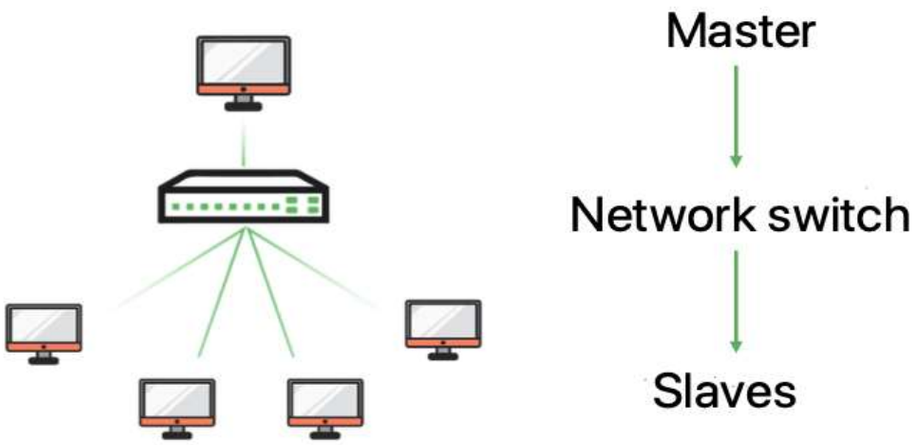
The nodes can be built according to the user's needs, so you can even work with other processor models, GPUs and other components as long as the nodes are the same in construction.

The only essential requirement is the network connection, so you must have a switch and cables that can transfer at least 1000 Mbps. If lower transfer components are used, this will cause a bottleneck that will cause the farm to work at its lowest capacity.

Each computer will need to be connected to the switch with the network cables so that the software can detect their IP addresses.

In summary, the render farm hierarchy is composed of the Master Node, Network Switch, and Slave Nodes as shown in Figure 1.

Figure 1 Schema implemented for the render farm



Source: Authors' Own Creation

2.3. Software

The operating system of each node is Windows 11, this is because the farm is designed to be built with more accessible tools for a not so experienced user.

2.3.1. Blender

"*Blender is a public project hosted on blender.org, licensed under the GNU GPL, owned by its contributors*." (Blender, 2023).

This software allows us to create 3-D scenes that can be rendered with the help of the farm. For this, we will also have secondary software that will allow us to connect the nodes.

2.3.2. LogicReinc.BlendFarm

BlendFarm is a cross-platform program that allows you to connect nodes so that they can work together on any project assigned to them. The main feature of this program is that it is open source, so its use is accessible to all users.

The program is a GitHub repository developed by LogicReinc that is intended to help the community that does not have access to render services or simply does not have access to a powerful computer.

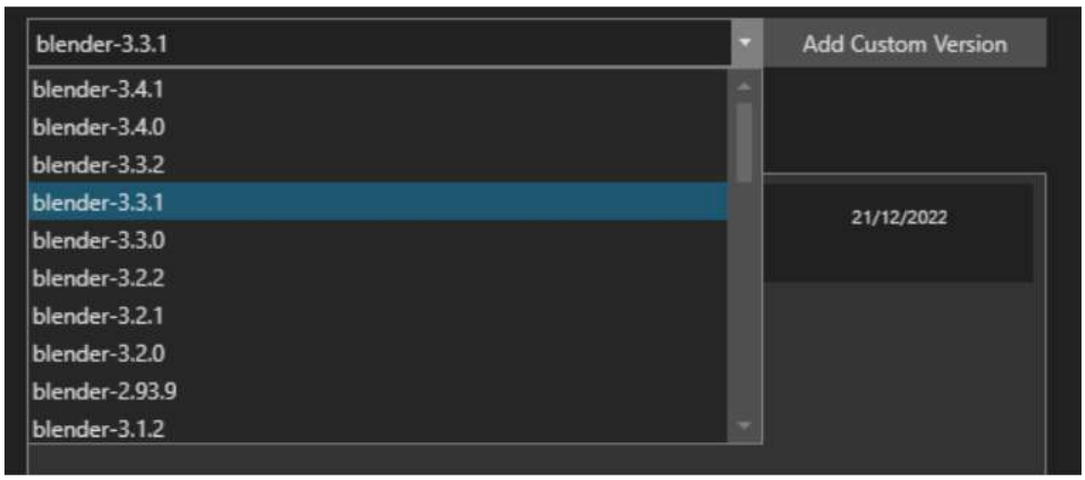
2.3.3. BlenFarm Interface

When you run the installer, a window will open with three sections (Figure 2) of which the first will allow you to select your file from which you want to render, the second section will allow you to choose the version of blender (Figure 3) and finally there is the section that will show you the projects you have recently opened.

Figure 2 Program Opening Interface

Source: Authors' own creation

Figure 3. Program Opening Interface



Source: Authors' Own Creation

In this case, we worked with version 3.3.1 of blender and selected an animation project which can consist of several elements that make the animation more realistic.

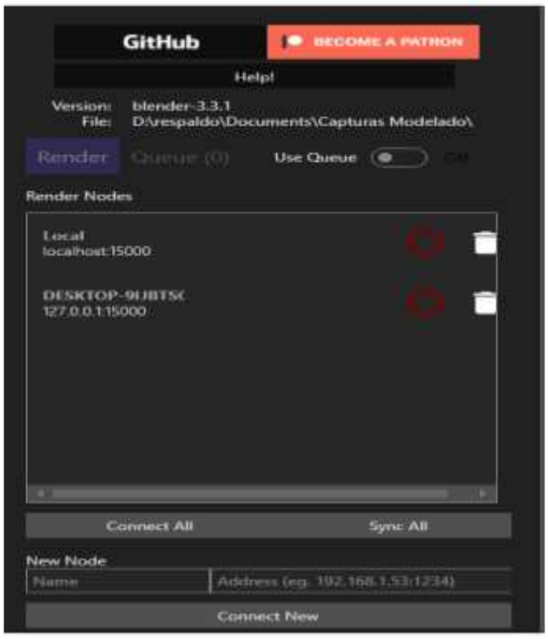
Once you've selected your project, a window will be displayed that will show you the main work interface where you can configure your scene and render the project.

Being on the main interface we will be able to see some panels and options that we will be breaking down little by little, from where we can see two main panels of which the larger one will allow us to visualize the scene we are rendering and the small panel on the right will allow us to configure the nodes and the configuration of the scene.

In Figure 4 you can also see the *Render Nodes panel* and in it we will be able to configure our *Slave nodes* thanks to the IP of each slave computer. To do this, the program must be run on each node with the same configuration used in the *Master*.

Having the program running on each slave, the master will automatically detect them by marking the nodes in green.

Figure 4 Render nodes panel



Source: Authors' Own Creation

Once the nodes are configured, we will click on the Master node gear, which in this case has the default name "*local*" and immediately we will start downloading the version of blender that we previously chose.

Once the version is downloaded, we can also notice that the gear gives us more options to configure the node, which are:

- Cores: This option allows you to choose the number of CPU cores to render the scene
- Auto Performance
- Render Type: Displays a list of options with which we can choose which component we want to work on, whether by CPU, GPU or both.
- Performance

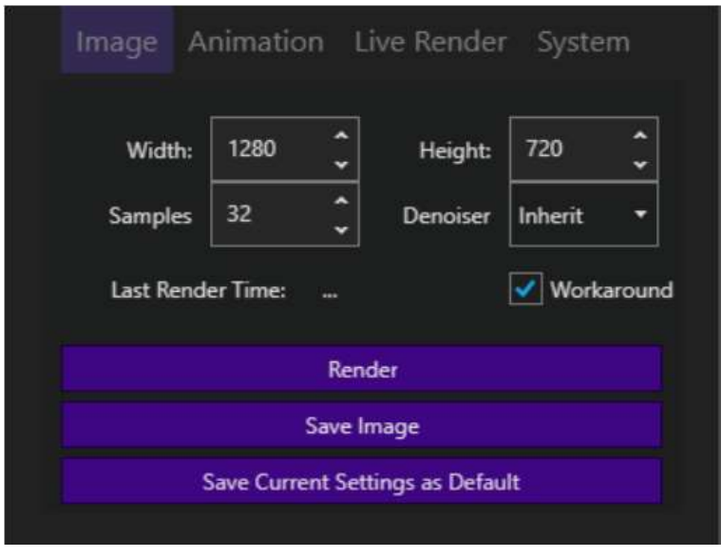
The configuration that was maintained for each node was 16 cores with auto performance enabled and finally we chose the CUDA option that is responsible for using the CPU and GPU to render the project.

2.4. Rendering Options

Image Rendering (Image Tab)

This tab shows us different options that we can configure for the output format of the Render. In Figure 5 we can see four boxes, the first two serve to adjust the output resolution of the image, which in this case has by default 1280 pixels wide (Width) and 720 pixels long (Height).

Figure 5 Image rendering settings



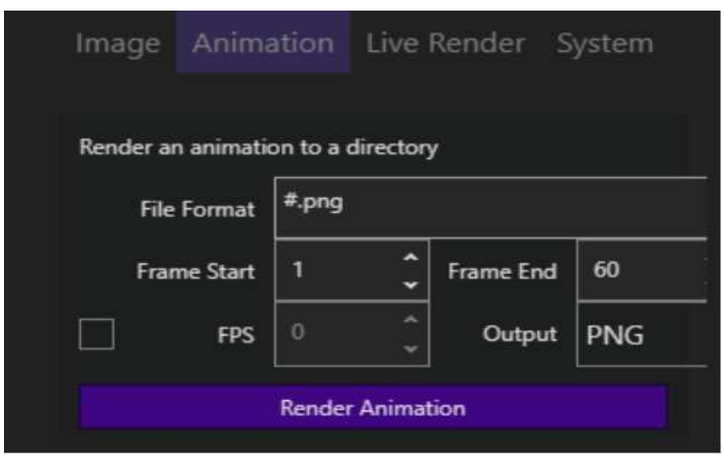
Source: Authors' Own Creation

Rendering an Animation

The *Animation* tab (Figure 6) has five frames. In the first box you can name the output files or frames, for example Image# .png where the # represents the frame number of the animation. The second and third boxes allow us to choose the number of frames to be rendered, as well as the specific range we want to render. The first (Frame Start) is the starting frame and the second (Frame End) is the final frame of the animation. The number of frames must match the number of frames in the original project. In the fourth box we can choose the animation speed (FPS) so it is up to the user to consider if they want to use this box.

Finally, we have the output box where we can choose the format of the image sequence whether it is .png, .jpg, etc. Having the configuration ready you can press the *Render Animation* button for the rendering process to begin.

Figure 6 Animation panel



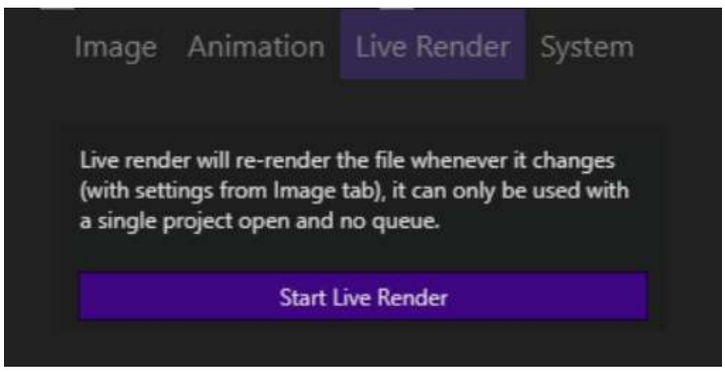
Source: Authors' own creation

The third box (Samples) allows us to control the number of samples that the render engine will take, that is, the limit of calculations of points of light that interact on the object. The fourth box (Denoiser) allows you to configure the noise that the image may have at the end of the render, since the final result can usually give us a very grainy image or with white dots.

Real-time rendering

In Live Render we can visualize the render of our project in real time so that we can manipulate the scene and the result will be seen simultaneously in the main panel. To do this, we must have our blender project open and hit the *Start Live Render button.* (Figure 7).

Figure 7. Panel by Live Render

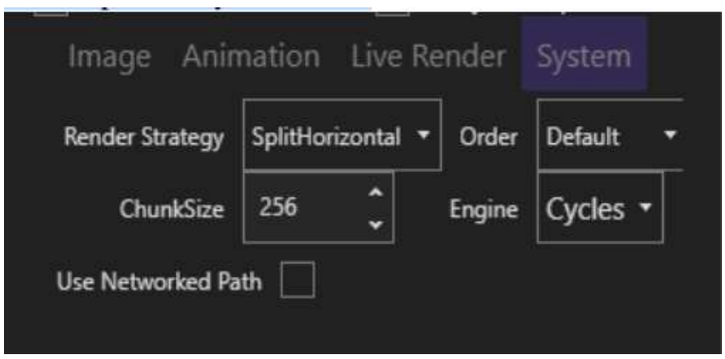


Source: Authors' Own Creation

Configuration (System)

Here we can configure the technical preferences of the render farm. (Figure 8) To do this, we will have four boxes, of which the first one (Render Strategy) allows us to change the render display mode and the flow of tiles or frames while rendering. The second box (Order) allows us to configure the order in which tiles, boxes or chunks can be rendered either sparsely or originating from the center of the panel. The first two boxes go hand in hand with the third (ChunkSize) which allows you to adjust the size of the tiles. The last box (Engine) allows you to choose the render engine to use, which in this case Blender has two default render engines, which are Cycles and Evee.

Figure 8 Farm rendering settings



Source: Authors' Own Creation

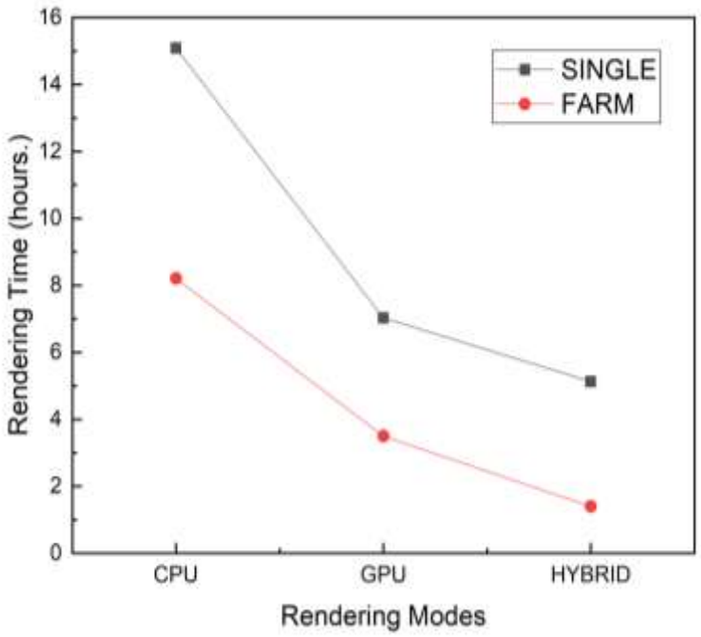
3. Results

The first tests made within the Render farm were done using the CPU, GPU and mixed mode applied to an animation of a ship, which consists of the simulation of fluids and various hard-surface textures due to the type of material that the ship is made of, which makes the animation on its own complicated to render on a conventional computer (Figure 9). This animation was made in Blender which consists of 250 frames, this animation tried to address the most outstanding physical aspects and then compare its efficiency with an individual node; For the comparison with the individual node, a computer was used, which consists of GPU: NVIDIA GeForce RTX 2070 SU- PER, CPU: Intel Core i7-10700K at 3.80 GHz 8 cores with 32 GB of DDR4 RAM and a 500 GB SSD hard drive.

Figure 9 3-D Boat Animation

Source: Authors' Own Creation

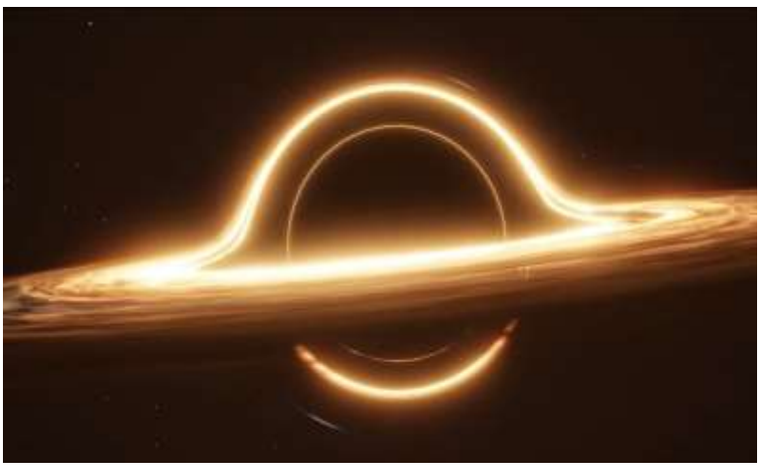
Figure 10 Comparison graph between an individual node and the render farm



Source: Authors' Own Creation

Figure 10 shows the behavior of the 3 main architectures for the elaboration of the render farm compared to an individual node, from which for the three cases we can see an individual decrease in the efficiency of the farm before the individual node, decreasing for each of the three cases the rendering time by almost 50% due to the fact that when using the CPU for the individual mode we have a render time of almost 16 hours, while for the farm we have that the 250 frames were rendered in 8:30 hours, for the case of using the GPUs the time was 8 and 4 hours for the individual node and the farm respectively; while for the case of the hybrid architecture, the time was 5:40 hours and 2:50 hours for the individual node and the farm, respectively, showing that the rendering time decreases to more than 50%, for this case the efficiency of the farm before the individual mode was demonstrated, so that for each of the cases the farm shows a time efficiency.

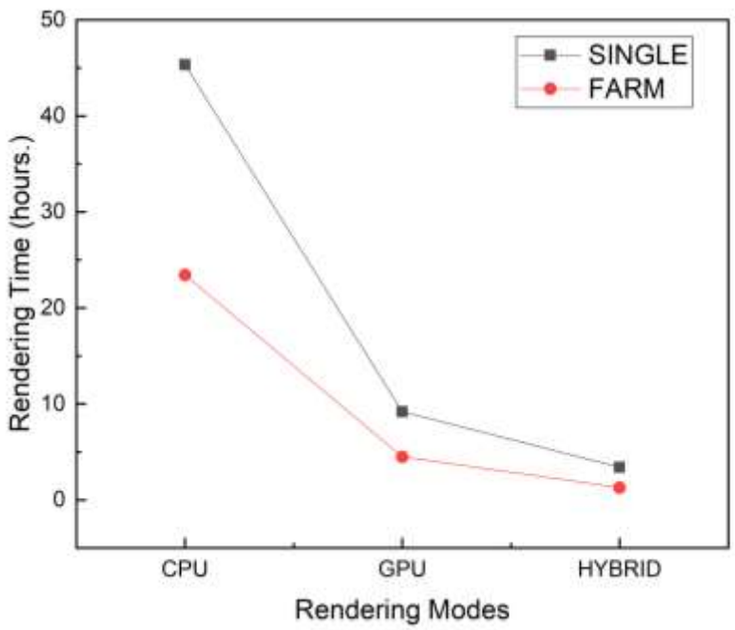
Figure 11 Animation of a black hole



Source: Authors' Own Creation

Figure 11 shows the animation of a black hole which consists of 250 frames, in which we tried to address the most salient physical aspects of where it makes the animation more complicated to render because of all the details that compose it, because we tried to stick to it as realistic as possible. In order to make these effects, the geometry nodes were implemented, which makes our animation heavier, as well as the lighting and shading effects, which are present, in addition to the rotation and vorticity effects.

Figure 12. Comparison graph between an individual node and the render farm



Source: Authors' Own Creation

Figure 12 shows the behavior of the farm before the individual node in rendering times, as can be seen in the graph, the 3 possible forms of architecture were compared when rendering the final project, which is in CPU, GPU and mixed mode; In which for the three cases it was found that the implementation of the render farm reduces about 50% in time for each of the cases, also finding that of the 3 possible forms of rendering, the mixed mode is the one that meets the objective of reducing the rendering times compared to the other two cases. because when the CPU mode is implemented it is 48 hours and 24 hours using the individual node and the farm respectively, for the GPU case the times were 12 and 6 hours respectively, while when using the mixed architecture the render times for such animation were 5 and 2:30 hours, finding that for all 3 cases the efficiency of the farm before the individual node is approximately 50%.

Conclusions

The implementation of a render farm in the culmination of projects that have to do with the world of digital animation, plays an important role because it helps us to make these animations more efficient and enable within the industry, because it contributes to the reduction in the rendering times of very complex animations compared to if you intend to render in individual teams. In this work it was shown that the implementation of a render farm from 4 slaves and a master reduces the rendering time by half compared to an individual node, which allows to reduce costs within animated works and speed up the post-production of such animations, in addition to it was shown that to achieve this the mixed mode architecture is the one that yields the best result because it does not Not only does it reduce the rendering time by half, but it also does it in less time compared to using only CPU or GPU, therefore it is an effective and reliable alternative to emerging production houses with low budgets which will help you develop quality audiovisual content in less time.

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Chapter 3 Language Recognition through Context-Free Grammars and Natural Language Processing

Capítulo 3 Reconocimiento de Lenguajes mediante Gramáticas Libres de Contexto y Procesamiento del Lenguaje Natural

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A. Reyes, E. López and B. Hernández (AA. VV.) Computer Technology and Innovation. Handbooks-TI-©ECORFAN-Mexico, Mexico City, 2023

Abstract

At present, language recognition systems have great relevance, because these systems allow to identify if the lexical units belong to a certain language, this type of tools have allowed to generate translators, word identifiers, and recently sentiment analyzers have been built, thanks to current advances it has been possible to achieve with natural language processing the analysis of sentences developed by human beings to be interpreted by computerized systems. This research shows the application of techniques for recognizing the belonging of strings to formal languages using context-free grammars, on the other hand, a software has been developed for the recognition of feelings in text. The results achieved indicate a recognition of 100% of the analyzed strings, as well as the interpretation of the analyzed sentences, performing the coding of a parser and a sentiment analyzer.

Context, Sentiment, Recognition, Analyzers

Resumen

En la actualidad los sistemas de reconocimiento de idiomas tienen gran relevancia, debido a que permiten identificar si las unidades léxicas pertenecen a un determinado idioma, este tipo de herramientas han permitido generar traductores, identificadores de palabras y recientemente se han construido analizadores de sentimiento, gracias a los avances actuales. se ha podido lograr con el procesamiento del lenguaje natural el análisis de oraciones desarrolladas por seres humanos para ser interpretadas por sistemas computarizados. Esta investigación muestra la aplicación de técnicas para el reconocimiento de la pertenencia de cadenas a lenguajes formales utilizando gramáticas libres de contexto, por otro lado, se ha desarrollado un software para el reconocimiento de sentimientos en un texto. Los resultados obtenidos indican un reconocimiento del 100% de las cadenas analizadas, así como la interpretación de las frases analizadas, realizando la codificación de un analizador sintáctico y de sentimiento.

Procesamiento del lenguaje natural, Gramáticas, Reconocimiento

Introduction

Language is one of the most powerful tools that human beings must transmit information and thus achieve different objectives (Denning, 1978). With the development of computers, language research became important, to generate programming languages that would speed up the process of execution of computer programs. Currently, new tools have been developed that take advantage of the creation of lexical and syntactic analyzers to guide them to the interpretation of the language of the human being and to be able to carry out the construction of the meaning of the sentences that are emitted digital networks, as well as the generation of automated responses by digital assistants.

Because a large part of the knowledge that currently exists is on the internet, whether in text or video format, in volumes of great concentration, artificial intelligence has been harnessed for information processing through machine learning, big data, visual recognition, as well as natural language processing, this last area specializes in probabilistic analysis, ambiguities as well as the extraction of information that is present in text and to be able to generate discourses, natural language responses between machines and people (Chowdhary & Chowdhary, 2020).

In computer theory a formal language is a set of strings of finite length symbols formed from a finite alphabet (**Σ**), has a series of rules, with which an explanation or meaning (Hopcroft, Motwani, & Ullman, 2001). The empty set is represented by *Æ,* and the set formed by the empty string, represented by the symbol Î, are languages. Formal languages can be specified as:

– Strings produced by a formal grammar (Chomsky hierarchy).
– Strings produced by a regular expression.
– Chains accepted by an automaton, (as an example you have the Turing machine).

On the other hand, a Turing machine is a formal model, which has a finite control, an input tape that is divided into cells, and a tape head that sweeps one cell from the tape at a time (Hopcroft, Motwani & Ullman, 2001).

The structure of languages can be described through grammars. One type of grammar is context-free grammar (FCG), which is a set of variables also known as syntactic nonterminal categories each of which represents a language (Vayadande *et al*., 2023). Languages that are represented by variables that describe recursively in terms of the same variables and primitive symbols called terminals. The rules of grammar that relate to variables are known as production rules. A common production states that the language associated with a given variable contains strings that are formed by concatenation of strings taken from languages represented by other variables (Sipser, 1996).

The symbol "=>" denotes the act of derivation, which is understood as the substitution of a variable for the right side of a production. A context-free grammar is defined as.

$$G = (V, T, P, S) \quad (1)$$

Where:
V is a set of variables
T is a set of terminals
P is a finite set of productions of the form A=> α, where A is a variable and α is a string of symbols taken from (V È T).
S is the initial symbol.

Therefore, L is called a Free Context Language (CFL) if it is L (G) for some CFG. A string of terminals and α variables is known as a sentence form if S=> α. The L (G) language is the set of all the words that belong to an alphabet (Qureshi *et al*., 2023). The alphabet is that element that contains the set of terminals (Xing *et al*., 2009).

The Chomsky *Normal Form* or CNF is described as a context-free language without Î, it is generated by a grammar in which all productions are of the form A = > BC or A = > a. Here A, B and C are variable and α is a terminal (Kosheleva & Kreinovich, 2023). Grammars allow to pose the rules of a language because it describes the phases for the realization of some process or several subprocesses of an entity or phenomenon to be characterized.

Note that regular grammars restrict the rules that contain on the left to a non-terminal and on the right a single terminal, usually followed by a non-terminal. The rule $S \rightarrow \varepsilon$ is allowed if *S* does not appear to the right of any rule (Chen *et al*., 2020).

The implementation of grammars in computer software requires the development of a lexical analyzer (scanner) and a parser. The lexical analyzer is a program that analyzes a certain language and produces as output a series of *tokens* or symbols. Symbols are used in the parser stage. A parser is responsible for converting the strings or tokens to a data structure, in this way the data organized to later generate an analysis of the previously treated code and make the compilation process possible. The final product is the analysis tree.

The descending parsers are what build the syntactic tree of the statement to be recognized, starting with the initial symbol or root, until reaching the terminal symbols that form the statement. Lexical and parsers are implemented in the compiler, which is software dedicated to the translation of one language to another, which can be interpreted by a computer, to execute the instructions that have been written. Particularly context-free grammars are used to identify the primordial elements and proceed to check the belonging of sentences to a language (Lasser *et al*., 2019).

With the development of artificial intelligence (AI) it has been possible to solve tasks, which were particularly intended to be solved by expert systems, which were limited to evolve to adapt to new solutions. AI is a discipline related to the theory of computation whose goal is to emulate some of the human intellectual faculties in artificial systems. Human intelligence refers to sensory perception processes (vision, hearing, taste, among others) and their consequent pattern recognition processes, so the most common applications of AI are data processing and system identification. The most frequent applications of AI include fields such as robotics, image analysis or automatic word processing (Russell & Norving, 2004).

Artificial intelligence has different branches, of which the following stand out.

a) Fuzzy logic. It is a method based on the reasoning of logical expressions that describe the memberships to fuzzy sets. The important concepts are the fuzzy sets, responsible for interpreting the predicate of a set that has no bounded boundaries. One of the disadvantages of fuzzy sets is that the rules are defined from the construction of the model.

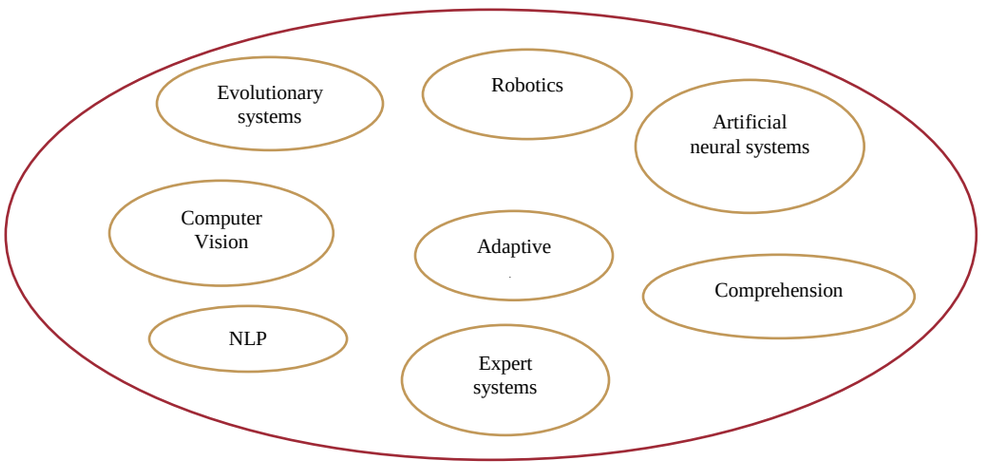
b) Genetic algorithms. Represent a stochastic search in which successor states are generated by combining two parent states, genetic algorithms are created with sets of randomly generated states, which are named population, individuals are represented with a string over a finite alphabet. The population in the GA evolves in a different way than it would in a real situation, because the model does not take other variables that exist in a real environment.

c) Neural networks. Neural network models are based on the functioning of biological brains, and have gained skills to develop distributed computing, digital image recognition, among others.

d) Expert systems. Expert systems are programs based on a knowledge base to make inferences and solve problems of high complexity that are traditionally solved by human beings (Brock & Grad, 2022). An expert system is a computational system capable of emulating the decisions of an expert human (Giarratano, 2001).

Some areas of artificial intelligence are contained in Figure 1.

Figure 1 Areas of artificial intelligence



Source: Giarratano (2001)

Due to the complexity involved in natural language recognition, there are different methods used by NLP for this (Nadkarni, 2011). These methods are listed below.

Support vector machines (SVM). SVMs are responsible for classifying the entries that are defined as words to categorize them, using mathematical transformations. Generally, the most used functions are Gaussian functions, to form a series of subsets of data that will be used for training (Galindo *et al*., 2020), (Murillo-Castañeda, 2021).

Hidden Markov models (HMM). The systems where a variable can change state, and a series of passible outputs are generated. The sets of possible states and unique symbols are finite and known. These models are used for speech recognition, where the waveform of a spoken word is matched to the sequence of individual phonemes (Ching, 2006), (Norris, 2011).

Other models used in NPL are CRFs, which are responsible for generalizing logistic regression to sequential data in a similar way to HMMs. The models are used to predict state variables based on the observed variables. As an example, there is the moment to write or pronounce the distinction that a person has, by which the model would interpret that it must follow the name of a subject (Nadkarni *et al.*, 2011).

Computer systems have had a profound evolution, because, from the first information systems to the development of artificial intelligence, it has allowed them to acquire new capabilities for solving the problems of everyday life. Evolutionary algorithms have proven their efficiency for numerical analysis (Neri & Tirronen, 2010), (Qin *et al*., 2008), (Qin & Suganthan, 2005), (Dragoi *et al*., 2013).

The systems that implement evolutionary algorithms have the characteristic of entering information through pure text, audio, or video, then this information is analyzed and filtered for analysis, all the information is stored to function as the memory of the system, this memory can change position to adapt to the resolution of problems.

Literature review

The developments on string recognition mechanisms belonging to formal languages have been widely studied and there are different applications for language validation in various areas as can be seen Aschermann *et al*. (2019) for the verification of errors in languages, while in M. Ganardi *et al.* (2021) they presented the development of grammars to achieve balance in programs (Numaya *et al.*, 2023). Some other applications have focused on the use of grammars for biological applications as in (Huang *et al*., 2019) for RNA strand modeling.

In other works, such as Torr *et a*l. (2019) they relied on extracting knowledge from the definitions of synthesis problems to guide the construction of the grammar used by Grammatical Evolution and complement its adequacy function to improve the precision in the set of synthesis problems of reference programs in the field. In research such as Hemberg *et al.* (2019) and Shin *et al*. (2020) they focused their efforts on studying the evolution of grammars in computational environments, as well as on language recognition.

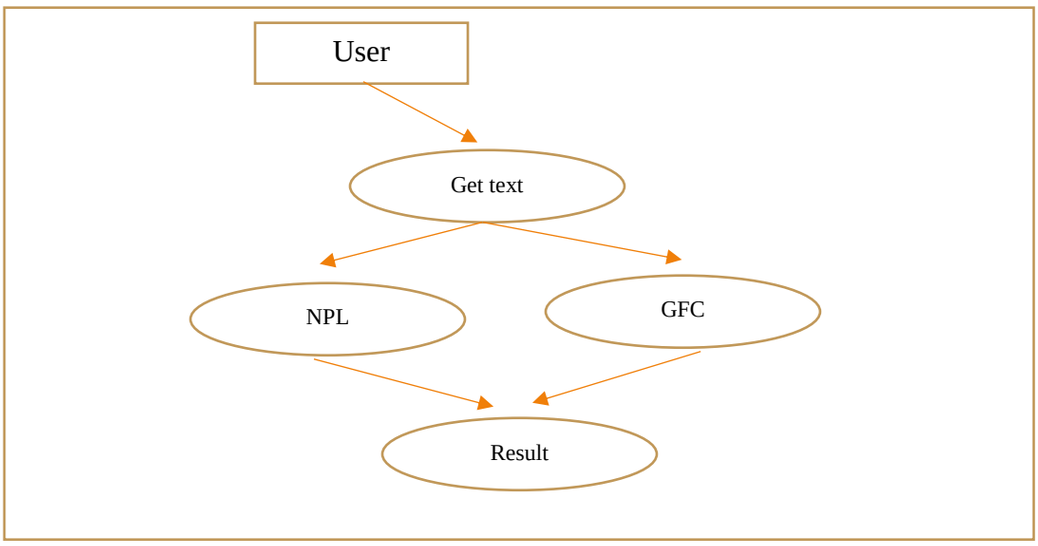
Due to the important advances that have been achieved in formal languages, it has been possible to accommodate the development of new tools that can analyze information in social networks Zucco *et al*. (2020), Can & Alatas (2019). In research such as that of Kauffmann *et al*. (2020) they have focused on developing a framework for the analysis of feelings with commercial uses, because commerce in social networks is of high importance, on the other hand, in Himelboim *et al*. (2020) they deal with problems the analysis of feelings in social networks such as Twitter through data cluster. Sentiment analysis on the internet is extensive, due to the study of mental health conditions Htet *et al*. (2019), commercial applications Khrais (2020) and in the field of education Xiao *et al*. (2020).

As can be seen, computational linguistics and natural language processing, present large areas of application, due to their extensive management of information, allowing the generation of new languages for computer, with tools that accelerate the coding process, as well as commercial, biological, and educational applications, being one of the tools with greater in computing and informatics.

Proposed Scheme

The present proposal consists of integrating a software with the ability to analyze the input strings of a language which is analyzed using context-free grammars, as well as the ability to interpret the natural language of a person to perform a sentiment analysis on the input strings. Figure 2 shows the general structure of the string analysis system.

Figure 2 General diagram of the recognition system



Source: Own Elaboration

According to Figure 2 the proposal presents a context-free grammar analyzer, which aims to interpret grammars that have this type of structure. Traditionally this type of grammars begins with the symbol S and determines the beginning of the production rules, the model must identify all the non-terminal symbols that are before "=>" (produce), to analyze which are the rules to process and the terminal symbols (alphabet of the language).

The model of the lexical analyzer consists of verifying the elements that belong to the language that is represented through the terminal and non-terminal symbols, in algorithm 1 the steps that indicate the general operation for the identification of the characters are presented.

Algorithm 1. Lexical analyzer.

- Beginning
- Check if there are characters written in the input string of the grammar to be analyzed.
- If there are written characters, append in a string array the production rules unitarily, otherwise end.
- The position of the string array is incremented when a line break (/n) is found at the end of the line.
- Terminates until a line break with an empty string is encountered.
- The end

Algorithm 1 specifies four essential steps for generating the grammar, the first step of the program generates the production rules, each production rule is separated by a line break, it is represented by the symbol "/n". When a line break is located, the characters that make up the production rules are joined, the process ends when a line with 0 written characters is found. Once algorithm 1 is executed, the non-terminal symbols are located using algorithm 2.

Algorithm 2. Localization of non-terminal symbols.

- Beginning
- Read the array containing the production rules.
- Concatenate all characters before finding the "=>" symbol in each production rule.
- When the symbol "=>" is found, the previous characters are appended, and the concatenated string is saved in an array called rules.
- If the number of production items is [production count] +1 == [production count] finish, otherwise go back to the beginning.
- The end

Nonterminal symbols are usually found before the symbol "=>" this symbol is read as produces, any character found before a symbol produces, is recognized as nonterminal, and is likewise a rule of production. Algorithm 2 indicates that now of executing the analysis of the production rules previously stored by algorithm 1, all symbols after "=>" are concatenated, these symbols are stored in an array that has been called *rules*. The processing cycle ends until the end of the chain array is found.

Once the previous points have been established, the set of non-terminals will have been obtained, then the operations are executed to obtain the alphabet of the grammar, for this algorithm 3 is executed.

Algorithm 3. Obtaining the alphabet of the grammar.

- Beginning
- Read array containing production rules.
- Delete all content older than "=>", including "=>".
- All subsequent content of "=>" will be concatenated as a new production in the production chain arrangement2.
- Finish until you find the end of array elements (numelem <[count array]).
- The end

To obtain the terminal symbols, two steps are implemented, the first is contained in algorithm 3, in which the reading of the string array is executed, where all the characters after "=>" are obtained, so that the new string array has the same number of locations as the rules array. Once the new array containing the production rules without "=>" and the non-terminals prior to it is obtained, it is executed with algorithm 4.

Algorithm 4. Production rules.

- Beginning
- Replace all symbols of the production lines that correspond with the non-terminal symbols to separate the chain into *tokens*.
- Later when finishing placing the separators in the chain, generate a loop and add the tokens to the alphabet array.
- Insert until the end of each chain found in the locations of the array where the production rules of the chain are located.
- When exhausting the memory positions of the arrangement finish.
- The end

Created the alphabet array (S) of the grammar proceeds to the implementation of the string array called *wildcard*, in which the grammar is rewritten in the form of a stack structure, following the steps of algorithm 5, this new algorithm involves the implementation of a parser, which is responsible for analyzing if the strings received by the grammar present the structure described by the production rules.

Algorithm 5. Replacing elements

- Beginning
- Initialize a loop and append the elements in an *array of objects*, the non-terminal elements of the rule array are replaced by the symbol "/+*/".
- Record at each position *of the object array*, the elements that make up the production rule include all the symbols of the grammar.
- *The end*

Figure 3 Example of grammar to be stored in algorithm 5

S=>Trenmotor

Trenmotor=>Version_mAmodFechfErrorDDDD

Version_m=>-2.0|-1.8|-1.6|-1.2|-V2.8|-R2.8|-3.6|-3.2|-4.2|-FsI2.0|-16V1.6|-TsI-1.8|-T1.8|-1.4|-TFsI-1.4|-TsI1.2|-1.9|-FsI4.2|-16V1.4 Amod=>DDDD

Fechf=>DDDD

Source: Own Elaboration

The new array generated by algorithm 5, presents a replacement of the non-terminal elements by the symbol "/+*/", the elements containing the production rule are stored in a new location of the *object array*, in Figure 4.1 algorithm 5 is exemplified using part of the grammar. In this process the parser checks the sentences obtained that are obtained from the database. In Figure 4 some elements of Figure 3.1 are presented, which are introduced on the left side of Figure 4, the non-terminal symbols that specify the production rule become /+*/, the other symbols become equal to that of the previous arrangement and without changes in its structure.

Figure 4 Process of transformation of the original grammar

S	"=>" Nonterminal becomes	/+*/
Trenmotor	The symbol is kept	Trenmotor
Trenmotor	"=>" Nonterminal becomes	/+*/
Version_m	The symbol is kept	Version_m
Amod	The symbol is kept	Amod
Fechf	The symbol is kept	Fechf
D	The symbol is kept	D

Source: Own Elaboration

When generating the array called "wildcard", the method of evaluation of membership of a chain X is used, for this algorithm 6 is executed.

Algorithm 6. Evaluation of the chain.

- Beginning
- Read the first symbol of the "wildcard" arrangement and verify its position in the rule array, compare the position of the first element of the rule array and then verify to which production rule it belongs.
- When obtaining the rule and its position in the rules array , the lane() method is invoked to execute the path of the production options of the rule.
- If it is terminal, it is sent to be concatenated, otherwise the position of the new terminal symbol to be evaluated is returned.
- The lane() method until it finds a symbol "|" or a symbol "/+*/"
- If the string to be evaluated does not end yet go to step 2, incrementing a position in the "wildcard" array, otherwise end.
- Determine if a state of acceptance has been reached the chain under evaluation.
- The end

If the *lane() method has returned a terminal string, the* evaluate() *method verifies* the string obtained by the grammar, comparing it with the string previously entered by the application, thus obtaining the answer whether the written string belongs to the OBDII language. Figure 5 exemplifies the process of transformation of previously written grammar.

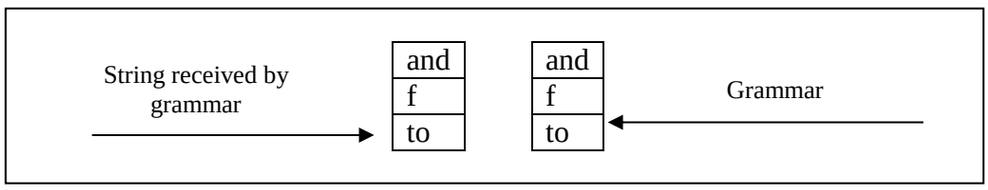
Figure 5 Grammar transformation process

Original grammar		Equivalent grammar
S	=>	/+*/
Trenmotor	----	Trenmotor
Trenmotor	=>	Trenmotor
Version_m	----	Version_
Amod	----	Amod
Fechf	----	Fechf
D	---	D
Version_m	=>	/+*/
-2.0	---	-2.0
|	----	|
-1.8	----	-1.8

Source: Own Elaboration

Figure 6 contains the string "efajk" for evaluation, on the right side of Figure 8.1 is the rule in progress that is being used to perform the language membership operation, for this example it is assumed that the production rule *S* contains the non-terminal symbols "efa". The basic principle of the stack method is to replace the characters that correspond to those in the string stack, left side of Figure 8, with those in the grammar stack, right side of Figure 8.1. At the end those characters are replaced by the symbol "#", which occupy the same position and that presents an equality in its morphology in both stacks, the above represents the characters of the string and is replaced by an empty symbol called as ø to the characters that belong to the grammar stack, the number symbols "#" and symbols "ø" must coincide between each stack.

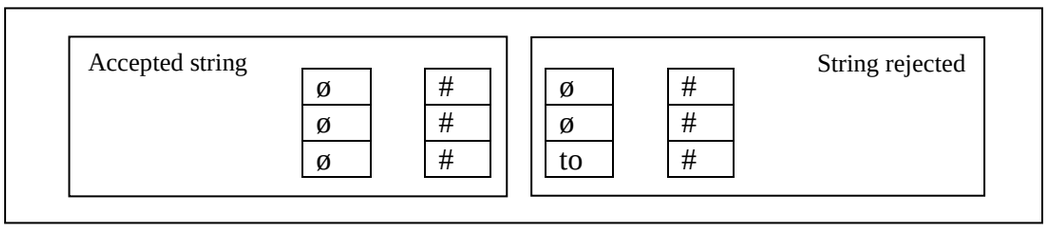
Figure 6 Implementing a Stack for String Evaluation



Source: Own Elaboration

If the entered string does not correspond to the grammar as shown in Figure 7.1, right side, while on the left side of Figure 7 a valid acceptance state has been reached:

Figure 7 Valid acceptance status of the stack left side. Invalid acceptance status of the stack, right side



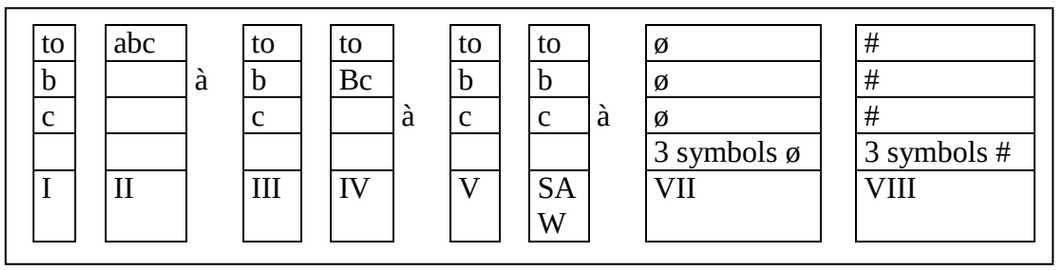
Source: Own Elaboration

In Figure 8.1, it is visualized how the two stacks on the right side do not contain the same *number of elements "#" and "ø" therefore the entered string does not belong to the language, this result is obtained by initializing a counter* the number of symbols "#" exist in a stack and the number of symbols "ø" In the other, if the total number of symbols in each stack is equal to their size, a state of favorable acceptance is reached, as in the example in Figure 9.1.

Because other methods of solving grammars suggest the expansion of grammar through the syntactic tree, in this section, a similar process is exposed, but without using a syntactic tree, a mutable array is used (the number of elements can increase or decrease in real time) to achieve expansion when a non-terminal containing one or more of these is found.

On the other hand, Figure 8 shows the process of expanding one of a grammar to give rise to the generation of a response to the input string. First the character *c is stacked, then b* and at the end *a* (column I), in column II, rule *S* replaces the content to be evaluated by *aBC*, then *column III does not vary compared to column I, while the non-terminal* B *is replaced by its terminus* b (column 4). Continuing with the expansion of the grammar, the nonterminal *C*, is replaced by *c*, and remains as exemplified in column VI. The final process consists of having stacked the non-terminals are compared with the start chain, it begins to generate an equal relationship between the content of the indexes of the arrays, if they are equal, they change by the empty and # symbols. When there are 3 voids and 3 # symbols, the state of valid acceptance is reached, as it is possible to analyze in Figure 7.1.

Figure 8 Example of expanding a grammar using the stack method

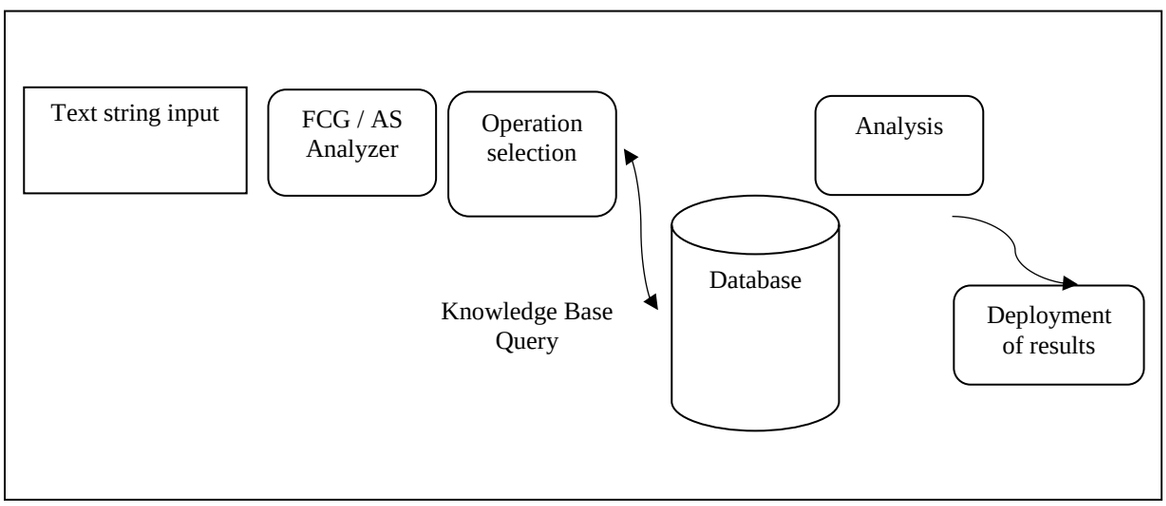


Source: Own Elaboration

Only 4 variables have been taken for the analysis of estimation of failures, because time is one of the main factors involved in the process of wear of a vehicle, as well as the operation of an engine varies from one to another, in addition the complexity of its system rises or decreases, affecting the number of OBDII codes you can present.

Figure 9 shows the general structure of the chain evaluation system, where the input is evaluated by an FCG analyzer or by sentiment analysis, from this evaluation the results are displayed by its visualization. The sentiment analyzer is based on a statistical model, which forms a structure based on a corpus of syntactic categories, to determine the classification of words, as well as to interpret based on probabilities the trend involved in the sentences that are analyzed.

Figure 9 General representation of the system with data acquisition



Source: Own Elaboration

Experimental Results and Discussion

The string recognition models for verifying language membership, and sentiment recognition have been implemented in the Python language in version 3.11, have been run on a MacBook Air M1 computer with 8 GB of RAM. For the validation of both models, the following entries have been considered.

1. Evaluate 10 text strings using context-free grammar that represents the fault code system of systems for cars that work OBDII.
2. Evaluate 10 text strings to analyze sentiment analysis.

The perspective of the analysis of the analyzer and syntactic has been raised to recognize the OBDII codes, which has an alphabet (OBDII symbols such as P, B, C, U y), remembering that all codes of this type have 5 characters. The main rule is that an OBDII code always starts with any letter either P, B, C, U, once, the other 4 symbols are a four-digit hexadecimal number, figure 10.

Figure 10 Grammar used for the analysis of OBDII codes.

```
S=>Trenmotor

Trenmotor=>Version_mSepAmodSepErrorDDDD

Version_m=>2.0|1.8|1.6|1.2|V2.8|R2.8|3.6|3.2|4.2-FSI2.0|16V1.6|TSI-1.8|T1.8|1.4|TFSI-
        1.4|TSI1.2|1.9|FsI4.2|16V1.4

Amod=>DDDD
```

Source: Own Elaboration

Figure 10.1 shows the interface used for the evaluation of the evaluation model. In the left section the strings to be evaluated by the grammar of Figure 11 are entered, while in the right part the section to enter the text to be evaluated by the sentiment analyzer is presented. To perform the corresponding operations, it is only required to operate the buttons that are at the bottom of the application.

Figure 11 Proposed Interface for Text Evaluation

Source: Own Elaboration

Table 1 presents the evaluation results of the analyzed chains. According to the data analyzed, it was possible to observe that the results with respect to the chains corresponding to the FCG adhered to the previously established structure, resulting in the acceptance or rejection of these, on the other hand, in the analysis of feelings, the chains that tended to express a description of facts, without phrases of emotional attachment, The results tend to be classified as neutral, while sentences with words denoting rejection or acceptance will be classified as positive or negative.

Table 1 Results obtained from the analyzed chains

Grammar text evaluation	Result	Sentiment analysis text	Result
Chain 1	Accepted	Text 1	Neutral
Chain 2	Accepted	Text 2	Negative
Chain 3	Accepted	Text 3	Positive
Chain 4	Accepted	Text 4	Positive
Chain 5	Accepted	Text 5	Positive
Chain 6	Rejected	Text 6	Negative
Chain 7	Rejected	Text 7	Neutral
Chain 8	Accepted	Text 8	Neutral
Chain 9	Accepted	Text 9	Neutral
Chain 10	Accepted	Text 10	Neutral

Source: Own elaboration

The figure shows the results obtained, according to the evaluation of the text strings processed by the models, in subsection a it is shown that the sentence was analyzed as neutral in the analysis of feelings, because it expresses a definition of the mammal bears, while in subparagraphs b and c, the results indicate that the software obtained a negative and positive evaluation, respectively, with respect to the exposed sentences, finally, in subsection d of Figure 12, it is shown that the string has been accepted.

Figure 12 Results obtained from the evaluation of text strings for grammars and sentiment analysis

a) Example of sentiment analysis result with neutral result

b) Example of a positive sentiment analysis result

c) Example of sentiment analysis result with negative result

d) Example of grammar analysis result with accepted string

Source: Own Elaboration

In the tests carried out, the implemented model obtained a correct performance, because in 100% of the cases analyzed it was possible to obtain the expected recognition, as well as the appropriate classification in the analysis of feelings, although it is important to highlight that in this last part it was observed that the corpora available for the Spanish language present a lower development with respect to the corpora destined for the English language, which generates that the accuracy of the classification of phrases for the verification of the sentiment that is being expressed is lower than expected.

Conclusions

The model presented allows, on the one hand, to affirm or reject the belonging of a string to a language by reading a particular FCG, allowing it to be adaptable to different changes in grammar. On the other hand, sentiment analysis is of great importance to obtain information about the mood of people who deposit their comments in digital media such as social networks, or opinion space.

Sentiment analyzers require a large amount of data to determine if the expression read tends to be positive, negative, or neutral, in addition to that, in real applications, these require a large database to obtain relevant statistics.

Acknowledgement

We are grateful to the CONAHCYT [3873836-2022] and the Technological Institute of Higher Studies of Jocotitlán, for the support given in carrying out this research project.

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Chapter 4 Machine learning in the detection of gender violence in digital job offers in the technological sphere

Capítulo 4 Aprendizaje automático en la detección de la violencia de género en las ofertas digitales de empleo en el ámbito tecnológico

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DOI: 10.35429/H.2023.13.40.52

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Abstract

Gender violence is a social problem that continues to affect women in various sectors and areas, specifically in the workplace, where their right to equal employment is undermined by the existing gender discrimination, which is evident in the selection process of candidates observed in the publication of digital job offers, which can result in one of the many unfair practices, which result in a negative impact, hindering equal opportunities, diversity and even innovation. This research work presents a qualitative analysis of different Machine Learning algorithms, classified into supervised and unsupervised machine learning. A literature review is established, where the information obtained allows an evaluation of the advantages and disadvantages of the algorithms, Decision Trees, Naïve Bayes Classification, Ensemble Methods, Support Vector Machines (SVM) and Unsupervised Deep Learning (Autoencoders): Neural Networks, to determine the best and most relevant characteristics of each one, which can be implemented in the proposal of an algorithm that allows identifying patterns of gender violence in the field of digital job offers.

Gender violence, Discrimination, Digital job offers, Diversity, Machine Learning, algorithms

Resumen

La violencia de género es un problema social que sigue afectando a las mujeres en diversos sectores y ámbitos, específicamente en el ámbito laboral, donde su derecho a la igualdad laboral se ve menoscabado por la discriminación de género existente, que se evidencia en el proceso de selección de candidatos que se observa en la publicación de ofertas de trabajo digitales, lo que puede resultar en una de las muchas prácticas desleales, que se traducen en un impacto negativo, dificultando la igualdad de oportunidades, la diversidad e incluso la innovación. Este trabajo de investigación presenta un análisis cualitativo de diferentes algoritmos de Machine Learning, clasificados en aprendizaje automático supervisado y no supervisado. Se establece una revisión bibliográfica, donde la información obtenida permite evaluar las ventajas y desventajas de los algoritmos, Árboles de Decisión, Clasificación Bayes Naïve, Métodos de Ensamble, Máquinas de Vectores de Soporte (SVM) y Aprendizaje Profundo No Supervisado (Autocodificadores): Redes Neuronales, para determinar las mejores y más relevantes características de cada uno, las cuales pueden ser implementadas en la propuesta de un algoritmo que permita identificar patrones de violencia de género en el ámbito digital ofertas de trabajo.

Violencia de género, Discriminación, Ofertas de empleo digitales, Diversidad, Machine Learning, Algoritmos

Introduction

Gender-based violence in the selection process of candidates continues to be a practice carried out by some organizations on a recurring basis, causing a negative impact on equal opportunities, diversity and innovation. It is important to analyze the problem, with the intention of detecting the negative consequences, in turn, in future work to find solutions that allow detecting and preventing gender violence in the technological workplace.

This research paper presents different Machine Learning algorithms, where their characteristics and advantages are explained. In addition to a literature review that allows us to address the problem of gender-based violence in the technological workplace, raising the central hypothesis that Machine Learning can be used to detect patterns of gender-based violence in digital job offers. The methodology used, through the literature review, allows a qualitative analysis of Machine Learning algorithms for the detection of patterns of gender-based violence in digital job offers, evaluating the advantages and disadvantages of each algorithm, as well as its ability to identify patterns of gender-based violence in the field of digital job offers.

Previous research that has applied these algorithms was reviewed, with the intention of determining their efficiency in the detection of gender-based violence in digital job offers, allowing an evaluation of their effectiveness. Additionally, the inherent limitations of algorithms, such as Decision Trees, Naïve Bayes Classification, Ensemble Methods, Support Vector Machines (SVM) and Deep Unsupervised Learning (Autoencoders): Neural Networks, were explored.

In the discussion section, the proposal of an algorithm with a hybrid approach is shown, which contains the strengths of each algorithm analyzed above, this, to correctly address the detection of patterns of gender violence in the technological field, together with the presentation of the operation and possible results of the algorithm in the data analysis. The conclusions show the main findings of the study together with some recommendations for future research in this field.

Literature Review

1. Gender-based violence in the technological field

We are currently living in a digital era, where the technology sector has experienced exponential growth, transforming life in different environments, such as: social, educational, business, work, to mention a few. However, this situation has highlighted some social issues, such as gender-based violence, which still persists in the technological workplace. According to Hernández (2022), between 2012 and 2021, there is a 42% increase in women who decided to study careers related to science, technology, engineering and mathematics, known as STEM (for its acronym in English), however, the gender gap continues to be an obstacle for women seeking to develop in these areas, emphasizing that gender discrimination is present from childhood to participation in the labor market.

A study published by Grant Thornton's International Business Report (IBR) shows that in management positions in global mid-matket companies, the integration of the female gender has grown slowly, with only 32.4%, which is just half a percentage point (pp) increase for the year 2022, while compared to its study carried out in 2004 it only increased by 13 pp, In addition to the above, the World Economic Forum (WEF) Global Report mentions that with this growth until 132 years from now, the gender gap can be corrected worldwide (Guerra, 2023). In addition to the above, the United Nations Population Fund (2023), mentions the type of gender-based violence triggered through technology, known as digital violence, which is exercised through the use of information and communication technologies, in digital spaces against a person for gender reasons.

Statistical data reveal a worrying reality in the technological field, regarding gender-based violence, despite the growth in women's participation, the gender gap persists in various areas, from education to the world of work. The slow progression in the integration of women in managerial and executive roles manifests a challenge for women to be able to access management positions in the business world. Moreover, the forecast that it will take more than a century to close the global gender gap, as noted by the World Economic Forum's Global Report, emphasizes the need for effective action to address this problem. This information shows the importance of using technology, in particular, machine learning, to analyse gender-based violence in the technological workplace, with the aim of focusing efforts to advance towards gender equality in this sector.

Technology is not only an area of professional development, as well as a labor one, it also helps to carry out a hiring process, thus revolutionizing the way in which job offers are sought as part of the process to obtain a job. Currently, searching for jobs on the internet through social networks is one of the most popular ways to look for a job, two clear and most used examples are: Online Career Center (OCC Mundial) and LinkedIn. Within these, more and more people are going through the job search process, due to the convenience, accessibility and a wide variety of options offered by online job search, this modality is increasingly predominant due to digitalization in the globalization of the economy.

2. Gender-Based Violence in Digital Job Offers

Job offers on digital platforms represent an opportunity to enter the world of work, where people manage to find important professional jobs. However, even today, gender-based violence is still present within job search processes, a problem that is of urgent concern, because it remains in digital job offers. It is necessary to analyze this phenomenon, with the aim of exploring its scope, its manifestations, which help to determine the importance of using technologies to detect its components that continue to cause the lack of inclusion of women in high-ranking jobs.

The language with which a candidate is applied for a job position, according to Piras *et al*. (2023), can act as a barrier to aspiring to a job, since the advertisement may show explicit or implicit language indicating a preference for a specific gender. The Inter-American Development Bank (IDB) conducted the first large-scale research on the impact of inclusive language, addressing biases in job advertisements, finding that the way job searches are conducted can be a barrier to entry for women in highly masculinized sectors. In turn, Cortina *et al*. (2019), conducted an experiment that addresses gender discrimination in job offers, where women between the ages of 37 and 39 are on average 30% less likely to be called to a job interview than men, with the same professional preparation.

Gender-based violence is a problem that is implicit in different areas of society, from gender discrimination in job offers in the candidate selection process, affecting equal opportunities in the workplace. This not only represents an unfair practice, but also has a negative impact on diversity, innovation and the economic progress of organizations and societies as a whole.

In addition to the above, access to employment for women in the 21st century is not only an odyssey, but at the same time, a risky activity, some job offers on digital platforms, ask women, without children or without family dependents, even a type of height, weight or even breast size, without such characteristics being decisive for the correct development of the work offered (Burriel, 2020). Therefore, addressing gender-based violence in job offers is essential not only from an ethical perspective, but also to promote a more productive and equitable work environment.

3. Machine Learning in the Detection of Gender-Based Violence

According to Jiménez and Díaz (2021), Machine Learning (ML) belongs to a type of artificial intelligence (AI), which, according to its name, performs the action of "learning", that is, it can adapt over time, by identifying programmed patterns, resulting in algorithms that evolve over time. ML provides several options for applying machine learning to help detect patterns, becoming a valuable tool in the fight against gender-based violence in the technological workplace. ML makes it possible to analyze large data sets to identify patterns that indicate the presence of gender-based violence in job offers. There are different types of machine learning algorithms, which are located, from classification to neural networks, which learn to recognize indicators of gender violence in texts published within job offers, such as gender bias, offensive language or implicit discrimination, with the aim of identifying early job advertisements that may perpetuate gender stereotypes or discriminate against candidates based on their gender.

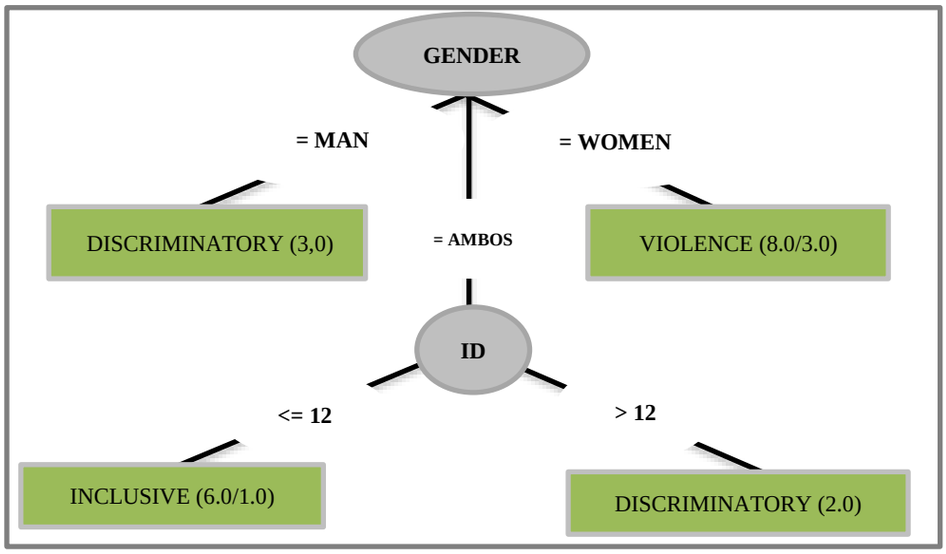
ML contains algorithms classified into two modalities: supervised and unsupervised learning, which are described below.

Supervised Learning: It allows the training of an algorithm, through the application of questions, as well as the implementation of certain characteristic labels, in obtaining answers. The algorithms that belong to this modality are categorized by: classification, where digits, diagnoses, or detection are identified, commonly used in problems such as identity theft. Regression, to obtain continuous or immediate response values, commonly used for climate predictions, or growth projections.

The algorithms belonging to the machine learning modality are:

1. Decision Trees: This algorithm is a prediction algorithm, which works, showing results based on a series of related decisions. There are three important elements to take into account, the integration of decision-making nodes (decision moments), random nodes (events) and branches (associated probabilities). Figure 1.1 shows the graph obtained from Three's algorithm, J48.

Figure 1.1 Decision Tree Chart

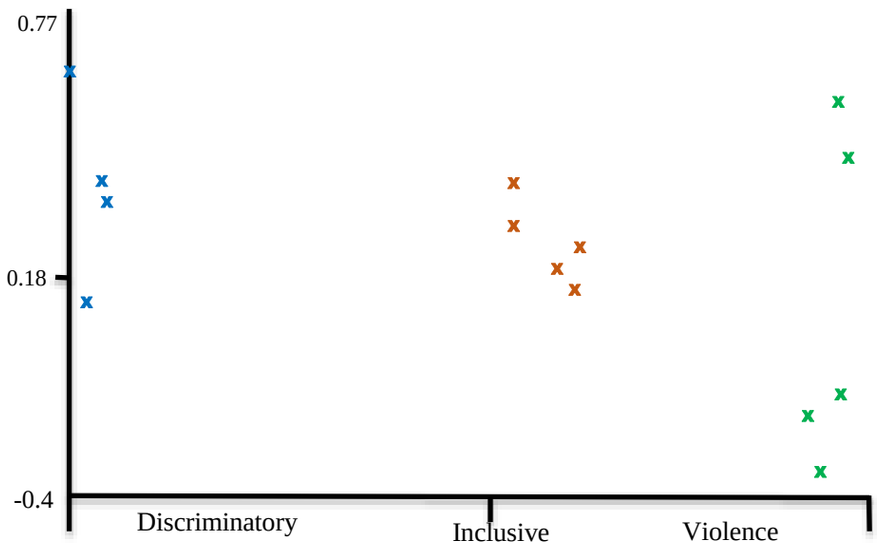


Source: Own Work

The figure above shows a decision tree graph, where a classification, as well as decision-making, is used to identify patterns of gender-based violence in the digital workplace. The decision tree is made up of nodes that represent the characteristics of the data and branches that represent the decisions based on those characteristics, in this case it classifies digital job offers as inclusive or discriminatory based on a delimitation of words within those ranges.

2. Naïve Bayes classification. Simple probabilistic classification algorithm with strong independence assumption. On the a priori basis of each class, a frequency calculation is made of the class labels in the training set, together with the conditional probabilities of each given attribute in each class. Figure 1.2 shows a graph corresponding to the Naïve Bayes algorithm.

Figure 1.2 Naïve Bayes Chart

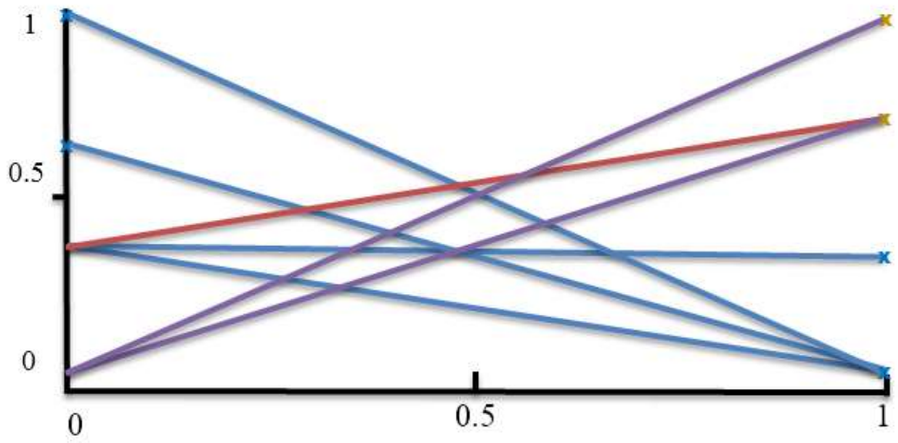


Source: Own Work

Figure 1.2 illustrates an example of gender classification, which can take data such as age and inclusion or discrimination in the job offer, to name just one example. The chart shows how the conditional probabilities of each given attribute in each class (in this case, gender) are calculated to classify new data.

3. "Ensemble" methods: An algorithm that performs the combination of multiple classifiers, with the intention of improving performance and accuracy to make the best decision, contribute to significantly improving performance in a variety of machine learning applications. Figure 1.3 shows the representation of the RandomForest algorithm.

Figure 1.3 RandomForest chart

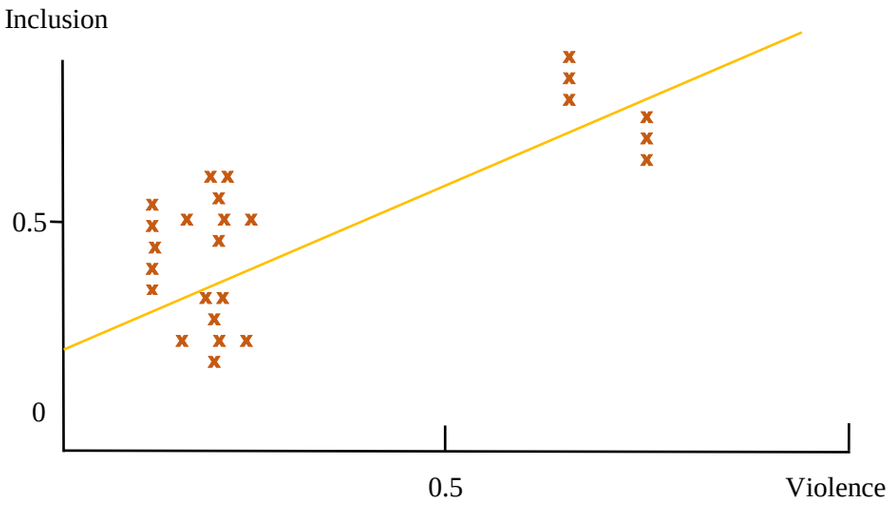


Source: Own Work

The figure above shows the graph of the RandomForest algorithm, which is an "Ensemble" method of classification that combines multiple classifiers to improve performance and accuracy in decision-making. The graph shows an example of classification, which can be in relation to gender, age or some other elements that allow determining inclusion or discrimination in the labor offer.

4. Least squares regression: Based on two variables, dependent and independent, in which it models a relationship between them, using a set of data, with the intention of predicting numerical values based on independent variables. Figure 1.4 shows the graph corresponding to the least-squares regression algorithm, showing that it can be obtained from a prediction using numerical values based on independent variables.

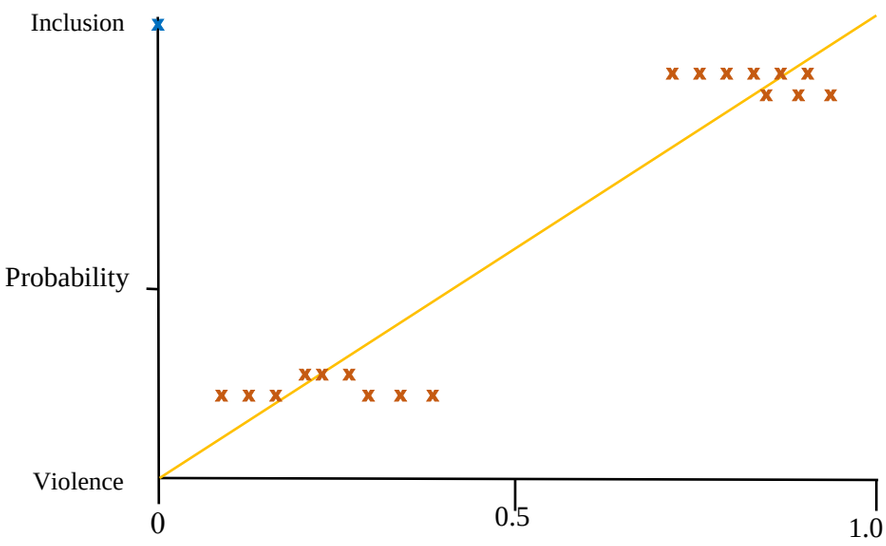
Figure 1.4 Least-squares regression chart



Source: Own Work

5. Logistic Regression: Classifies data in a binary and multiclass way, used for classification problems. It uses logistics to model the relationship between a dependent variable and a set of independent variables. Figure 1.5 contains the representative graph of the logistic regression algorithm.

Figure 1.5 Logistic Regression Graph

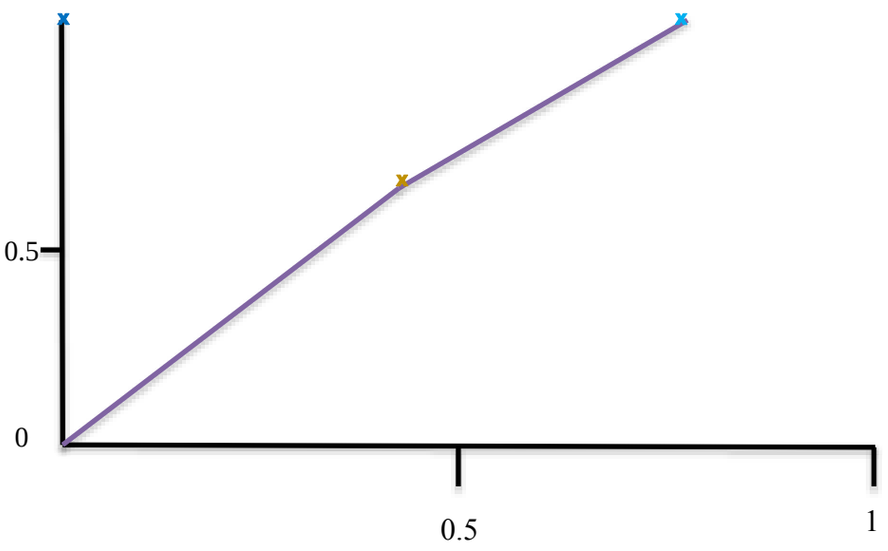


Source: Own Work

As shown in the figure, the data to be obtained can be binary and multiclass in classification problems. The graph shows an example of how the relationship between a dependent variable and a set of independent variables is modeled using the logistic function.

6. Support Vector Machines (SVM): Used in classification and regression problems, it maximizes the distance between classes in feature space, in a linear fashion, used in applications such as text classification, image detection, and bioinformatics. Figure 1.6 shows the graph of the SMO algorithm, representing a variable, in this case, discrimination.

Figure 1.6 Support Vector Machines (SVM)



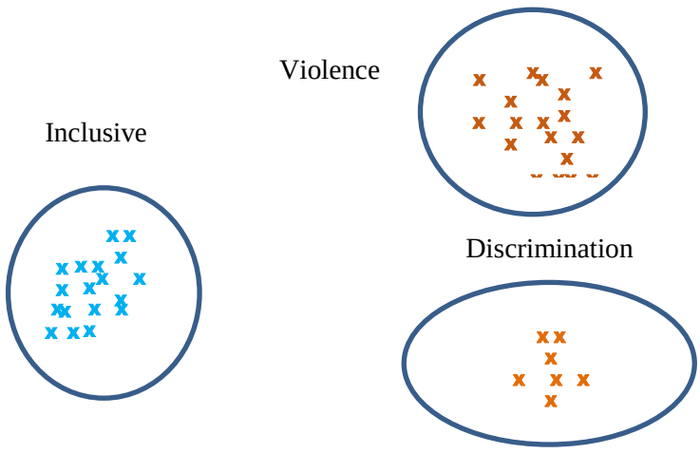
Source: Own Work

Figure 1.6 shows a graph corresponding to the Support Vector Machines (SVM) algorithm used in classification and regression problems. The graph shows an example of how the distance between classes is maximized according to certain characteristics, in a linear way, to classify new data based on the independent variables.Unsupervised Learning: The algorithm is developed with the ability to autonomously assimilate various characteristics and data elements classified in input, where it returns them for output in a coded form.

Two unsupervised algorithms are shown below.

1. Clustering: A model of grouping a set of similar objects or data into groups, with the aim of finding patterns to understand a situation to make informed decisions, used as a technique for customer segmentation, content recommendation, anomaly detection, among others. As an example, there is K-Means: where data is grouped into K, i.e. clusters, where K is a user-predefined value. Hierarchical Clustering: Creation of a hierarchical clustering tree, to observe the clustering structure at different levels of granularity.

Figure 1.6 Clustering

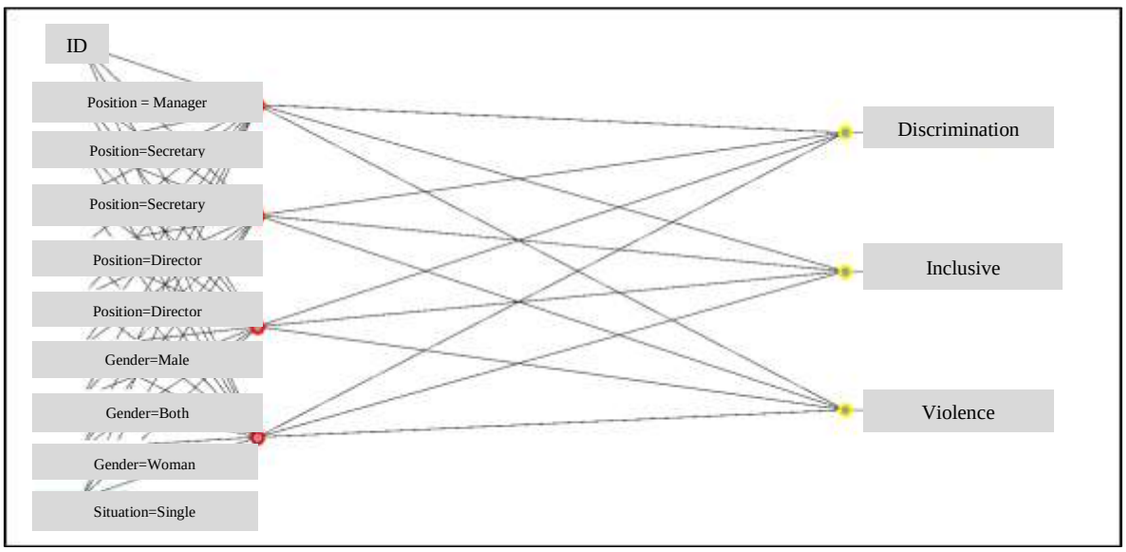


Source: Own Work

The figure above illustrates the grouping of similar data into groups, allowing us to find patterns to understand a given situation. It looks at the different data points grouped into different clusters, some examples of use are: customer segmentation, content recommendation for anomaly detection, among others.

2. Deep Unsupervised Learning (Autoencoders): It uses neural networks to learn latent representations of data, which can help in feature extraction and data generation, being neural networks, the ones that learn continuously by corrective feedback to improve the prediction analysis it performs, the data flows from the input node to the output node through many different paths in the neural network, as shown in Figure 1.7.

Figure 1.7 MultilayerPerceptron



Source: Own Work

Figure 1.7 shows an example of a neural network called Multilayer Perceptron, which makes use of autoencoders, which allow the representation of latent data, with the intention of extracting certain characteristics for the generation of data, which are flowing from the initial node to the output node, following several different paths in the neural network. where learning is done through corrective feedback, which allows improving the prediction analysis carried out by the neural network.

To address the detection of gender-based violence in digital job offers, some specific algorithms have been identified for the analysis of the information. These algorithms include: Decision Trees, Naïve Bayes Classification, "Ensemble" Methods such as Classifier Sets, Support Vector Machines (SVM) and Deep Unsupervised Learning, specifically the use of Neural Networks. They allow a visual representation, which helps to understand the patterns of gender-based violence in the data, through the representation of the information through specific graphs, with the intention of identifying and understanding hiring trends in digital job offers.

Methodology

Through a qualitative analysis, the advantages and disadvantages of each algorithm are established, as well as its ability to identify patterns of gender-based violence in the field of digital job offers.

The analysis consists of a review of previous research that has applied these algorithms, with the intention of determining their efficiency in the detection of gender-based violence in digital job offers, allowing an evaluation of their effectiveness. Additionally, the inherent limitations of algorithms are explored: Decision Trees, Naïve Bayes Classification, Ensemble Methods, Support Vector Machines (SVM) and Deep Unsupervised Learning (Autoencoders): Neural Networks, which help to determine a possible existence of biases in the data, allowing to determine the strengths and weaknesses of the algorithms.

Table 1.1 shows a comparative table of the algorithms proposed for the analysis of information in the detection of gender-based violence in digital job offers.

Table 1.1 Analysis of Machine Learning Algorithms

Id	Algoritmo	Ventajas	Desventajas	Ejemplos de aplicación
1	**Decision Trees**	Effective decision-making. Easy to use and understand. Implement usability. Fast. Constantly updated. Simple graphic design. Intuitive reading. Handles alphanumeric data.	The more training information, the more unstable. It does not guarantee that the tree generated with new data is optimal. Skewed trees. It has drawbacks when generating new data.	According to Dueñas (2020), it mentions the development of a predictive Machine Learning model, using decision trees, to classify HTTP requests classified as normal and anomalous, with 100% accuracy in the classification of HTTP requests.
2	**Naive Bayes Classification**	Perform operations faster. Requires a small amount of training data to estimate parameters. It is extremely fast.	Its attributes depend on others to continue learning (variable independence). You may observe a probability of 0 (zero).	Mostly used for spam detection in emails. García and Guevara (2023) analyzed Phishing, using Naive Bayes, where they obtained 99.04% confidentiality, precision and effectiveness in detecting poisoning attacks on DNS servers.
3	**Ensemble Methods (RandomForest)**	Combine multiple models to improve performance. Functional in hyperparameter adjustments in classification and regression problems. Reduces the risk of overfitting.	Hyperparameter tuning, that is, setting specific values. It comes to present overfitting with high costs. Too much training time. Does not work with small datasets. Difficulties in implementation.	According to Deborah *et al*., (2020), it combines different classifiers, offering better generalization performance, where it minimizes the expected error with respect to the trained data set. Mostly used for web applications, such as: Ecommerce, banking apps, medicine, to name a few.

4	**Support Vector Machines (SVM)**	Learn through features. Extracts large amounts of data, to reduce dimensionality and generate synthetic data. Effective in high-dimensional spaces. Efficient memory management.	Its effectiveness depends on the chosen kernel They are inefficient with large datasets (the kernel calculation can be very slow) The greater the characteristics, the greater the number of samples, causing overtraining.	It builds one or several hyperplanes in a very high-dimensional space that separates groups, used in classification or regression problems (Moreno *et al*., 2020). Examples: medical applications of signal processing, natural language, image and speech recognition.
5	**Deep Unsupervised Learning (Autoencoders): Neural Networks**	Capture complex relationships. Fault tolerant. Recognizes patterns that have not been learned. They correctly capture complex features, for high-precision results.	It requires adjusting the architecture and prolonged training. Greater data preprocessing. Prolonged time and complexity in learning acquisition.	Castillo *et al*., (2022), analyzed data on the Internet through Web Mining, to identify suicidal traits in students, finding suicidal tendencies, with 98% accuracy, coupled with validation, aggregation, data analysis, prevention and detection of failures in complex software systems. Creation of autonomous systems and robots.

Source: Own Work

Discussions

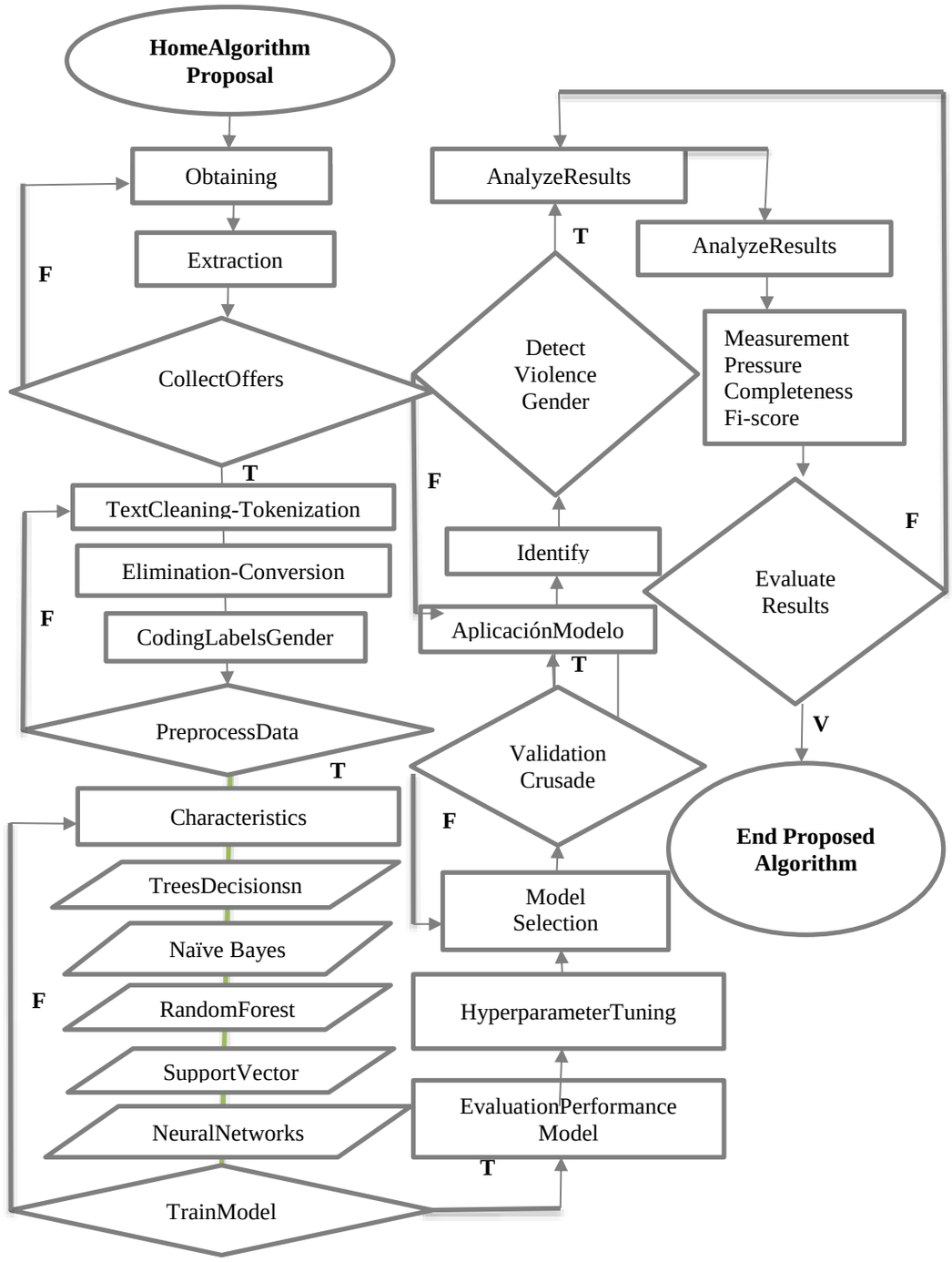
A comparison of different machine learning algorithms is conducted to address gender-based violence detection in digital job postings in the technological domain. Each algorithm presents distinct advantages and disadvantages based on its operational nature. Decision Trees prove to be more efficiently faster, coupled with their easy understanding during implementation. However, their stability is compromised with large training sets. Naïve Bayes classification is fast with small datasets but exhibits variable independence, limiting its effectiveness in more complex scenarios.

Ensemble methods, such as RandomForest, help mitigate risks like overfitting, but their hyperparameter configuration results in long training times on massive datasets. Support Vector Machines (SVM) excel in high-dimensional spaces due to memory management efficiency, dependent on the chosen kernel's capabilities. However, in large datasets, SVM can become slow. Deep Unsupervised Learning (Autoencoders) in neural networks is useful for complex relationships and capturing previously unlearned patterns with high precision. Still, it requires specific architecture for careful training, along with extensive data preprocessing. The above observations demonstrate that there is no one-size-fits-all approach, highlighting the importance of creating technological solutions that integrate the best features of different algorithms.

Given these observations from the comparison, a hybrid approach is proposed that capitalizes on the strengths of each algorithm. This involves using decision trees for efficiency and ease of use, employing ensemble techniques like RandomForest to mitigate overfitting, and incorporating SVM skills to handle large datasets and capture complex patterns. Additionally, elements from deep neural networks, such as Autoencoders, can be utilized. Figure 1.8 illustrates a flowchart depicting the operational process of the proposed algorithm for gender-based violence detection in digital job postings. The flowchart begins with job posting collection, feature extraction, and text cleaning through tokenization, allowing gender label encoding.

Subsequently, data preprocessing involves the removal of conversions. Following that, model performance evaluation is carried out using cross-validation and hyperparameter tuning, if necessary. Finally, the model is applied to detect gender-based violence in digital job postings, coupled with result analysis to assess model accuracy and completeness.

Figure 1.8 Flowchart, Proposed Algorithm



Source: Own Work

To better address the detection of gender violence in digital job offers in the technological field, the algorithm allows combining the positive elements of each algorithm, with the intention of improving the precision in the identification of patterns of gender violence, to contribute to mitigate the risk of overfitting in complex data sets, and thus efficiently manage large volumes of information. In addition, an ability to capture complex patterns is required, due to the subtlety of the language to be analyzed, such as the detection of more discreet or direct manifestations of gender violence.

The expected results through the implementation of the proposed algorithm for the detection of gender violence would allow working from:

- Data Collection, with a total number of digital job offers collected greater than 500.

- Data Preprocessing, a number of offers with clean text resulting in a tokenization of 450, with a minimum of 50% of stop words removed, and 100% conversion to lowercase: 100%, for gender coding: Male (0), Female (1), Not Specified (2).

- Model Training: the characteristics taken from the Decision Tree must have a minimum training precision of 85%, for the Random Forest, a minimum of 90%, in SVM, there must be a minimum of 88%, for the Neural Network (Autoencoders) of 92%.

- Cross Validation, the percentages to be taken must be the same as the training.

- Detection of Gender Violence, the number of job offers with and without indications of gender violence must be counted to determine the percentage.

- Evaluation, the analysis of the detection results is carried out, the measurement of precision, completeness and F1-score is carried out, as part of the feedback for continuous improvement of training, the hyperparameters of the SVM model must be adjusted to improve the exhaustiveness.

Conclusions

Machine Learning provides tools that allow gender violence to be detected in digital job offers in the technological field. Where through different algorithms, such as Decision Trees, Naïve Bayes Classification and Neural Networks, patterns in text within web pages can be analyzed. It is necessary to look at the advantages and disadvantages of each algorithm, to choose the best approach to measures that can be taken to reduce the gender gap in the STEM sector.

Gender violence in society indicates gender discrimination in the candidate selection process, affecting equal opportunities in the workplace, which represents an unfair practice with a negative impact on diversity, innovation and progress. economic of organizations with societies as a whole. Access to employment for women is still a challenge that results in a risky activity in the 21st century, since the gender gap persists in various areas, from education to the world of work, therefore, effective actions are needed to address it.

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Chapter 5 Wizard based on natural language processing for Java programming language

Capítulo 5 Asistente basado en procesamiento del lenguaje natural para lenguaje de programación Java

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DOI: 10.35429/H.2023.13.53.68

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A. Reyes, E. López and B. Hernández (AA. VV.) Computer Technology and Innovation. Handbooks-TI-©ECORFAN-Mexico, Mexico City, 2023

Abstract

Smart assistants are a technology that has become very popular today, due to the multiple functions they have, and somehow allow a natural interaction between devices and human beings. The objective is to develop an assistant based on NLP (Natural Language Processing) focused on the Java programming language, with the feature of guiding the user on the use of this language from reliable and validated sources, through speech recognition and speech synthesis by the assistant, allowing communication between the software and the user through natural language, in order to make the time in the consultation of information more efficient since it is considered that from the implementation of the speech to text engine and the subsequent processing of natural language, The search will be carried out on the web obtaining relevant results of precision. In the implemented methodology, the general requirements were defined, such as the voice recognition and identification modules, the search module and the internal storage structure, the design was based on a file-based controller view architecture, implemented through technologies such as PyQt5, Speech Recognition, Pyttsx3, Beautiful Soap among others, developed with the python programming language with the paradigm of object-oriented programming obtaining satisfactory results of precision in the searches by concepts and syntax carried out.

Virtual Assistant, Speech recognition, Paradigm, Web scraping

Resumen

Los asistentes inteligentes son una tecnología que en la actualidad se han vuelto muy populares, debido a las múltiples funciones con las que cuentan, y de algún modo permiten una interacción natural entre los dispositivos y los seres humanos. El objetivo es desarrollar un asistente basado en PLN (Procesamiento de lenguaje natural) enfocado al lenguaje de programación Java, contando con la característica de orientar al usuario sobre el uso de este lenguaje a partir de fuentes confiables y validadas, a través del reconocimiento de voz y síntesis de voz por parte del asistente, permitiendo la comunicación entre el software y el usuario a través de lenguaje natural, con el fin de hacer más eficiente el tiempo en la consulta de información ya que se considera que a partir de la implementación del motor de voz a texto y el posterior procesamiento del lenguaje natural, se realizara la búsqueda en la web obteniendo resultados relevantes de precisión. En la metodología implementada se definieron los requisitos generales como lo son los módulos de reconocimiento e identificación de voz, el módulo de búsqueda y la estructura interna de almacenamiento, para después realizar el diseño que es con base a una arquitectura modelo vista controlador basada en archivos, implementándose a través de tecnologías como PyQt5, Speech Recognition, Pyttsx3, Beautiful Soap entre otras, desarrollado con el lenguaje de programación python con el paradigma de programación orientada a objetos obteniendo resultados de 92% de precisión en las búsquedas por conceptos y sintaxis realizadas.

Asistente virtual, Reconocimiento de voz, Paradigma, Web scraping

1. Introduction

Smart assistants are a technology that can be implemented in many areas, from the development of an assistant with a particular function, to assistants with the purpose of meeting the general needs of a user. This technology has been present since 1960, which is why various works have emerged that have increased its development.

Education is a very important factor in the development of a person, therefore, the relationship between technology and education are two aspects that should be handled together for a good performance in learning various subjects. As mentioned in (Ssanyu, 2023), there are a wide variety of educational tools and several of them deal with aspects of language processors, which can be used according to the needs and interpretation of the results, in the case of the aforementioned quote he carried out a research focused on PAMOJA which is a framework of components based on Java and supports the construction of grammatical applications.

The objective of developing this research project is to implement an assistant based on NLP (Natural Language Processing) dedicated to learning the Java programming language, with the characteristic of guiding the user on the use of this language from reliable and validated sources, promoting the bases for a good development in learning through speech recognition and speech synthesis by the assistant. allowing communication between the software and the user through natural language.

It is considered that the topic of intelligent assistants is of great relevance today, and probably will have an even greater impact in the future, and being part of that development is what motivates the realization of this research, in order to implement the creation of this type of software.

Various contributions have been found regarding the aforementioned topic and each project has contributed in the field of virtual assistants, mentioned some in the year 2017 article by Arteaga Maza *et al* (Maza A., 2017), presents the implementation of a tutor assistant based on cognitive computing for use in visual learning environments, in order to improve the knowledge of students, resolving doubts. The project had only one interface developed through the Node.js framework, with the conversation service "IMB Watson", with keyboard requests, which reduced a little the efficiency of querying the information but fulfilled correctly based on the subject.

The field of assistants is not only in academics or personal help, it also covers more areas, an example is the assistant project implemented on a Raspberry Pi 2, with the ability to perform tasks that a user requests with the use of their own voice, obtaining a response to the request and executing an action such as turning on lights or devices (Díaz Fernández, 2018). The project was developed from a Python library "Speech Recognition", with which speech recognition was achieved.

The accuracy of this wizard was 88.66% according to the accuracy tests in recognizing commands, however, the requests it executed were very limited. As already mentioned, virtual assistants have many applications as mentioned in "Voice application, as a virtual assistant for the management of emotions in students of UT Tehuacán", a project that helped to identify emotions with the help of color codes where each one symbolizes a domain or kind of feeling, using voice commands. In this project, multiple tests were carried out on the Alexa Developer Console platform where results obtained were satisfactory, I also seek to contribute with an alternative tool for early detection of emotions, through its voice application information was provided to the interested party without having a physical approach (ORTEGA-GINES, 2019).

There have been projects focused on a specific sector, where the beneficiaries are a small region, as an example is the chatbot-type virtual assistant. In this research work for the degree, a chatbot-type virtual assistant was developed, having the characteristic of receiving requests through the keyboard, with the purpose of speeding up the reception of a request from PQR's (The System of Requests, Complaints, Claims and Suggestions) in the San Isidro corporation "Colegio Anglo Americano". This is done through a web administration module for user interaction, with the only shortcoming being limited word identification (García-Reina, 2018).

Voice recognition is a technology that speeds up the execution of various actions, an example of this is the thesis work "Voice Recognition Security System" written by the authors Eyra Pérez & Fernando Martínez *et al* (Pérez, 2013). In this dissertation, a security system was developed with the characteristic of the use of voice recognition so that the system can interact in a more fluid and precise way, in order to make fast and reliable decisions.

The design and implementation of this system was carried out MATLAB with algorithms to obtain audio input. An important factor to avoid errors was to be in an environment of 70 dB (Decibels), with the problem of lack of speech recognition when changing emotions as it had an error rate of 40%. Voice programming is also a potentially useful method for people with motor disabilities, as mentioned in (Nowrin, 2023), and is also challenging for a standard speech recognizer due to the variability in spoken programs.

Virtual assistants are intelligent tools that help users search for information in a conglomerate of web resources. The natural deployment of these is carried out on the web pages themselves, where they allow users to solve their doubts formulated in natural language using Artificial Intelligence techniques such as Natural Language Processing (NLP) (Jorge Matich, 2001). Also as mentioned in (Camacho-Alvarez, 2020), Natural Language Processing (NLP) has had enormous growth thanks to the large amount of data that can be obtained through the internet. NLP investigates the use of computers to process or understand natural language (LN) for the purpose of performing useful tasks.

Likewise, natural language processing is the ability of a machine to process communicated information through the use of natural language. It could be said that NLP consists of using a natural expression that can communicate with the computer directly, by written means or voice command, facilitating commands or requests with language (Moreira, 2020), in this way speech recognition is simply speech recognition allows a human being to communicate with a computer. Broadly speaking, the computer captures the voice signal emitted by a person through a microphone, converting it into digital information (Sánchez. G.A., 2021). To do this, it is important to identify Speech Synthesis, also known as text-to-speech (CTV), which consists of providing the system with the ability to convert a given text into speech.

The voice of the computer can be generated by joining the recordings that have been made, whether they are whole words, or phonemes, but always trying to make the sound produced seem as natural and intelligible as possible, correctly chaining the sounds within the speech (Cuentas Chavez, 2020), now the files will allow storage, so to speak, since a file is a set of related information, recorded in the secondary storage system and referred to by a name, finally, web scraping refers to the techniques that allow data to be collected or obtained from the web through automatic or manual methods.

With web scraping, you can extract the content of an HTML from websites to filter the information and store it to later make use of the data of interest (Gonzalez. D, 2013). Some other variants of language processing can also be found, such as word processing, in the work (GARCÍA-AMARO, 2017) "Review of text preprocessing techniques for the automatic classification of tweets in Spanish " where techniques were applied to obtain text in tweets, which made it possible to classify them more easily to detect patterns and keywords. Likewise, the cleaning and normalization techniques reviewed in this research helped them to standardize and refine the content of each tweet.

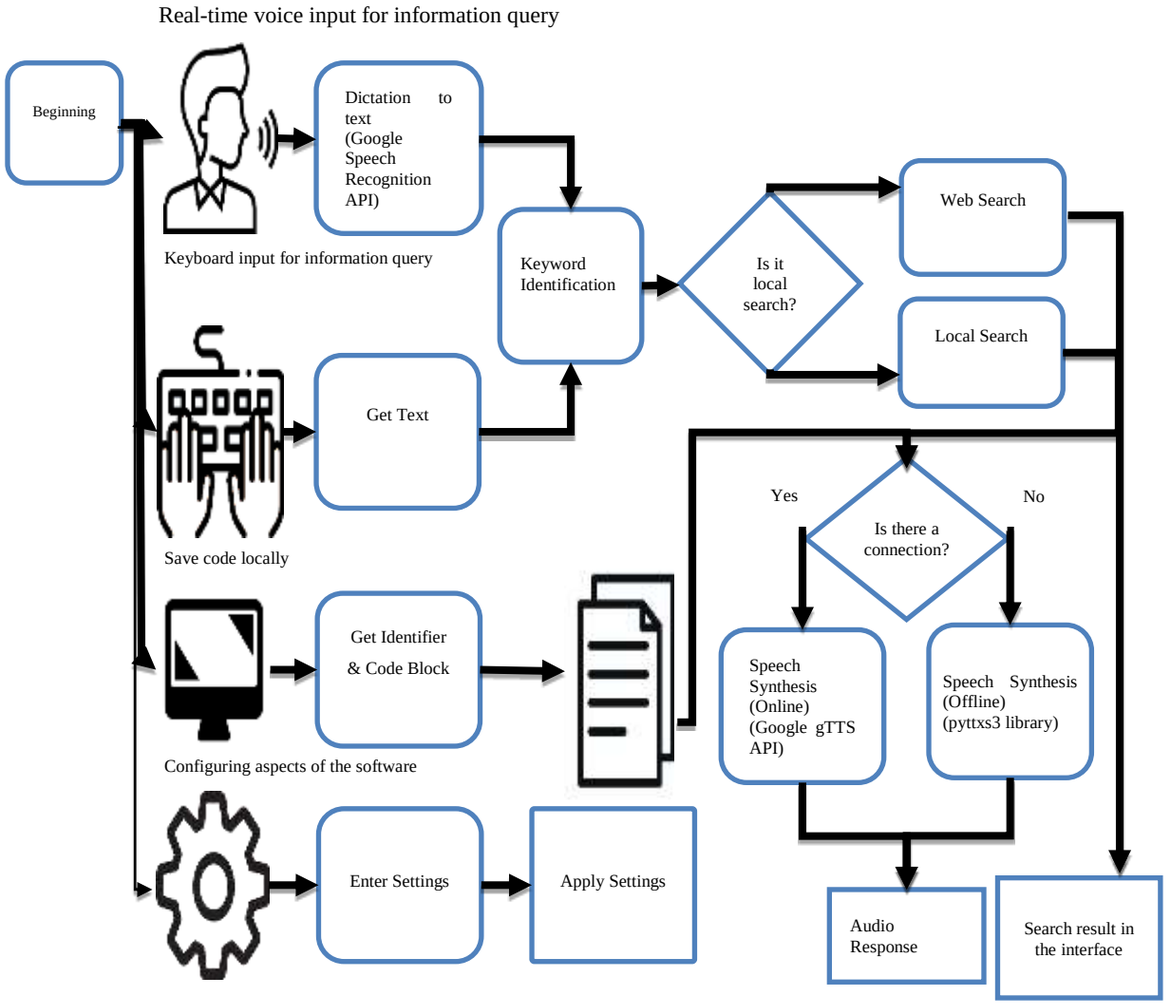
2. Work Architecture

The architecture that will be implemented to carry out this project is based on the agile software methodology, SCRUM, because the field of development of this project requires a lot of programming, this methodology is ideal, taking into account its particularity of implementation of a development divided by "Sprint", which is equivalent to a certain amount of time in which it proposes to implement specific aspects. The methodology includes the planning stage where various activities will be developed that will serve as a guide for the beginning and culmination of the project, defining the time for the beginning of the development.

Determination of general requirements of the software, which is a fundamental aspect, since based on the product, the planning of each of the Sprints can be carried out. Sprint planning will allow you to achieve the objectives, and each sprint will trigger the implementation of the project, in which important activities are carried out that increase the overall progress of the project. In the design phase, the logical operation of the software is proposed, determining how the flow, the technical, logical and visual design will be. In the implementation, the coding of the software is carried out through the technologies and algorithms designed. Finally, the testing, documentation and evaluation of the software

Based on the requirements, the logical operation of the wizard was precisely defined, which has several modules that allow it to fulfill the purpose of assistance for the java language, which is shown in Figure 1.

Figure 1 Logical Design



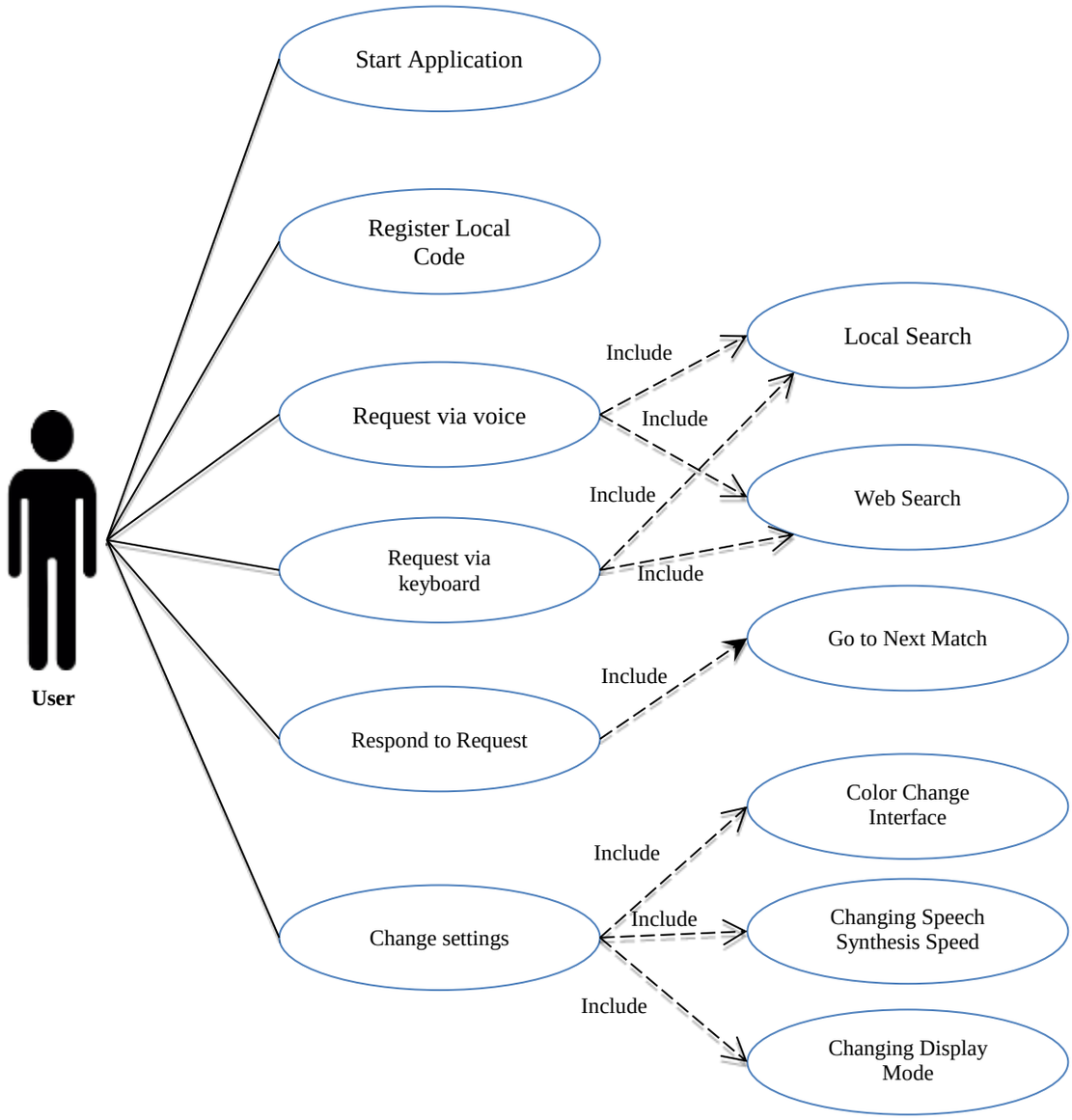
Source: Own Work

As can be seen in figure 1, you can see the diagram that represents the execution of the wizard, having different paths to follow depending on what the user decides to do.

In total there are 4 modules: voice dictation to carry out a query, whether web or local, consultation through the keyboard that shares instructions with the previous module; the local code storage module, in which based on an identified and a block of code can be stored in the local code file for quick queries, as well as the configuration module, in which the user simply determines parameters of the software of his preference and applies them.

In figure 2 it can be seen that the software will not only present type of use, since among the interfaces it will allow to perform various types of actions with which the user can interact, so it can be seen that the main use cases are the use of local code registration, web and local search by code or by concept, as well as the configuration of software parameters.

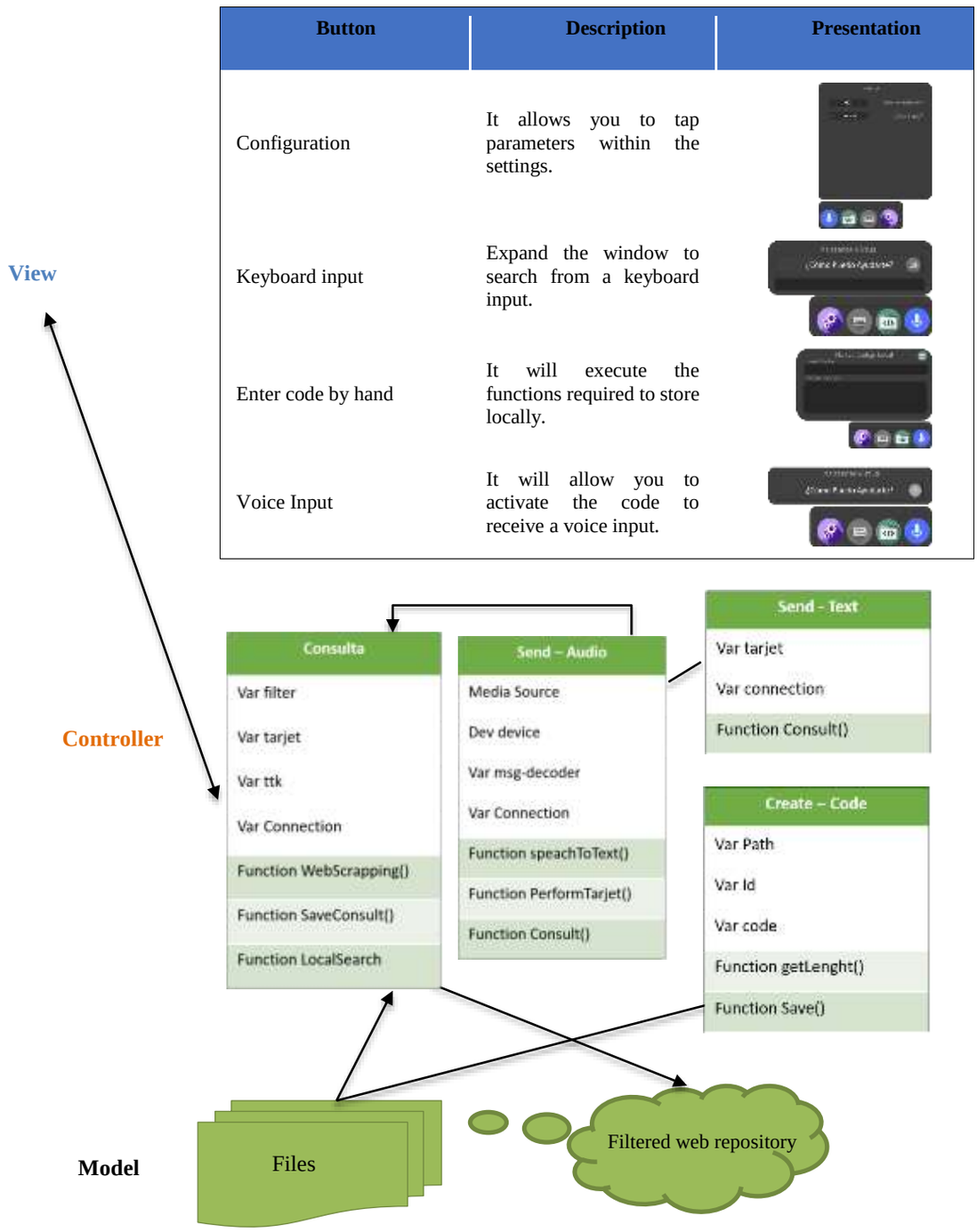
Figure 2 Designing Use Cases



Source: Own Work

The model view controller is a design pattern that allows you to separate the database (Model), the view (GUI) and the controller that allows the connection between the previous elements. In this case, the model is the files stored locally, which are constantly consulted with programmed functions and displayed in view so that the user can access the information in a clear way. Figure 3 depicts the distribution of the wizard through this design pattern.

Figure 3 Model Controller View

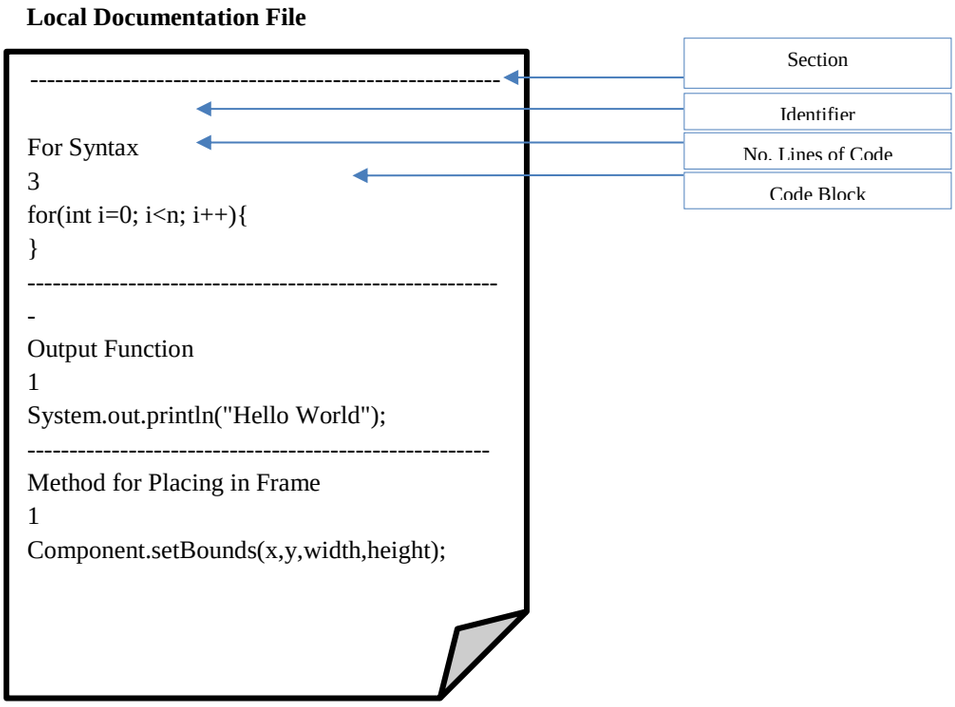


Source: Own Work

The files in the project play the role of a database, since they will store useful information to maintain a good functioning in each of the software modules. In most of the files to be used Send-text are a list format, accessing through the name and getting the value in front of it, however, the local code file is different and follows the format that can be seen in figure 4, in which it is graphically explained how it works.

The codes are stored in 4 parts, the identifier which is the top, the number of lines of the code block (counting the sections) which will serve to extract only the code block or jump to another identifier in case it is not what you are looking for.

Figure 4 Local Code Format



Source: Own Work

3. Implementation

By default, Python has a large number of libraries and functions that allow you to develop correct and functional projects. Table 1 lists all the dependencies required for the coding of the project plus a previous description. These libraries are intended to develop advanced interfaces, implement speech synthesis and recognition, as well as Web Scraping search.

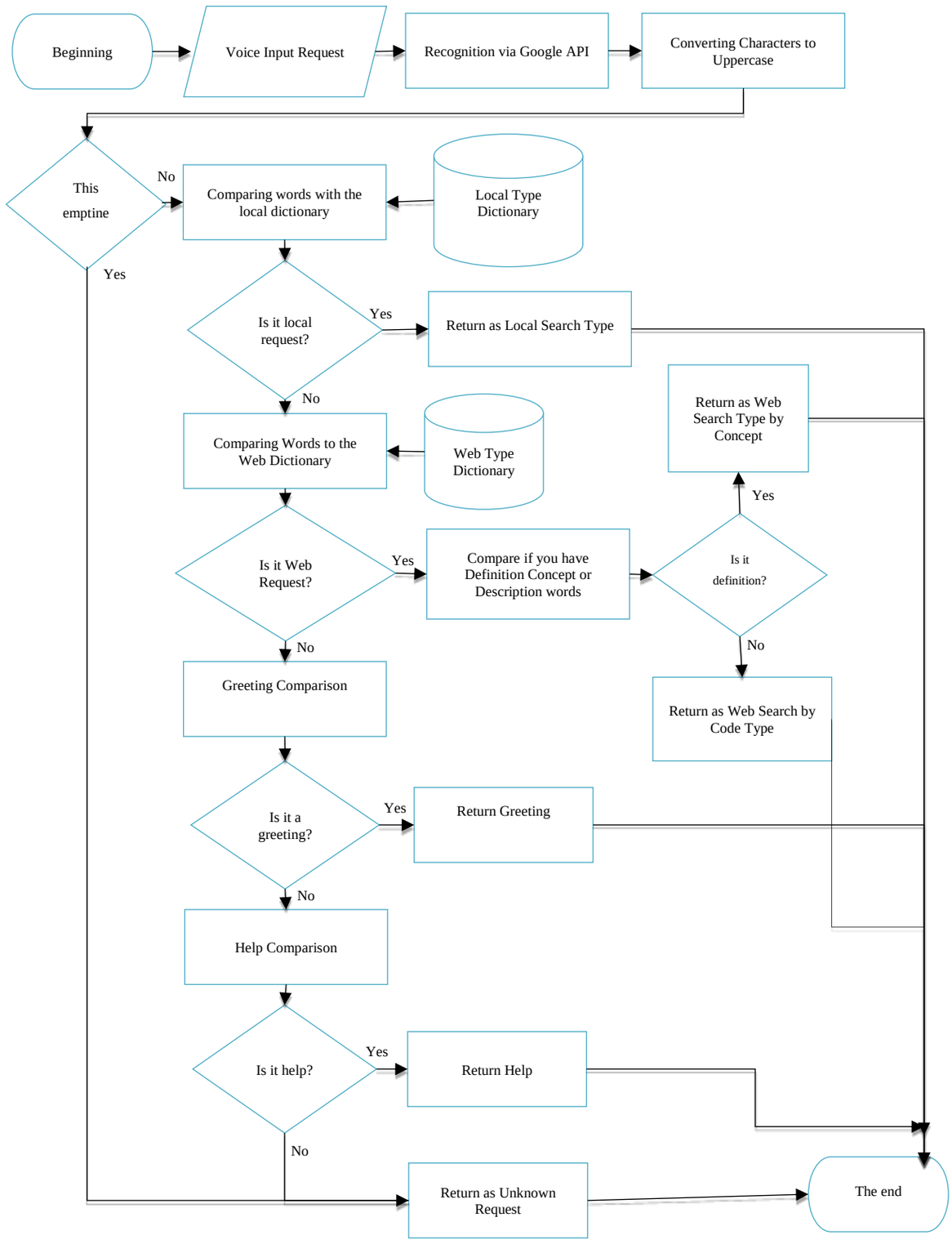
Table 1 Technologies implemented with Python

Package	Description
PyQt5	It is a set of modules of the Qt5 framework for the creation of advanced graphical interfaces
PipWin	A package that allows for the installation of packages with greater compatibility for Windows operating systems.
Speech Recognition	Library that allows speech recognition through various API's such as Google, Google Cloud, IBM, Sphinix, etc.
Pyttxs3	Python package for offline text-to-speech.
Pyaudio	It provides links to make use of the audio input and output devices.
PlaySound	It allows the playback of audio files through the various audio devices.
Google	Allows connection to Google services.
Google Search	It allows access to and use of the Google search engine to make queries on the web.
Beautiful Soap	It extracts information based on specific tags in the HTML of a queried site.

One of the characteristics of a virtual assistant is the use of natural language processing, accepting inputs from the keyboard or through voice, in this case it was emphasized that requests could be made from both means. Figure 5 shows the flow that follows the identification of the requests made by a user, where first the voice input is made through the microphone, and then based on Google Speech the conversion of speech to text is carried out. Once obtained, the text is converted into capital letters to avoid problems when comparing the different strings that allow identification.

Once the text is obtained, it is verified that it has really been recognized, then the comparison is made with a dictionary of words to perform a local search, if there is no match of 80% it goes to the comparison of words for web search, otherwise it is verified if it is a greeting or a request for help, In case any of these do match, it returns a string to be able to process the request, cleaning up the words that are not useful and performing the next process with only the most important data.

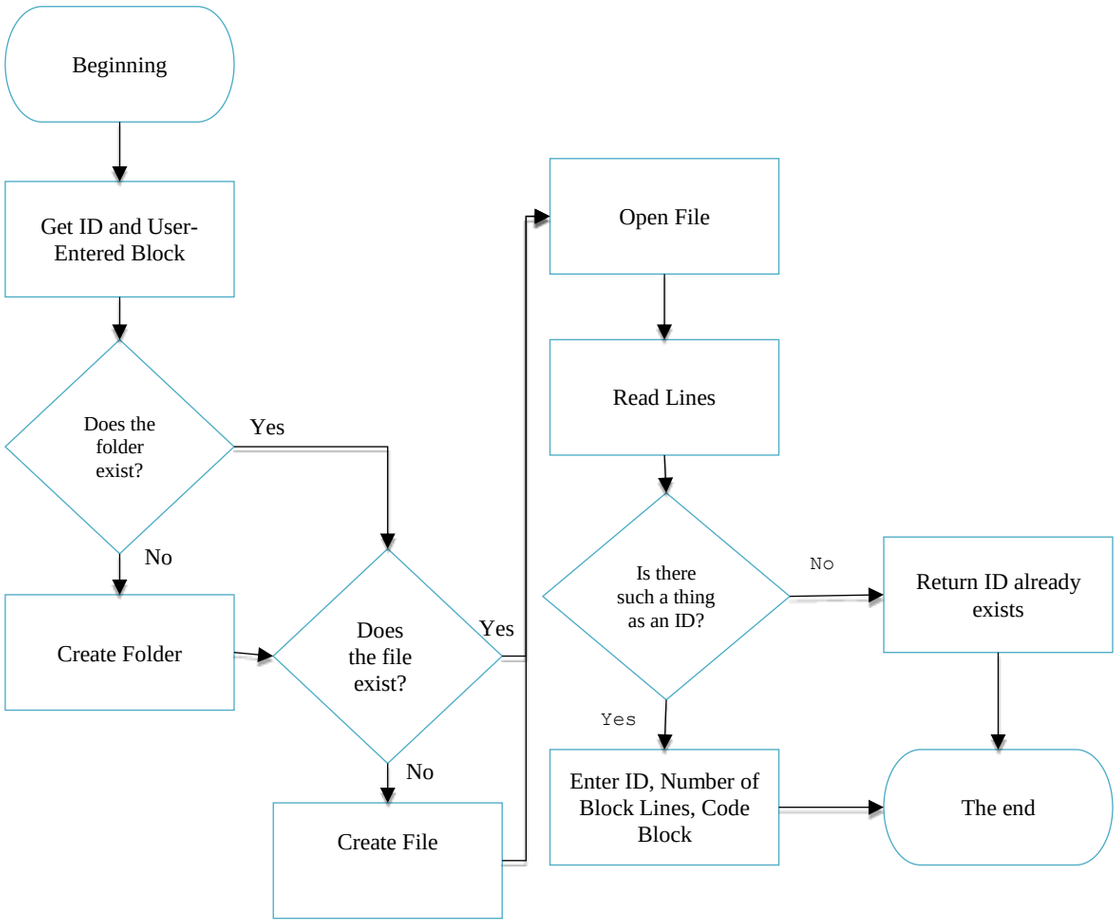
Figure 5 Speech Recognition Operation Flowchart



Source: Own Work

To enter a code locally, to be able to have it available at all times, an identifier and a block of code are required, which will be stored in a folder and a file stored in the same directory of the executable. In figure 6 you can see the process that is carried out to add codes to these files, in which it is mainly verified if the folder and file exist, if not it creates them to later analyze the file, it is worth mentioning that a line-by-line analysis is not performed, since the local file makes use of a format that allows skipping lines to save time based on the number of lines of Codes already stored and only read the code identifier to determine if the identifier already exists and avoid duplicate values, if not, it is added to the end of the file.

Figure 6 Handling Local Code Injection



Source: Own Work

When consulting the local file to obtain some code that the user needs, it will be displayed in a window where the code block can be edited, so that based on two buttons the user can update the stored code or delete it.

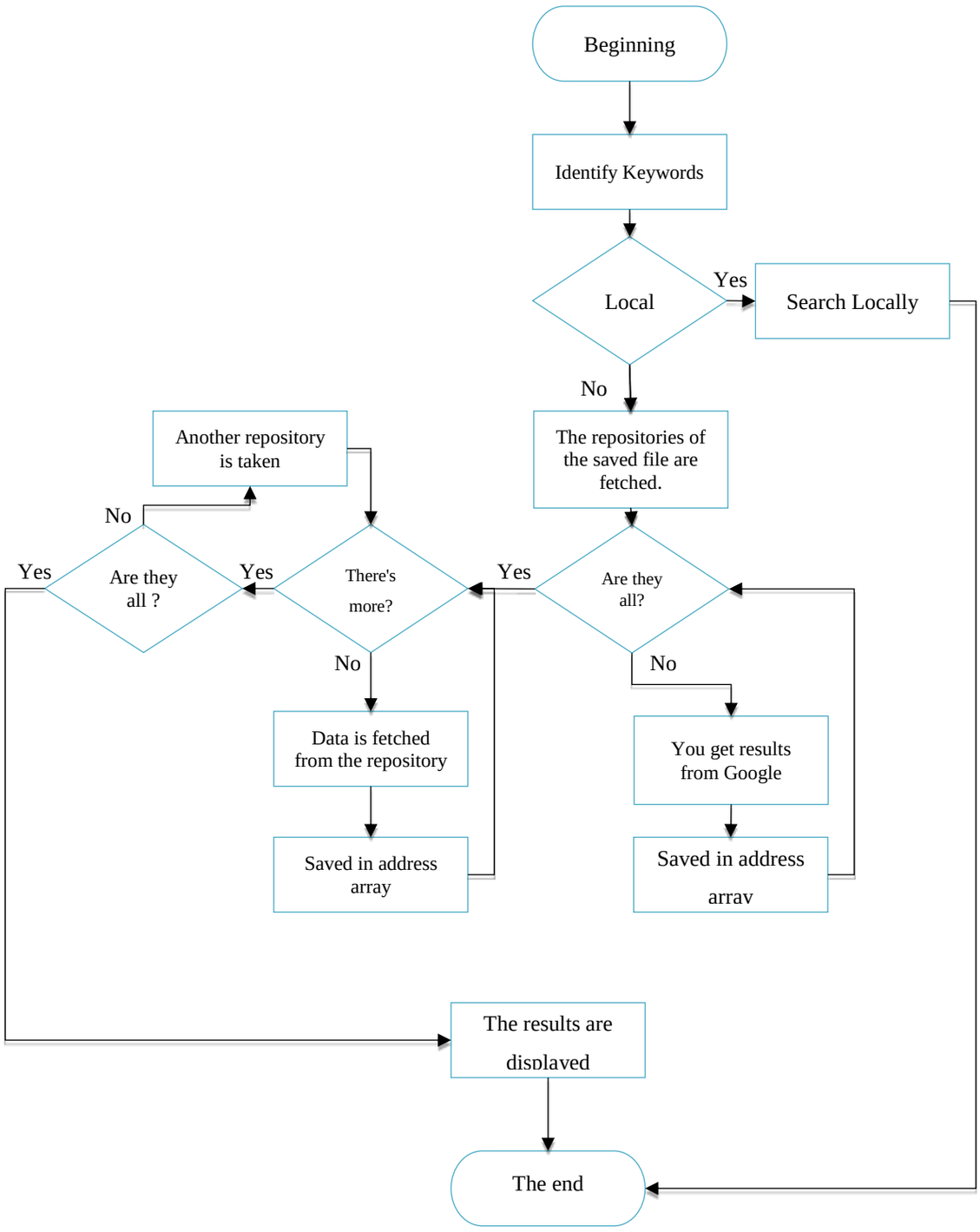
To delete locally stored codes, follow the following process:

a) Beginning
b) Open the local code file.
c) Read the number of lines in the file and store them in a variable
d) Open the file again and read by performing line breaks based on the number of lines per code block.
e) If the ID to be deleted matches the parsed file, store the ID, the number of lines, and the code block in a string variable.
f) Replace the text that matches the previous string in the variable where the lines of the entire file were stored.
g) Overwrite the local code file with the result of the text replacement.
h) The end

To update a local code, you run the algorithm to delete it and then add it back with the updated structure.

Likewise, in the search for data on the Internet, web scraping techniques were used from the Google search engine and beautiful Soup to obtain the information of the HTML tags. This algorithm can be seen in figure 7, in which the message is first identified, and then identified that it is a web search and based on the repositories that are listed in files, the search is carried out in those sites, taking the first two matches and performing the inspection to return it to the user.

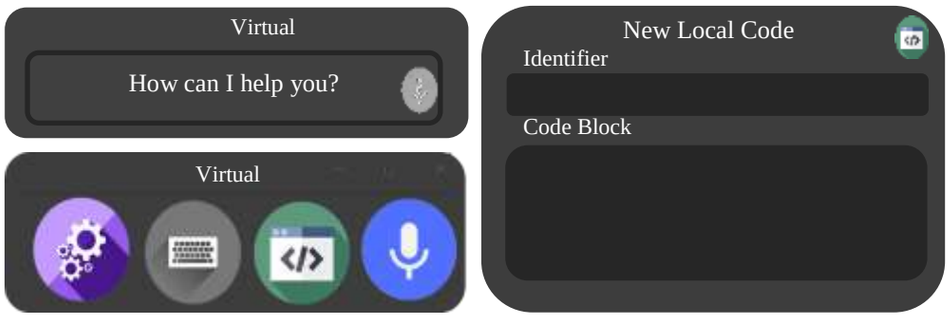
Figure 7 Web Scraping Algorithm



Source: Own Work

The coding of the graphical interface was developed based on the Qt5 framework through the modules of the PyQt5 library, which allows the development of advanced graphic components, making use of technologies such as CSS and HTML. Each of the windows has its own integrated action bar to perform the closing and minimization, this with the purpose that the interface is not visually affected when you have another theme or a different version of the operating system, avoiding display errors. And they are seen in Figure 8.

Figure 8 Software Interfaces

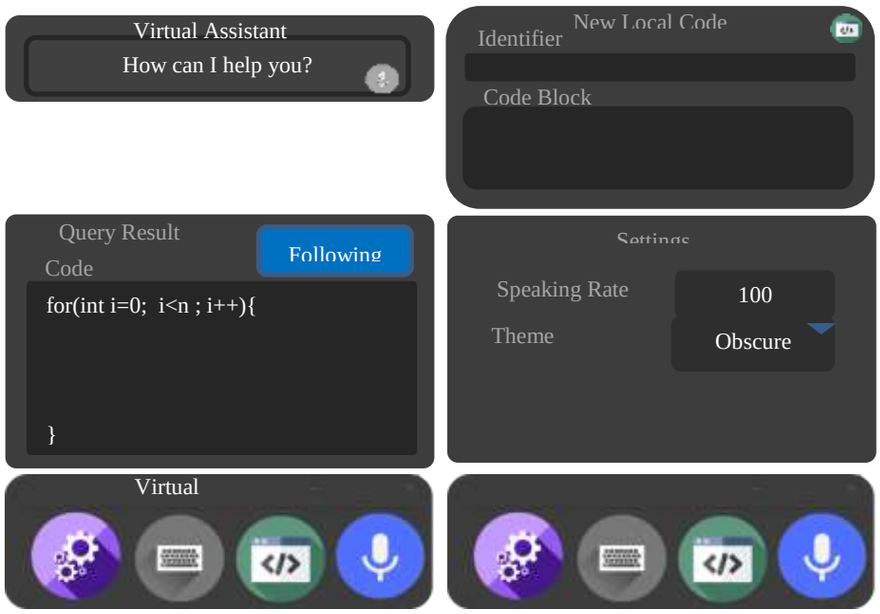


Source: Own Work

4. Discussion

Once each of the necessary modules has been developed and each of the interfaces has been coded, the final result is shown in Figure 9, being able to perform natural language processing via keyboard or voice and then make a query through the web based on techniques such as web scraping or a query in the local file.

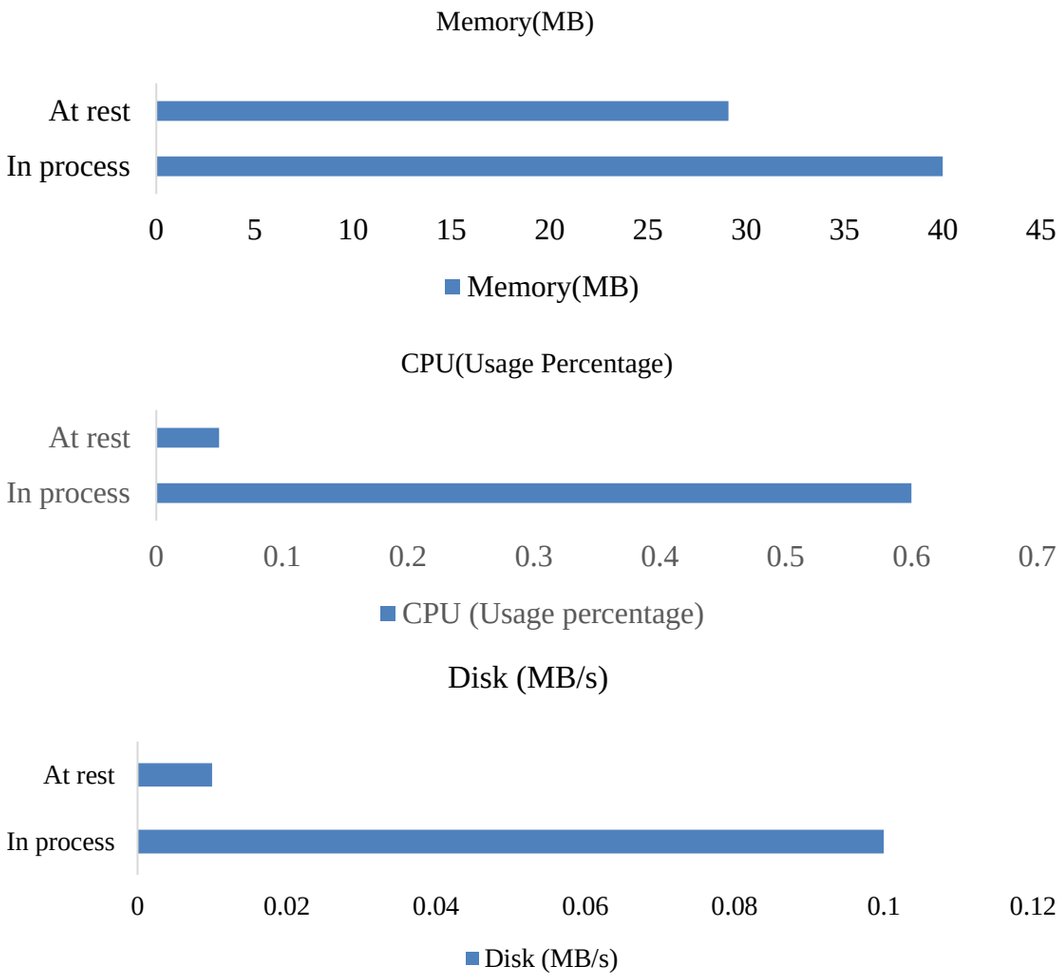
Figure 9 How the Software Works



Source: Own Work

The consumption of the software is quite low for a hardware with 4 cores and 8 GB of RAM, consuming as little as 40 MB of RAM and 0.60% when processing a request from the user, In Figure 10, you can see graphs of the overall consumption of the software.

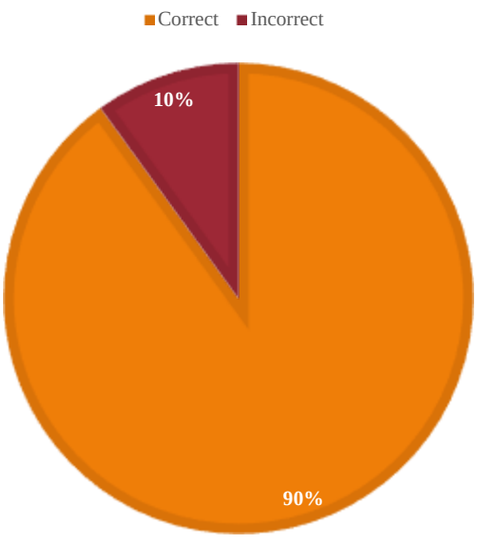
Figure 10 Consumption of developed software



Source: Own Work

The developed software correctly fulfilled the proposed query functions, however, to corroborate the hypothesis, several tests were carried out with different types of environments. The first test was carried out with a sample of 30 situations in which internet queries were made about concepts and syntax related to java programming, and as can be seen in figure 11, 90% of these had satisfactory results, with an error rate of 10%.

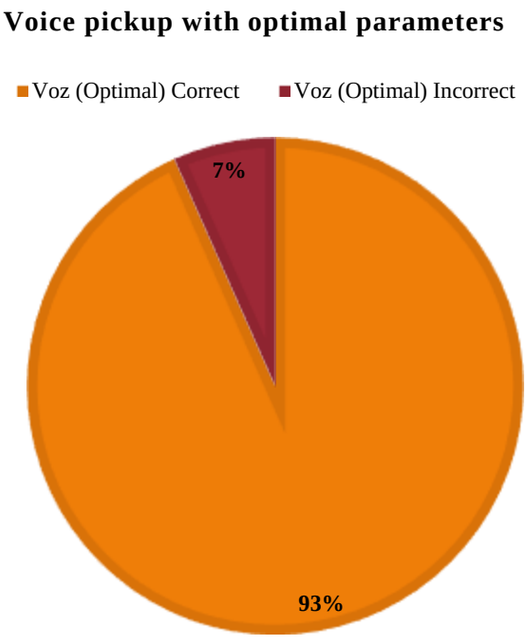
Figure 11 Consultations made on the internet



Source: Own Work

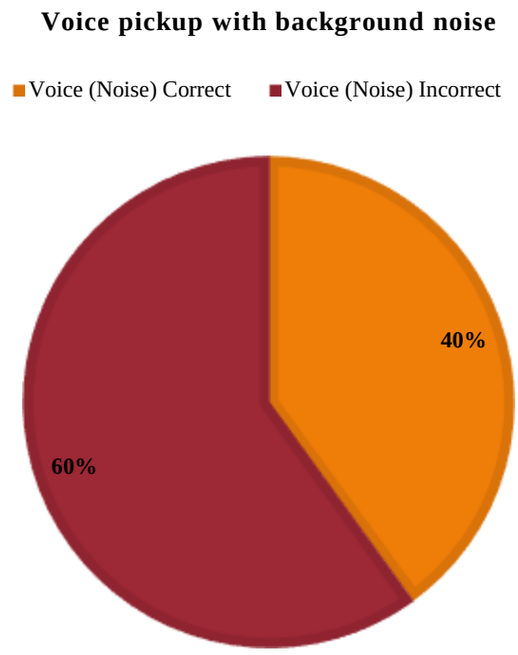
The internet query has the desired precision, another factor that can hinder the search for concepts is the voice due to the different noises that may arise, in this sense, the voice detection test was carried out with various parameters, in figure 12, it can be seen that in optimal conditions with little noise in the environment the accuracy is 93% in recognition, However, it is important to mention that if the environment is not controlled or there is a lot of noise, the accuracy percentage can drop to 40%, as seen in Figure 13.

Figure 12 Consumption of developed software



Source: Own Work

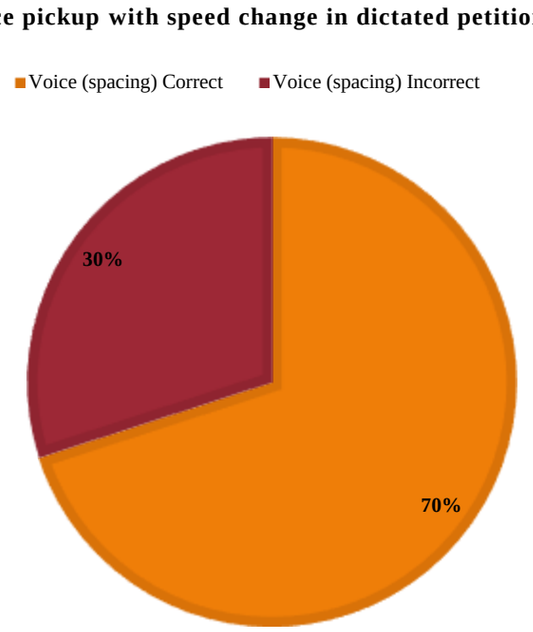
Figure 13 Speech recognition tests under different noise conditions.



Source: Own Work

An equally relevant factor when implementing natural language processing is to recognize speech regardless of what type of emotion is dictated or at what speed the pronunciation of the words is performed, therefore, tests were also carried out with changes in the speed when the user dictates a request and as seen in figure 14, The accuracy achieved when it comes to recognizing a request at high speed is 70%, reducing up to 20% compared to when the query is presented under normal condition.

Figure 14 Recognition tests when changing the speed of the speaker's request



Source: Own Work

5. Conclusions

Technology must be used for the growth of humanity's knowledge, in this case the intelligent assistant for learning the java language met the objectives, such as the search on the web through natural language recognition and its processing, locally with the implemented files and their respective identifiers, as well as more than acceptable results in the general set of implemented functionalities.

The main objective of this project was to develop an assistant that supports students who want to learn the java programming language, therefore, this software was more focused on searching for information on the internet or locally with an accuracy of 90% in the results so that the user obtains the information that is of help. And based on the tests carried out, this percentage of accuracy was adequately achieved, with a speech recognition of 93% under appropriate conditions.

The points to be improved in this project are especially in the validation of recognition in conditions where they are not favorable for the assistant, since, for example, in the capture of voice with background noise, the error rate increased by up to 60%, which is not optimal at all. Another aspect to consider is the implementation of an offline speech recognition engine in the future so that the assistant can understand the voice regardless of whether the device has an internet connection, this through technologies such as Sphinix, being that it would be very useful since the assistant can make queries locally based on the file that stores that data.

It can be concluded that the virtual assistant based on natural language processing for learning the Java language was done correctly, however, there are details that can be improved and that in future versions can be corrected or scaled the project to more programming languages since the java bases could be implemented in a correct and functional way.

Acknowledgement

We are grateful to the Tecnológico Nacional de México and Tecnológico de Estudios Superiores de Jocotitlán for the support given in carrying out this research project.

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Chapter 6 Optimizing the control of a Peltier cell using genetic algorithms

Capítulo 6 Optimización del control de una célula Peltier mediante algoritmos genéticos

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DOI: 10.35429/H.2023.13.69.90

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A. Reyes, E. López and B. Hernández (AA. VV.) Computer Technology and Innovation. Handbooks-TI-©ECORFAN-Mexico, Mexico City, 2023

Abstract

The Seebeck and Thompson effects explain thermal phenomena present in some materials when a certain electric current circulates in them. An application of these is found in some portable refrigeration units that use a semiconductor device called a thermoelectric cell or Peltier cell, which, according to specialized literature, is controlled by means of intelligent or classical control techniques, where a typical exponent of the latter is the PID controller, whose parameters are calculated using the Nichols criterion. An alternative for obtaining the proportional, integral and derivative constants is through the application of evolutionary algorithms which calculate these parameters to reduce the cooling time to a Desired temperature for this case in which the use of genetic algorithms is documented is 20 degrees.

Genetic algorithm, Thermoelectric cell, Peltier

Resumen

Los efectos Seebeck y Thompson explican los fenómenos térmicos presentes en algunos materiales cuando una determinada corriente eléctrica circula en ellos. Una aplicación de estos se encuentra en algunas unidades de refrigeración portátiles que utilizan un dispositivo semiconductor llamado celda termoeléctrica o celda Peltier, el cual, según la literatura especializada, es controlado por medio de técnicas de control inteligente o clásicas, donde un exponente típico de estas últimas es el controlador PID, cuyos parámetros se calculan utilizando el criterio de Nichols. Una alternativa para la obtención de las constantes proporcionales, integrales y derivadas es mediante la aplicación de algoritmos evolutivos los cuales calculan estos parámetros para reducir el tiempo de enfriamiento a una temperatura deseada para este caso en el que se documenta el uso de algoritmos genéticos es de 20 grados.

Algoritmo genético, célula termoeléctrica, Peltier

1. Introduction

Optimization is defined as the maximization or minimization of a process or function, it can be performed mathematically or numerically. Algorithms are used whose specific characteristics allow a certain type of problem to be solved; The function can range from a simple expression that includes and relates decision variables, to an equation that quantifies the behavior of a mathematical, probabilistic, or deterministic model. During the optimization process, the constraints or limitations associated with the function are taken into account, which are mathematical expressions that incorporate the particularities of the problem being solved.

One way to perform optimizations is through evolutionary algorithms, which were introduced by John Holland in the 1960s, suggesting the principles of this technique. Evolutionary algorithms include genetic, particle swarm, cultural, memetic, to name a few. The structure of an evolutionary algorithm is composed of a function that allows measuring the breadth of possible solutions for the resolution of the problem, to structure an evolutionary algorithm the following elements are required:

1. Generate a random population of N individuals.
2. Evaluate individuals in the population according to fitness function or target function.
3. Repeat for generations iterations:

– Apply the selection operator to choose N individuals from the population
– Apply the genetic operators to those N individuals to generate the offspring
– Evaluate new individuals according to fitness function or target function
– Replace the worst individuals in population with newly created individuals

Genetic algorithms are computationally modeled by simulating natural selection and interbreeding of species and thus prevail over time, evolving into better solutions. In the research carried out by (Reynolds, R. G., 1994) are based on the theories of some sociologists and archaeologists who have tried to model cultural evolution, these researchers indicate that evolution can be seen as a process of inheritance at two levels which are the micro evolutionary level which is the one that is inherited from the parents to their descendants and the macro evolutionary level which is the knowledge acquired by the individual through the generations (Reynolds, R. G., 1999).

Thermoelectric cooling is theoretically supported by some effects studied in physics such as those mentioned next to the thermoelectric cell or Peltier cell which is a semiconductor device based on the effects of Peltier, Thompson, Seebeck (Deng, M., Inoue, A., & Tahara, Y., 2008).

Peltier, which explains the generation or absorption of heat that occurs when an electric current circulates through two conductors of different material, then one of its faces generates heat and the other cools.

This technique is applied to a Peltier cell which will reduce its cooling time, depending on the values calculated by the genetic algorithms.$[k_p \quad k_i \quad k_d]^T$

Optimization is defined as the maximization or minimization of a process or that it can be performed mathematically or numerically. In the second option, algorithms whose specific characteristics allow solving a certain type of problem are used, since the function can vary from a simple expression that includes and relates the decision variables, to an equation that quantifies the behavior of a mathematical, probabilistic or deterministic model of a certain real system.

During the optimization process, the constraints or limitations associated with the function are taken into account, which are mathematical expressions that incorporate the particularities of the problem being solved or the system being simulated.

The concept of optimization can be reflected in equation (1)

$$\min(\max) f(x), x = [x_1, x_2, \dots x_n]^T \in \mathbb{R}^n \quad (1)$$

Constraints in a problem are usually expressed as

$$g_j(x) \leq 0, \qquad j = 1,2, \dots, m \qquad\qquad h_j(x) = 0, \qquad j = 1,2, \dots, r$$

Where y are scalar functions of the vector x. The components of are called variables, it is the objective function, and they are functions that describe the conditions of iniquity and equality respectively. The optimal vector that solves the expression (equation 1) is denoted by with the corresponding optimization value . Possible ways to solve the general problem described in (equation 1) are as follows.$f(x), g_j(x)h_j(x)x = [x_1, x_2, \dots x_n]^T f(x)g_j(x)h_j(x)xx^* f(x^*)$

Analytically emulating it and physically measuring the variables of interest, solving it through computational techniques, such as evolutionary algorithms, evolutionary algorithms had their origin in 1960 introduced by John Holland who in 1975 intuited the possibility of incorporating the semantics of natural evolution into optimization processes, thus suggesting the principles of this technique. which are well described in several texts that define them as a branch of artificial intelligence, based on stochastic processes (Jan A. Snyman, 2005).

Table 1 Parallelism between biological terms and evolutionary algorithms.

Population	A set of individuals or chromosomes. It is equivalent to a random sample of the solution space or a set of alternative solutions.
Chromosome	A chromosome is a carrier of the genetic information that each of your genes transmits. A possible solution.
Gene	Each of the traits or characteristics that make up the chromosome. They are also called parameters or aspects. Each gene equals a variable of the problem.
Genotype	In biology it is called the total genetic "package" in its internal form. In GA terminology it will be the genetic information of the entire chromosome in encoded form.
Phenotype	In genetics, the genetic package is called the way it interacts with the external environment. In artificial GAs it would be the aspects of the chromosome decoded.
Locus	It is the position of a gene, the chromosome
Allele	It is the value associated with a gene

Source: Authors' Own Creation

Evolutionary algorithms (AE) are a series of heuristics that have well-defined steps with application in optimization, they have 3 main characteristics which are mentioned below:

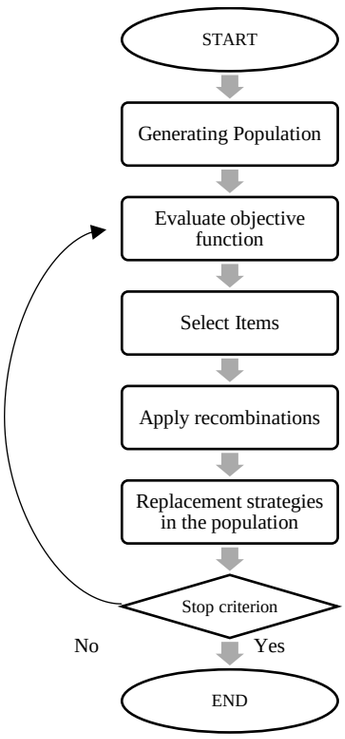
Population-based. An evolutionary algorithm maintains a set of solutions, called a population.

Fitness-oriented. Every solution in a population is called an individual, has a representation called a code, and the performance evaluation is called fitness.

Motor variation. Individuals in a population who undergo a series of operations in order to introduce variations in their code.

Broadly speaking, an algorithm that is described as simple evolutionary has the following structure (Figure 1)

Figure 1 Simple Evolutionary Algorithm



Source: Authors' Own Creation

The initial population is randomly generated from individuals with a normal probability distribution, which are then encoded in some specified form. The population of individuals is evaluated in the representative function of the problem to be optimized, and then some are chosen according to criteria, which depend on the heuristics.

The result of the selection processes is subjected to a series of operations that recombine the individuals who then replace, under heuristic criteria, the original population.

An evolutionary algorithm ends when the stop condition is met, i.e. after a certain number of iterations or when individuals converge at a certain point

Genetic Algorithm

GAs are search methods based on the laws of natural selection and species genetics described by Charles Darwin and Gregory Mendel, combining the survival and reproduction of individuals best adapted to the conditions with recombination operators called mutation and crossover (Yang, X. S., 2010).

One of the main applications of GA's is problem solving and optimization problems where they have proven to be efficient and reliable, although before applying them to a problem, some characteristics listed below must be taken into account:

The search space must be delimited within a range.

It must be possible to define a fitness function (or objective function) which will be able to indicate whether the answer is good or bad

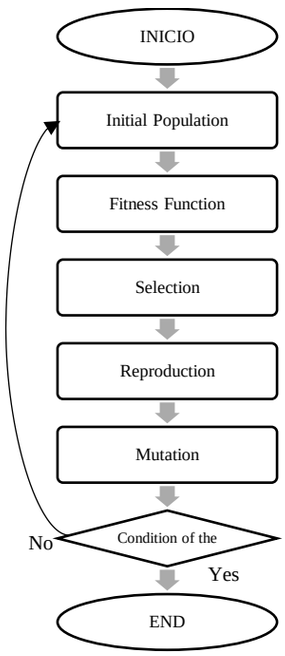
Coding should be done in a way that is easy to implement on the computer.

Structuring a simple genetic algorithm requires the following elements:

- Define a Skill Role or Target Role
- Generate a random population of N individuals
- Coding the population
- Evaluate the target function with the population, thus initiating the first generation
- Selection of solutions to be reproduced
- Population Crossing
- Mutation of elements resulting from crossbreeding
- Replacement of elements of the 1st generation population with the best elements of mutation and crossbreeding
- Stop if the stop criterion is met or re-evaluate the target function.

These replacement strategies for the population of a genetic algorithm are shown in Figure 2.

Figure 2 Replacement strategies in the population



Source: Authors' Own Creation

Target Function

The fitness function is the objective function of the optimization problem, the AG only maximizes, although for minimization only the reciprocal of the maximizing function is used.

The most common of the encodings is by binary strings, although real numbers and letters are also used. Binary strings are very popular due to the fact that they were originally proposed by John Holland and their simple implementation.

Codification

In a genetic algorithm, the space where the possible solutions to the problem to be solved are to be found must first be determined. It is necessary to encode the domain of the problem in some way to generate structures that can be handled by the genetic algorithm.

Since it was defined what type of coding will be handled in the problem and it is known as going from an element to its code and vice versa, it is necessary to set a starting point, genetic algorithms manipulate populations in successive generations, the algorithm will have an initial population and from this it will generate new populations where the parents will disappear leaving the place to their descendants and thus looking for one of the best options or until some termination condition of the algorithm is met.

Evaluation

It is necessary to establish criteria to decide which of the possible solutions of a population are better than the others, to determine which individuals are good solution proposals it is necessary to qualify them in some way and each individual will have a rating depending on the degree of adaptation or fitness. This real or negative rating will be greater the better the individual's solution.

Selection

Selection algorithms are responsible for choosing which individuals will be able to reproduce and which will not.

Since the individuals of a generation were qualified, the algorithm is given the task of selecting the most qualified individuals for a greater possibility of reproduction, thus increasing the possibility of having a better solution in a given generation, only those who meet a rating higher than a parameter established by the objective function are selected.

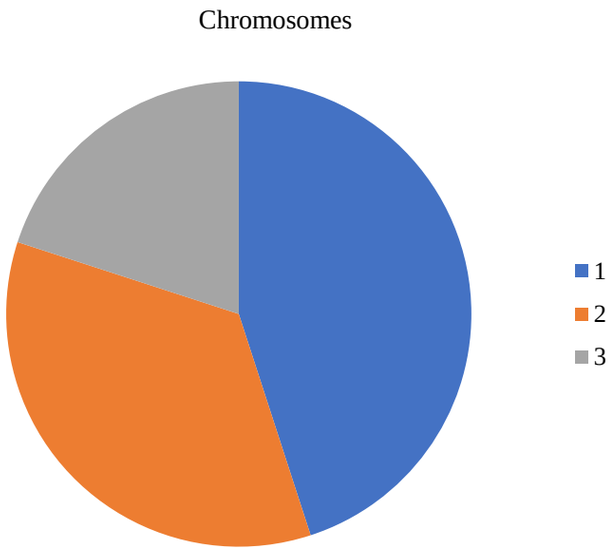
It is not convenient to have a strict selection strategy so that the population improves quickly and the algorithm converges, this is not good because it could happen that the population accumulates quickly around some individual who is good compared to the rest of the population considered but may not be the best possible, this is called premature convergence, The algorithm must not only select from the best it has found, it must explore the entire population at this is the function of crossover and mutation operators.

A common option is to select the first individual resulting from the crossing by some selection method as mentioned below:

Roulette Selection

It consists of creating a roulette wheel in which each chromosome has a fraction assignment depending on its aptitude, each of the individuals in the population is set a share equal to their roulette setting, the best individuals will be assigned a larger part of the roulette wheel compared to the less fit, Generally, the largest portions are at the beginning of the roulette wheel and to select an individual only a random number of an interval (0..1) is generated, as shown in Figure 3.

Figure 3 Gene Roulette



Source: Authors' own creation

Tournament Selection

It consists of making direct comparisons between individuals, there are two ways of making selection by deterministic and probabilistic tournament

Deterministic selection consists of selecting a number of individuals and then selecting the fittest among those selected to be part of the next generation

Probabilistic selection differs because the selection is not always the best, but a random number is generated within the interval (0..1) and, as the case may be, the highest or the opposite is selected.

Steady-state selection

The offspring of individuals selected in each generation revert to the pre-existing genetic population, replacing some of the less fit members of the previous generation. Preserving individuals between generations.

Selection by scale

When the average fitness of the population increases, selective pressure increases and the fitness function becomes more discriminatory, this method can be useful when all individuals have a high fitness and only minimal difference.

Hierarchical Selection

Multiple rounds of selection go through each generation. The first assessments are faster and less discriminatory while those that reach the higher generations are assessed more rigorously, the disadvantage of this selection method is that it reduces the total calculation time by making use of a faster and less selective assessment to eliminate the majority of unpromising or unpromising individuals subjected to a more rigorous and computationally expensive aptitude assessment highest only those who pass the initial test.

Elitist selection

Sometimes it can happen that after the crossing and mutation, the chromosome with the best adaptation is lost. This method of selection copies the best chromosome to some of the best chromosomes within the new population. The rest of the selection is done in the same way mentioned above. Elitism can improve the functioning of genetic algorithms by preventing the loss of the best solution.

A variation of elitism is that the best chromosome is only copied to the next generation if a better chromosome has not been generated after a mutation. (Garcia F. 2012)

Reproduction/crossover

The utility of the cross is a search operator that combines the genotypes of two solutions in order to obtain a new solution, the usefulness of this is based on the fact that the new solutions can become better than the parents if the best characteristics of both parents are combined.

Once individuals are selected, they recombine to produce offspring that will be inserted into the next generation. The goal of crossbreeding is to get offspring to improve their parents' aptitude.

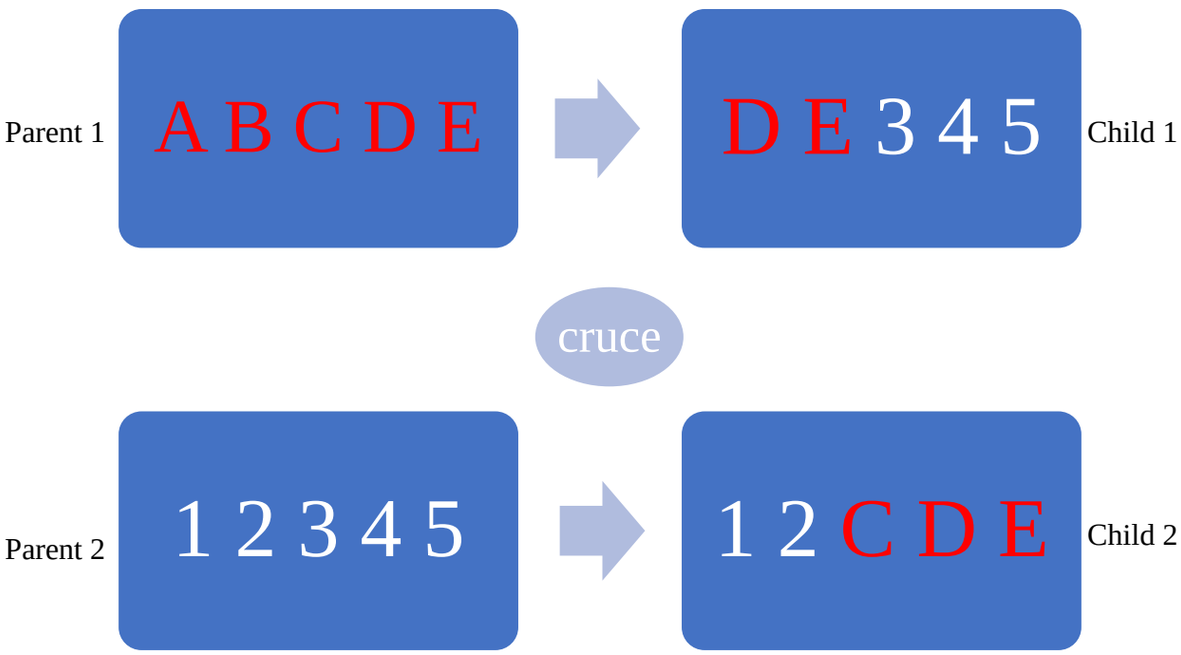
There are several crossover algorithms, however, the most commonly used ones are mentioned below:

1-point junction
2-point junction
Uniform Crossing

1-point junction

Since the individuals were selected to cross, they cut the chromosomes at a randomly selected point so that the segments, the head and tail, are generated, the heads and tails are exchanged between the selected individuals to generate the new dependency or children, in this way the two inherit genetic information from the parents. In the literature we can find reference to this type of cross with the name of SPX (Single Point Crossover)

Figure 4 1-point junction

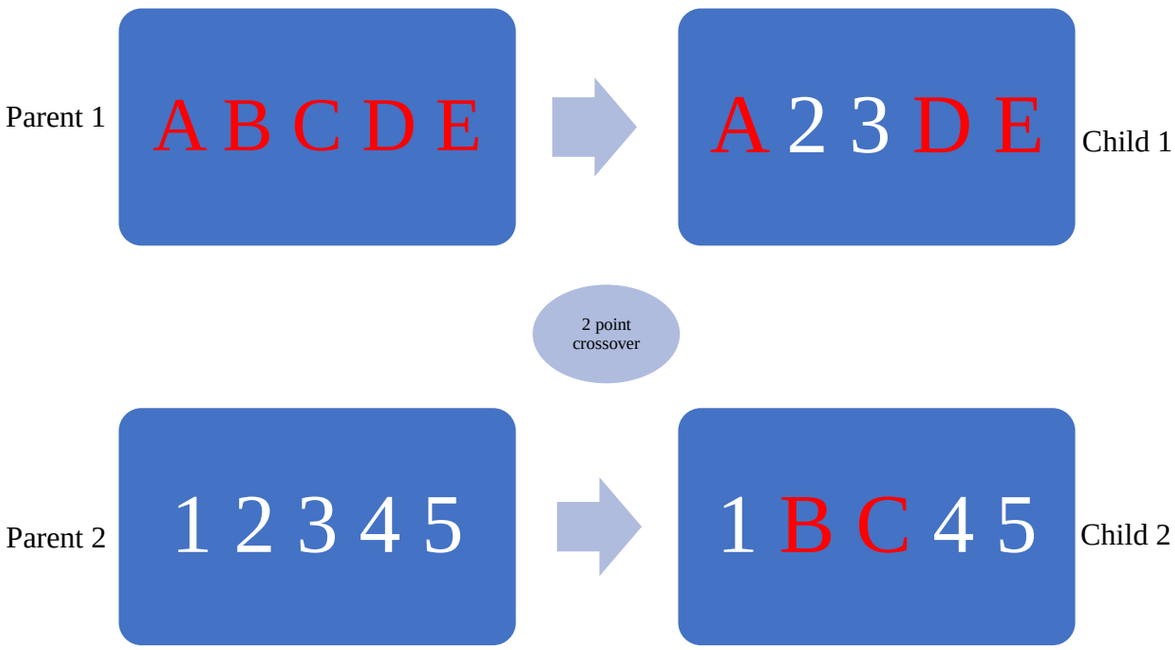


Source: Authors' Own Creation

2-point junction

It is a generalization of the 1-point crossover only that instead of making a single cut in the chromosomes two cuts are made, it must be taken into account that none of these cut-off points coincide with the end of the chromosomes so that it is guaranteed that three segments originate, to generate the offspring or children the central segment of one of the parents and the lateral segments of the other parent are selected.

Figure 5 2-Point Crossing

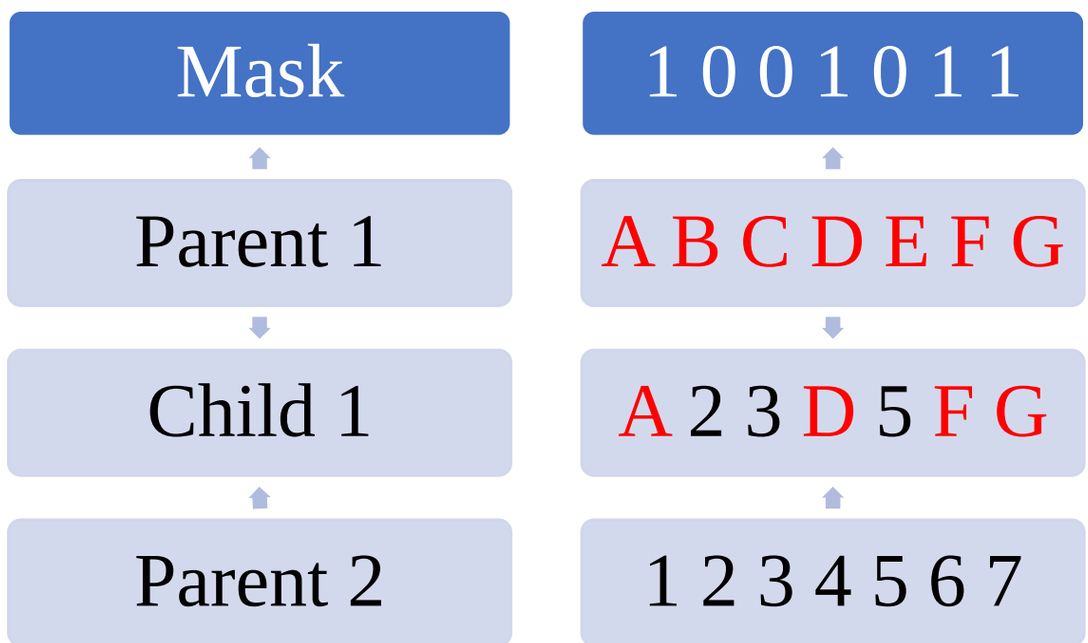


Source: Authors' Own Creation

Uniform Crossing

This technique is completely different from the previous ones, each of the genes of the offspring is obtained from either of the parents randomly, although it has several ways of implementation, the technique involves the generation of a mask with binary values. If in one of the positions of the mask there is a 1, the gene that is in this position in one of the offspring is copied from the first parent, while if there is a zero the gene is copied from the second parent, for the generation of the second offspring the parents are exchanged or the interpretation of the ones and zeros of the crossing mask

Figure 6 Uniform Crossing



Source: Authors' Own Creation

Mutation

The mutation is thought of as a basic operator that provides a small element of randomness in the environment of individuals in the population.

Mutation consists of the modification of certain genes randomly taking into account the probability of the established mutation. The mutation depends on coding and reproduction, if the mutation is abused, it can fall into the use of the GA as a random search, a very low percentage can cause premature convergence or that some areas of space are left unexplored.

The mutation is used in a low percentage, between 1% and 5% in binary or finite coding, and up to 10% or 15% in real coding, because there is a risk that it operates on the only copy of the individual, which is the best solution, and can ruin it.

The probability of mutation is very low, usually less than 1%, because individuals usually have a lower adjustment after the mutation. However, mutations are performed to ensure that no point in the search space has a zero chance of being examined.

For the proper functioning of a GA, it is necessary to have a method that indicates whether or not the individuals in the population represent the best solutions to the problem

2.9.1 Gene inversion: Genes are randomly selected and their value is reversed. It is used in representations of bits, changing 0 by 1 or vice versa.

11001001 ➡ 10001001

2.9.2 Change of order: Two genes are randomly selected and their positions are swapped. It is used in representations based on permutations.

(1 2 3 4 5 6 8 9 7) ➡ (1 8 3 4 5 6 2 9 7)

2.9.3 Gene modification: Small modifications are made to genes. For example, in a coding based on real numbers, sums of very small positive or negative numbers are made (De Jong, K. A., 1975 & GALIPIENSO, A., ISABEL, M., Cazorla Quevedo, M. A., Colomina Pardo, O., Escolano Ruiz, F., & LOZANO ORTEGA, M. A., 2003 & Syswerda, G., 1991).

(1.29 5.68 2.86 4.11 5.55) ➡ (1.29 5.68 2.73 4.22 5.55)

Control System

It is the set of several components that act in conjunction with the common objective for the proposed objective and that can regulate its behavior or that of other systems to minimize error in order to achieve the predetermined operation.

Elements of a control system:

Variable to be controlled. Generally known as the output signal, it forms the signal that we want certain values to acquire.

Screen or system. The plant forms the set of elements that perform a certain function, it is the one that is in charge of controlling or regulating.

Sensor. It is the element that allows the value of the variable to be controlled in a given time to be taken.

– Reference signal. It will be the control objective, the signal setpoint or value that you want the output signal to acquire.

– Actuator: this is the element that will act on the signal of the system, converting it into another signal that can be applied or another process.

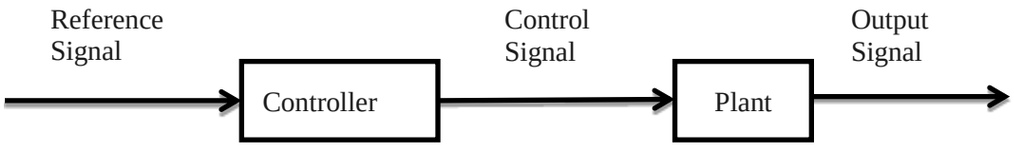
– Controller. O regulator is the element that drives the actuator depending on the control objective to process the difference between the input and output signals to generate a correct signal for the plant.

Open Loop Control System

An open-loop control system is one in which the output signal has no influence on the action of the control, in this way the controller does not take into account the output signal or compare it with the reference signal to decide the performance of the system, these work reasonably well as long as it has been studied perfectly and there are no alterations on the system.

Open-loop control (Figure 7) is mainly used when the relationship between input and output is known, as well as if there are no internal and external disturbances.

Figure 7 Open Loop Controller

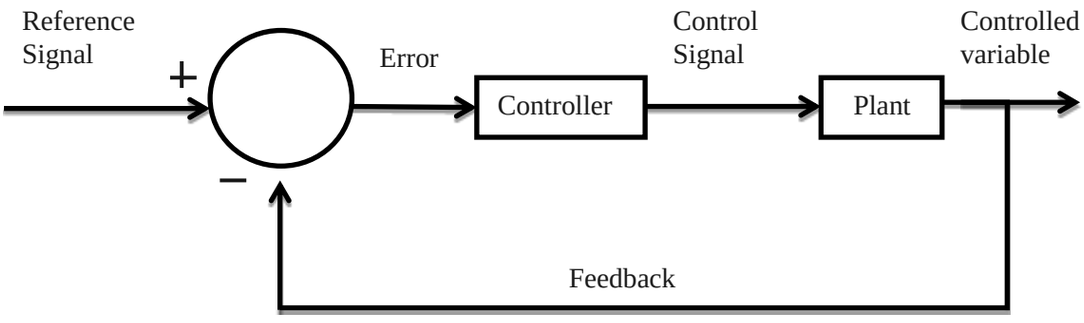


Source: Authors' Own Creation

Closed-loop control systems

In the closed-loop control system, there is feedback from the output signal, in this type of system there is a comparison of the variable to be controlled with the reference variable, so that depending on this difference between the two, the controller modifies the control actuator on the plant actuator Figure 8 (Asdrúbal, V. 2004, Holton, G. J. 1996).

Figure 8 Closed-loop control



Source: Authors' Own Creation

Control PID

The PID (Proportional Integral Derivative) controller is a feedback controller that has the purpose of making the error that is in steady state between the output signal and the plant reference signal zero asymptotically in time, this is achieved using the integral action.

PID Controllers

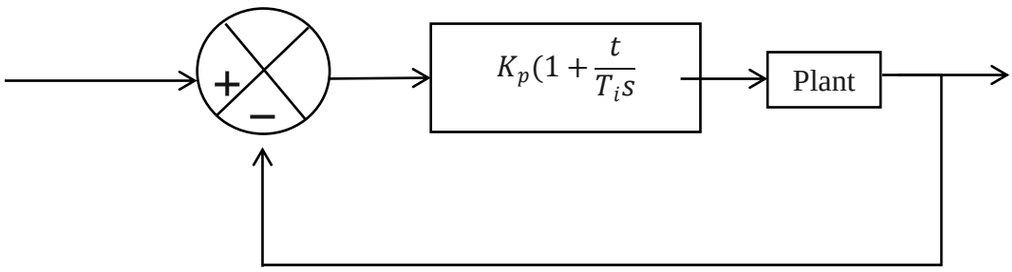
PID controllers make it possible to improve the responsiveness of a system, even if this response is not always optimal. The proposed tuning rules present a way to obtain the parameters of the PID controller, as long as you have a mathematical model of the system. A PID driver allows a system's response to have a null error.

Setting rules for PID controllers are convenient when the system model is known. By obtaining the parameters of a PID controller and observing the response of the controller and the system, it is possible to work on a system that allows the obtaining of these parameters autonomously and thus allow the PID controller to be self-adjusting (Ogata, K., 1997).

PID Driver Tuning Rules

If the mathematical model of the plant is obtained, it is possible to apply several design techniques to determine the control parameters so that the specifications of the transient and the steady state of the closed-loop system are met, on the contrary, if the plant is too complicated to not be able to obtain its mathematical model, an analytical method for the design of a PID controller is also not possible. In this case, experimental models are used for the tuning of PID controllers.

Figure 9 PID control of a plant



Source: Authors' Own Creation

In the process of selecting r the controller parameters that meet the behavior specifications are known as controller tuning. Ziegler and Nichols suggested rules for tuning PID controllers

Which means to give values to , and this is based on step responses K_P $T_i T_d$

Electrical phenomena associated with a thermoelectric cell

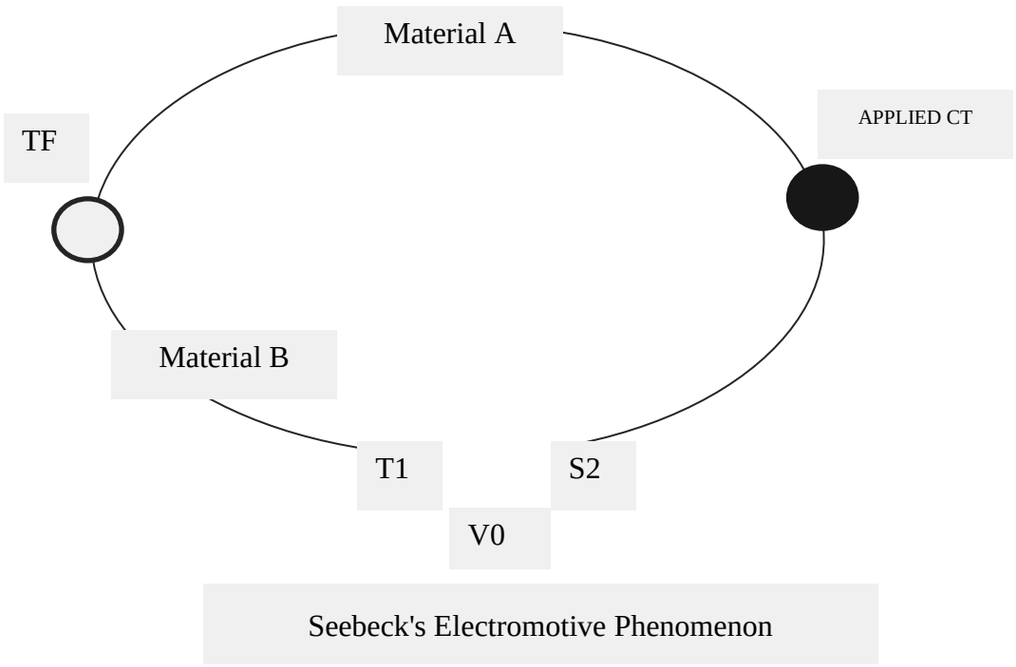
Thermoelectric effect

Thomas Seebeck, a German scientist, demonstrated in 1821 that if two different semiconductor materials were joined together, he deflated the needle of a compass by placing the welds between the two materials at different temperatures. In 1822 his experiments were published in the Proceedings of the Prussian Academy of Sciences under the title "Magnetic Polarization of Metals and Ores by Difference of Temperature", later Hans Chistian Oersted perceived that the difference of temperatures in the circuit induced a difference of electric potential and discovered that the circulation of a current through a conductor had similar effects on the needle of a compass (Hasdrubal, V., 2004 & Holton, G. J., & Brush, S. G., 1996).

Seebeck Effect

Thomas Johann Seebeck discovered that an electromotive phenomenon occurred in a circuit composed of two semiconductor materials when the junctions met at different temperatures, and that the materials responded differently to the difference in temperature creating a magnetic field, so he called the phenomenon the thermomagnetic effect, therefore, the electromotive phenomenon of the circuit was named Seebeck's fem figure 10.

Figure 10 Seebeck Effect

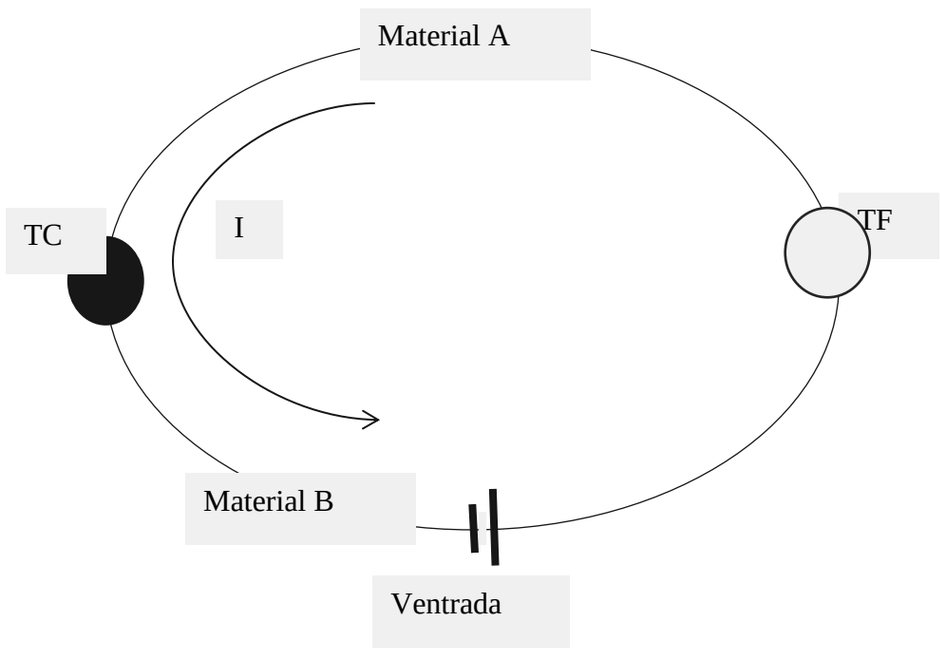


Source: Authors' Own Creation

Peltier Effect

This phenomenon was discovered by Jean Charles Peltier, a French physicist, and is considered the inverse of the Seebeck effect; says that if an electric current passes through the junction of two semiconductor materials, a release or absorption of heat is generated at the junction, depending on the direction of the current flow Figure 9, i.e., one of the joints is heated while the other is cooled, The amount of heat absorbed or emitted at the junction is proportional to the electric current by the Peltier coefficient (Sanchez, J. A., 2013 & Areny, R. P., 2004).π

Figure 11 Peltier Effect (Sánchez, J. A., 2013)

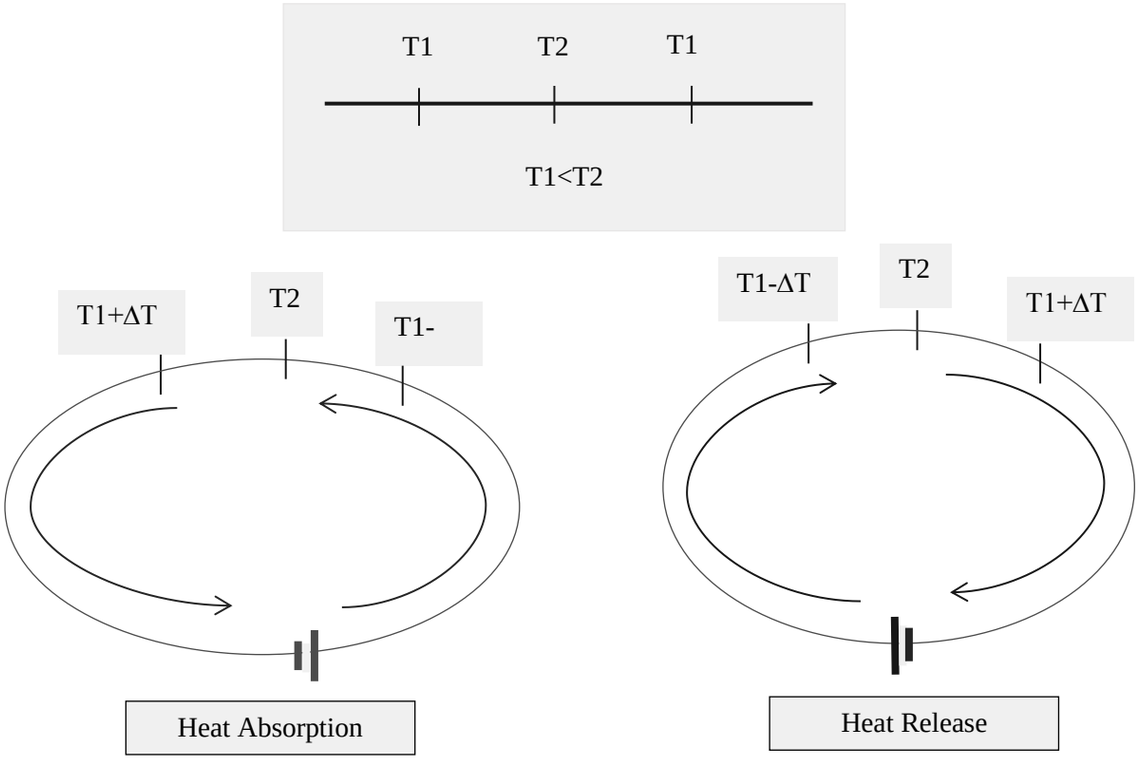


Source: Authors' Own Creation

Thomson Effect

The Thomson effect is a thermoelectric effect and was discovered by William Thomson, and consists of the absorption or release of heat through a homogeneous metal, with a non-homogeneous temperature, through which a current circulates, that is, there is an absorption of heat whenever the current flows in the opposite direction of the heat and is released if the heat and the current flow in the same direction (Sánchez, J. A., 2013 & Areny, R. P., 2004).

Figure 12 Thomson Effect (Sanchez, J. A., 2013)



Source: Authors' Own Creation

Mathematics of a thermoelectric cell

A thermoelectric cell (TEC) is a semiconductor device with the ability to generate heat or cold depending on the magnitude and polarity of an electric power current, TECs have application in the field of micro-refrigeration and mobile refrigeration given their small size and easy location not depending on the position in which they are located. long operating life and fluorocarbon-free operation (Stoecker, W. F., & Chaddock, J. B., 1963).

The functioning of a ECT is represented by a mathematical expression described in equation 2 (Bywaters, R. P., 1969).

$$\tilde{T}_L(s) = G_1(s)\tilde{I}(s) + G_Q(s)\tilde{Q}_L(s) + G_a(s)\tilde{T}_a(s) \quad (2)$$

Where

$G_1(s)$, are represented by equations 3, 4, 5 respectively$G_Q(s), \tilde{Q}_L(s), G_a(s)$

$$G_I(s) = \frac{N(s)}{sD(s)} \quad (3)$$

$$G_Q(s) = \frac{E_H \sinh(qL) + Akq \cosh(qL)}{D(s)} \quad (4)$$

$$G_a(s) = \frac{AA_F\, hkq}{D(s)} \quad (5)$$

While , are characterized by equations 6, 7, 8, 9, 10 respectively.$N(s), D(s)\ p(s), q(s)\ \ E_H$

$$N(s) = \{Akq[\alpha_L \bar{T}_L \cosh(ql) - \alpha_H \bar{T}_H] + \alpha_L \bar{T}_L E_H \sinh(qL)\}s + \frac{Akq\beta}{C\gamma}[E_H(1 - \cosh(pL) - Akpsinh(pL] \quad (6)$$

$$D(s) = AkqE_L \cosh(qL) + E_H E_L \sinh(qL) + AkqE_H \cosh(pL) + A^2k^2pqsinh(pL) \quad (7)$$

$$p(s) = \frac{\left(\frac{\tau\bar{I}}{A} + \sqrt{\frac{\tau^2\bar{I}^2}{A^2} + 4kC\gamma s}\right)}{2k} \quad (8)$$

$$q(s) = \frac{\left(\frac{\tau\bar{I}}{A} - \sqrt{\frac{\tau^2\bar{I}^2}{A^2} + 4kC\gamma s}\right)}{2k} \quad (9)$$

$$E_H(s) = (M_F C_F + M_H C_H)s + hA_F - (\tau + \alpha_H)\bar{I} \quad (10)$$

Finally, it is determined by equation 11 and assumes the value of equation 12 in $E_L\alpha_H$

$$E_H(s) = (M_L C_L + M_C C_C)s + (\tau + \alpha_H)\bar{I} \quad (11)$$

$$\alpha_{pn}(T) = \alpha_H + \frac{\tau}{\tilde{T}_H}\tilde{T}_H \quad (12)$$

Table 2 shows the nomenclature of the literals of the equations presented above

Table 2 Literals of the equations that describe the behavior of an ECT

Literal	Meaning
$\tilde{T}_L(s)$	Cooling Face Temperature
$I(s)$	Supply current
$\tilde{T}_a(s)$	room temperature
L	Length of thermoelectric elements
A	Total cross-sectional area of thermoelectric material
k	Thermoelectric conductivity of the P-N pair ()W m^{-1} K^{-1}
h	Convection Heat, Thermal Trigger Transfer Coefficient º W m^{-2} K^{-1}
γ	Heat Density of Thermoelectric Material(kg m^3)
A_F	Total Heat Transfer Surface
M_F	Thermal Trigger Mass
C_F	Thermal Capacity of Thermal Trigger (kJ kg^{-1} K^{-1})
M_H	Hot Plate Mass Thermoelectric Module End
C_H	Heat Capacity of Thermoelectric Module Heating Plate (kJ kg^{-1} K^{-1})
τ	Thompson's coefficient (V K^{-1})
α_{pn}	Seebeck coefficient of thermoelectric material (V K^{-1})
$\bar{I}$	Average Supply Current
M_L	Mass Thermal Trigger Cooling Charge
C_L	Heat Exchanger Charge Cooling Heat Capacity
M_C	Cooling Mass Plate of Thermoelectric Module
C_C	Thermoelectric Module Cooling Plate Heat Capacity (kJ kg^{-1} K^{-1})
s	Complex Variable

Source: Authors' Own Creation

Development

The original population proposed as a possible solution is randomly generated and consists of a total of 40 individuals with a uniform distribution, encoding the chromosomes with real numbers, in such a way that the format of the chromosome has the following shape $cromosoma = [k_p, k_i, k_d]^T$

The percentage of individuals to cross is 60%

This indicates that only 24 of the 40 individuals will be stochastically crossed by the roulette method where the entire population has the same probability of being within the possible solution to the problem, in none of the simulations will the same result come out since the algorithm always looks for one of the best solutions to the problem and the results vary according to the crossed individuals.

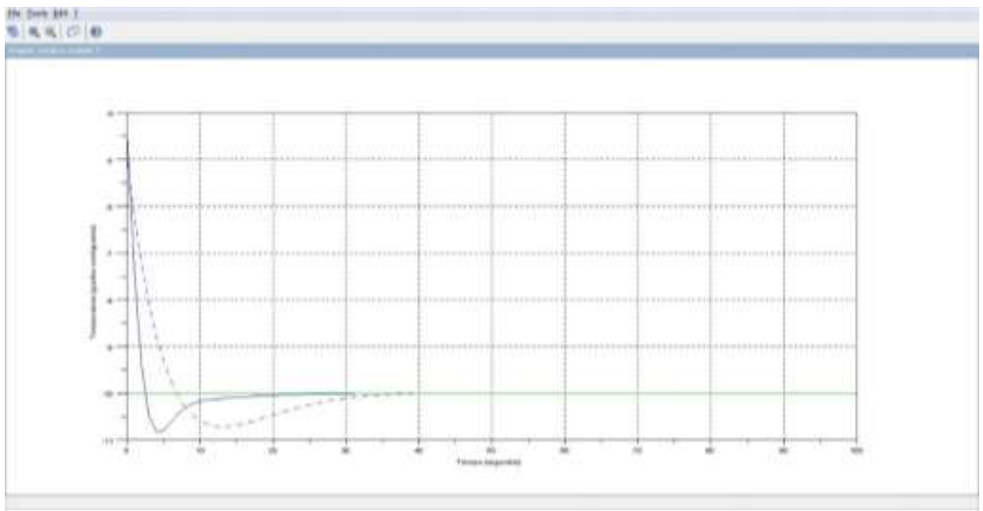
By varying the variable α from 0 to .3, the results change in terms of the time in which the Tec stabilizes, the over-impulse and the values of $[k_p \quad k_i \quad k_d]^T$

Table 3 Test α = 0

α	0
Cross-population	24
Uncrossed population	16
Generation in which it stabilizes	29
Time of Establishment of the Tec	38.9
RMS Value	0.4993431
About Impulse	-10.83
Values $[k_p \quad k_i \quad k_d]^T$	$-3.3780554 \quad -2.4647874 \quad -1.9349458$

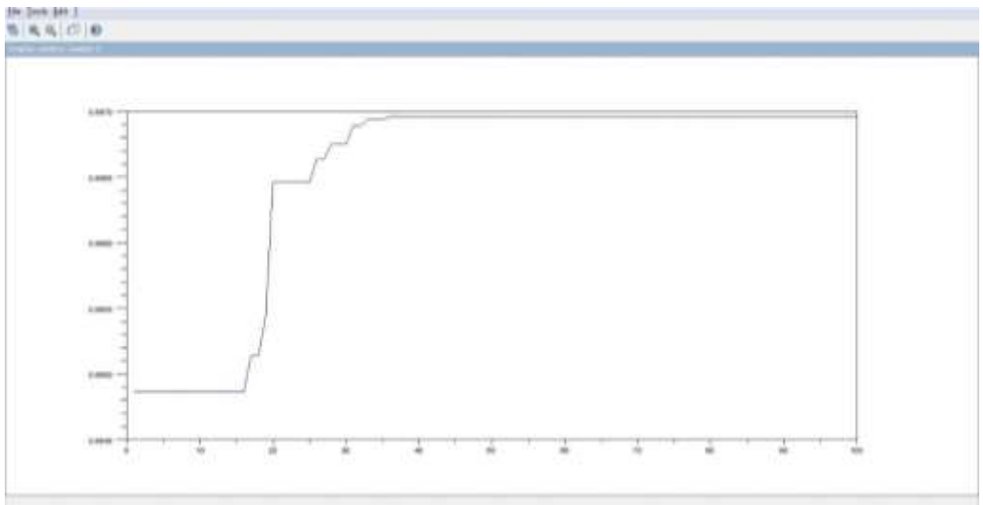
Source: Authors' Own Creation

Figure 13 ECT Establishment Time



Source: Authors' Own Creation

Figure 14 Objective function with a value α= 0'



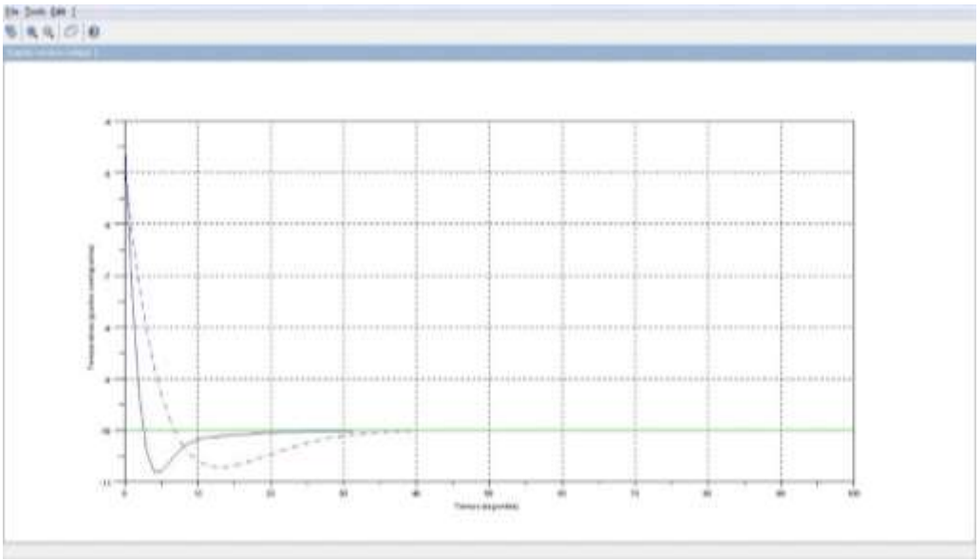
Source: Authors' Own Creation

Table 4 Test α = .1

α	.1
Cross-population	24
Uncrossed population	16
Generation in which it stabilizes	27
Time of Establishment of the Tec	39
RMS Value	0.6648669
About Impulse	-10.8
Values $[k_p \quad k_i \quad k_d]^T$	$-3.3746832 \quad -2.4124418 \quad -1.9899383$

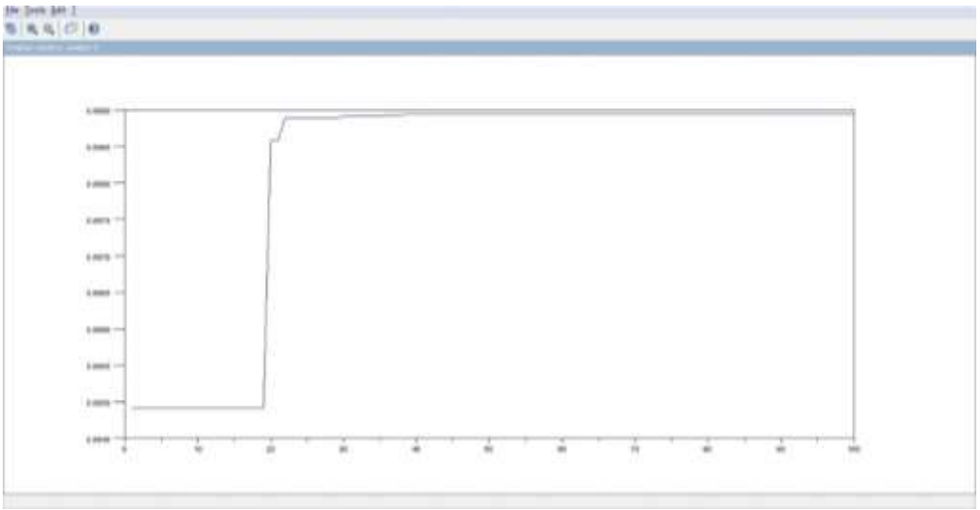
Source: Authors' own creation

Figure 15 ECT Establishment Time α = .1



Source: Authors' Own Creation

Figure 16 Objective function 'with a value α= .1'



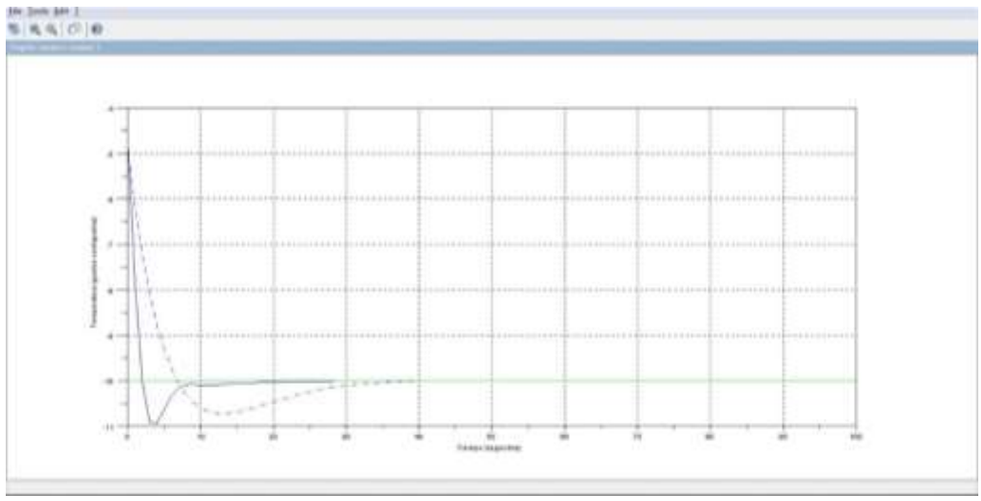
Source: Authors' Own Creation

Table 5 Test α = .2

α	.2
Cross-population	24
Uncrossed population	16
Generation in which it stabilizes	28
Time of Establishment of the Tec	38.5
RMS Value	0.6876463
About Impulse	-10.93
Values $[\mathbf{k_p} \quad \mathbf{k_i} \quad \mathbf{k_d}]^{\mathbf{T}}$	$-3.7085573 \quad -3.5835899 \quad -2.1844144$

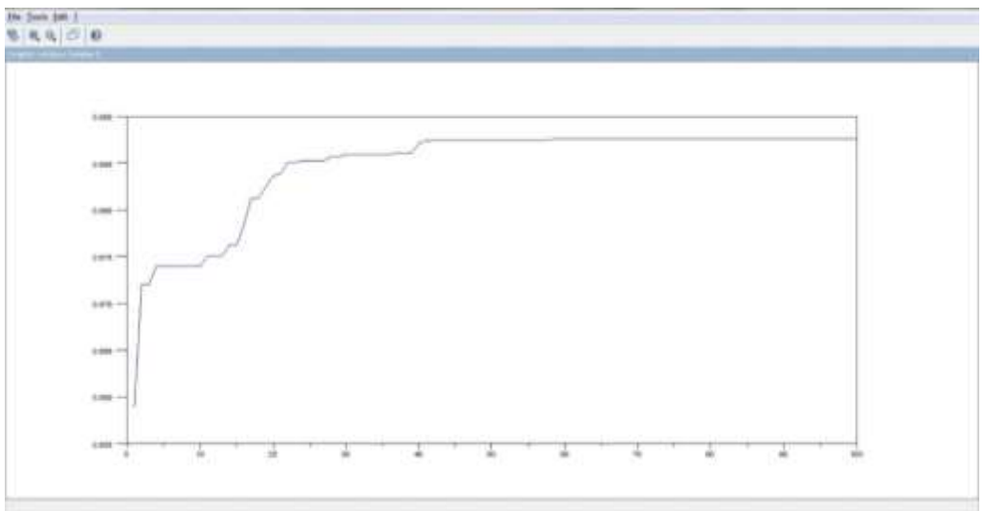
Source: Authors' Own Creation

Figure 17 ECT Establishment Time α = .2



Source: Authors' Own Creation

Figure 18 Objective function 'with a value α= .2



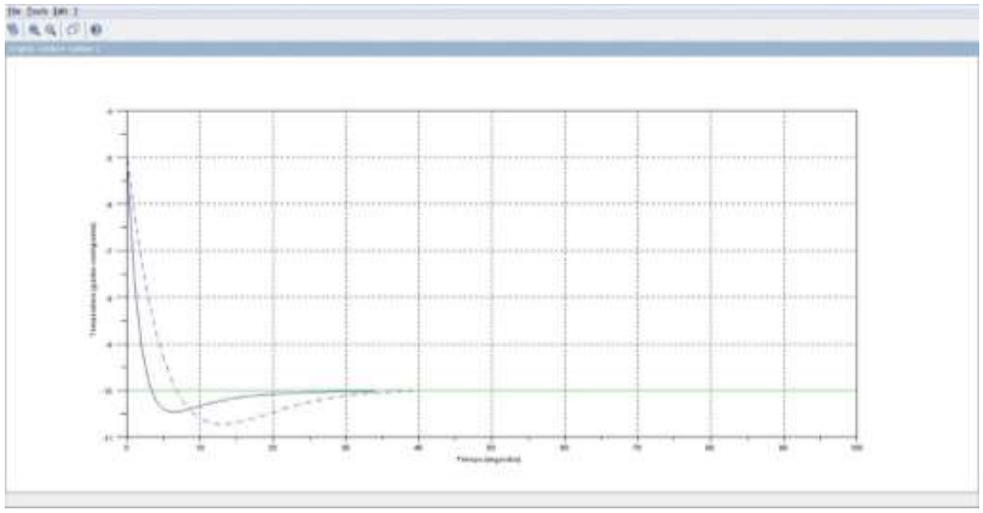
Source: Authors' Own Creation

Table 6 Test α = .3

α	.3
Cross-population	24
Uncrossed population	16
Generation in which it stabilizes	27
Time of Establishment of the Tec	44
RMS Value	0.6939176
About Impulse	-10.45
Values $[\mathbf{k_p} \quad \mathbf{k_i} \quad \mathbf{k_d}]^{\mathbf{T}}$	$-4.5094422 \quad -1.8841904 \quad -2.5851778$

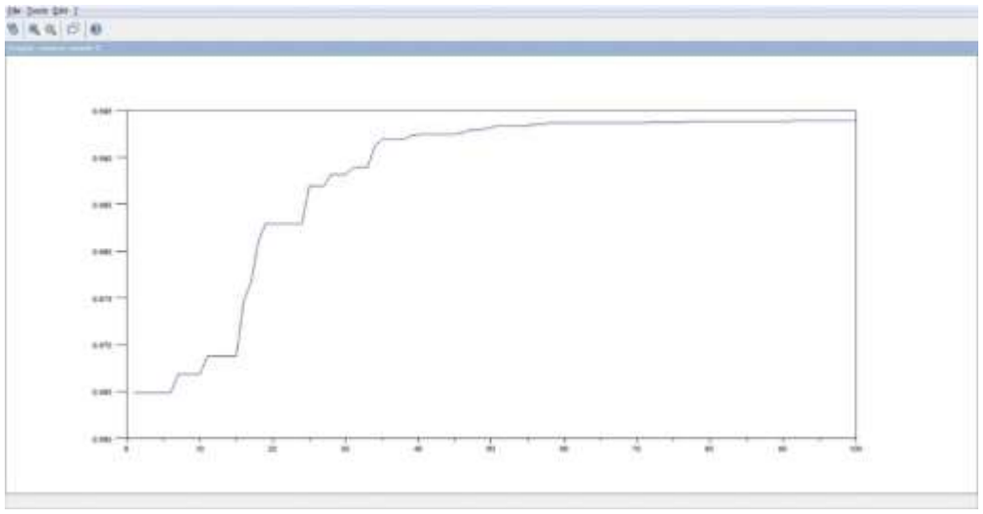
Source: Authors' Own Creation

Figure 19 ECT Establishment Time α = .3



Source: Authors' Own Creation

Figure 20 Objective function with a value α= .3



Source: Authors' Own Creation

Table 7 Probability of crossing

Percentage of individuals to cross	**10%**	**20%**	**30%**	**40%**
Population without crossing	36	32	28	24
Generation in which it stabilizes	22	15	26	23
Time of Establishment of the Tec.	27	31	27	33
RMS Value	15.218525	13.803818	13.172133	17.04658
About Impulse	-11.6	-10.5	-10.8	-10.7
Values				
K_P	-2.0404459	-4.1833099	-4.4147529	-3.0476789
K_i	-3.013042	-2.0256428	-3.5777777	-1.5794054
K_d	-1.3450577	-1.547587	-0.5881394	-1.1260359

Source: Authors' Own Creation

Table 8 Crossover Probability

Percentage of individuals to cross	50%	60%	70%	80%
Population without crossing	20	16	12	8
Generation in which it stabilizes	21	27	26	39
Time of Establishment of the Tec.	33	30	33	30
RMS Value	15.78307	14.625429	14.928188	15.557047
About Impulse	-10.7	-10.7	-10.6	-10.9
Values				
K_P	− 3.3973984	− 3.5448038	− 3.8585455	− 2.980842
K_i	− 1.9188595	− 2.1360178	− 1.8573233	− 2.2484185
K_d	− 0.9764242	− 1.3928514	− 1.1983353	− 1.0834272

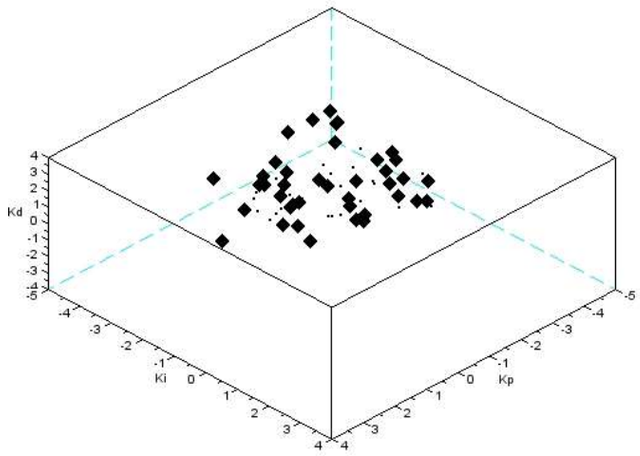
Source: Authors' Own Creation

Results

Algorithm convergence

Stochastic traversal through the population each dark rhombus represents the best individuals of during each generation, they explore the entire search space to find the best individual, each of the dots represents an individual or chromosome, the graph represents the search space.

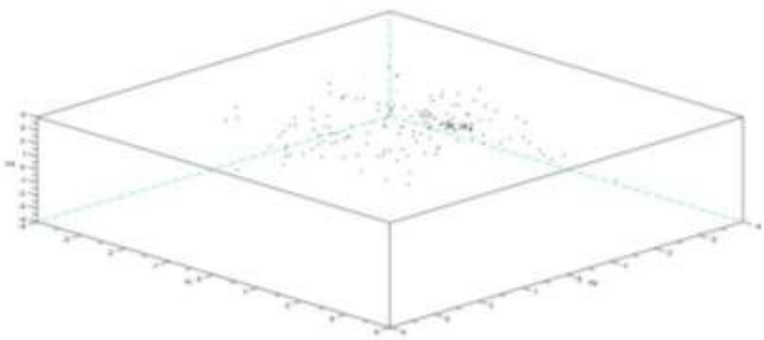
Figure 21 Beginning of the route through the town



Source: Authors' Own Creation

The randomly generated solutions with a uniform distribution, where the blue rhombus represents the optimal solution found when making the journey through the population.k_p, k_i, k_d

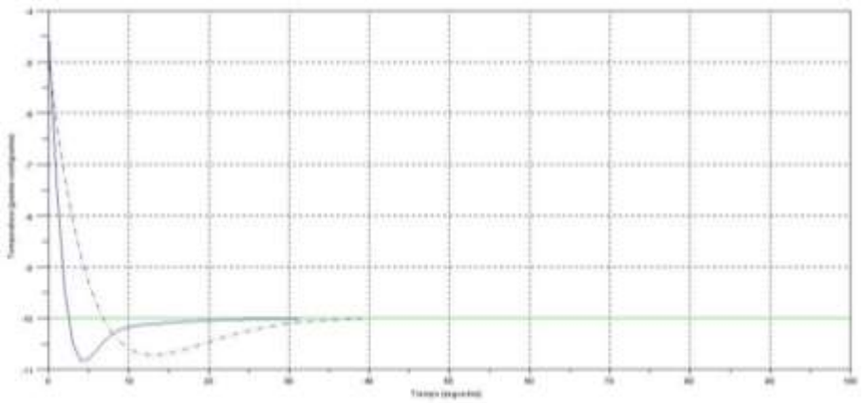
Figure 22 Solutions kp,ki,kd



Source: Authors' Own Creation

The following figure shows the solid blue line as the response obtained by means of the PID adjusted with genetic algorithms, the dotted blue line shows the Nichols fit, and the green line represents the reference.

Figure 23 Response obtained



Source: Authors' Own Creation

In the present work, the reduction of mean square error of a PID applied to a peltier cell decreased with the implementation of a simple genetic algorithm, the proposal presented decreases the mean square error by at least 20%.

In addition to the above, it was observed that the real crossover -α is suitable for this type of optimization as long as α does not exceed the value of 0.3, since it generates non-viable solutions, (values of) that caused an unstable operation in the cell.$BLXk_pk_ik_d$

Conclusions

The reduction of mean square error of a PID applied to a Peltier cell decreased with the implementation of a simple genetic algorithm, the proposal presented decreases the mean square error by at least 20%. As shown in Figure 21, where the solid blue line represents the response of the cell and the dotted blue line represents the Nichols criterion.

In addition to the above, it was observed that the real crossover -α is suitable for this type of optimization as long as α does not exceed the value of 0.3, since it generates non-viable solutions, (values of) that caused an unstable operation in the cell$BLXk_pk_ik_d$

Future Jobs

It is proposed to use a multiobjective genetic algorithm that considers various properties of a PID controller, it is also necessary to implement the use of constraints that control the convergence of the algorithm and the valid values.

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Chapter 7 Identification and classification of mature corn cob species using Artificial Intelligence algorithms

Capítulo 7 Identificación y clasificación de especies de mazorcas de maíz maduro mediante algoritmos de Inteligencia Artificial

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DOI: 10.35429/H.2023.13.91.102

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A. Reyes, E. López and B. Hernández (AA. VV.) Computer Technology and Innovation. Handbooks-TI-©ECORFAN-Mexico, Mexico City, 2023

Abstract

This work presents the identification of different species of mature corn cobs produced in the northern area of the State of Mexico, specifically white, yellow, black and pink cobs by using a Convolutional Neural Network associated to a classification algorithm, the analysis is performed by supervised learning since the labeling of the cobs for training and validation is previously performed, so that in the prediction stage the algorithm is able to identify unlabeled species to check the effectiveness of the algorithm. This work is divided into two phases: the first one is to determine the performance of the algorithm for a sample of images and analysis through real time video and the second one is the implementation of the physical mechanism that is in charge of the classification. It is worth mentioning that this work focuses on the development of the first phase, which is based on the development and training of the algorithm based on Convolutional Neural Networks for the correct identification and classification of the cob.

Artificial Intelligence algorithms, Supervised Learning, Mature Corn Cob

Resumen

Este trabajo presenta la identificación de diferentes especies de mazorcas de maíz maduro producidas en la zona norte del Estado de México, específicamente mazorcas blancas, amarillas, negras y rosas mediante el uso de una Red Neuronal Convolucional asociada a un algoritmo de clasificación, el análisis se realiza mediante aprendizaje supervisado ya que previamente se realiza el etiquetado de las mazorcas para el entrenamiento y validación, de tal forma que en la etapa de predicción el algoritmo es capaz de identificar especies no etiquetadas para comprobar la efectividad del algoritmo. Este trabajo se divide en dos fases: la primera es determinar el rendimiento del algoritmo para una muestra de imágenes y análisis a través de video en tiempo real y la segunda es la implementación del mecanismo físico que se encarga de la clasificación. Cabe mencionar que este trabajo se enfoca en el desarrollo de la primera fase, la cual se basa en el desarrollo y entrenamiento del algoritmo basado en Redes Neuronales Convolucionales para la correcta identificación y clasificación de la mazorca.

Algoritmos de Inteligencia Artificial, Aprendizaje Supervisado, Mazorca de Maíz Madura

1. Introduction

Nowadays, information analysis using artificial intelligence algorithms is one of the most important mechanisms for decision-making and automating complex tasks for human beings, such is the case of text, image, video and audio analysis. The applications of Artificial Intelligence are very varied and we can currently apply this type of technological implementation in practically any sector. In this sense, image classification is considered by many to be one of the most outstanding developments since it is the basis of training for the development of more complex systems (Ponce Cruz, P, 2011).

Currently, the evolution of algorithms has advanced by leaps and bounds and there are numerous investigations that focus on the analysis of images and video as case studies, having as their main objective, to analyze and solve a problem, provide knowledge and provide tools to different development sectors, in the same way they provide technological help to non-specialized people in search of functional applications for a specific task.

The case study of this work focuses on finding an efficient solution for the classification of mature corn cobs to determine the species to which it belongs, whether it is white, yellow, black or pink, also considering the identification of 4 common diseases that can occur and thus hinder their correct classification given the characteristics of these diseases. all this work is carried out through the application of Artificial Intelligence algorithms, in order to make the classification process in the northern region of the State of Mexico more efficient. Currently, the sorting process is done manually by people who sort by color and also by disease, but it is a time-consuming job that requires several people since normally more than a ton of corn is collected per hectare. The problem for which this classification arises is because the corn that is planted is criollo, that is, the best ears that are harvested from the previous year are chosen in order to obtain the seed, however, as it is already several generations old, alterations can occur and sometimes the seed not only belongs to the predominant color, but it has grains of a different color, which causes mixtures to begin to be made at ripening.

The second problem: once the type of cob has been identified, it must be verified if it is healthy or has some disease, normally this work is done by people over 50 years of age, while the younger generations do not know how to determine the type of disease and how to stop its spread. Currently there are many works focused on the analysis of images of people, wounds, fruits, vegetables, objects and plants, but there are not fully identified works of cob analysis, so the implementations of this type of development in this sector in the northern area of the State of Mexico are new.

A case where AI is applied is, for example, in the area of medicine, given that the use of AI in the classification of medical information is becoming more and more common and has proven to be a valuable tool in the diagnosis and treatment of diseases. In particular, deep learning has proven to be effective in the classification and segmentation of medical images, as exemplified by the article titled "Artificial Intelligence: Development of Classification and Segmentation Algorithms in Chest X-Ray." Two deep learning models were developed for the classification of thoracic structures and segmentation of posterior costal arches in chest x-rays. Model 1, based on a pre-trained Bayesian approach, was used for the classification of thoracic structures and the identification of cardiomegaly. Model 2 focused on autonomic segmentation of the posterior costal arches on PA chest radiographs. Manual labeling of the rib arches was required for model 2 in a set of images of subjects without diagnosed pathologies. Model 2 used a convolutional neural network architecture with three convolutional layers and was evaluated by comparing its accuracy with the results of human radiologists.

The results showed that Model 2 achieved an accuracy of 95.6%, slightly exceeding the accuracy of human radiologists (94.5%). These results underscore the high accuracy of AI in the classification of thoracic structures and the identification of cardiomegaly, as well as in the segmentation of posterior costal arches (Raschio, E., Contreras, C., Allende, F., & Maturana, P., 2021). This suggests that AI can be a valuable tool for automating some of the processes involved in medical imaging, which could have a significant impact on healthcare in the future.

On the other hand, in the field of environmental conservation, the AmazonCRIME dataset represents an innovative solution for detecting areas related to transnational environmental crimes in the Amazon rainforest. The AmazonCRIME dataset, consisting of 30,000 labeled and georeferenced multispectral imagery, generated using Sentinel-2 imagery and the Google Earth Engine platform. The dataset is used to feed advanced Geospatial Artificial Intelligence models for the detection of areas linked to transnational environmental crimes in the Amazon rainforest. Experiments have been carried out using convolutional neural networks (CNNs) to classify images and detect areas of deforestation, illegal mining, illicit crops, among others (Pinto-Hidalgo, J. J., & Silva-Centeno, J. A., 2022).

The results mentioned in the article under the title "AmazonCRIME: A Geospatial Artificial Intelligence Dataset and Benchmark for the Classification of Potential Areas Linked to Transnational Environmental Crimes in the Amazon Rainforest" are promising, as the CNNs models achieved a classification accuracy of over 90% in most classes (runways, deforestation, forestry, illegal mining, illicit crops/potential area of coca crops and water). In addition, the models also managed to identify areas affected by the mining of natural resources and airstrips with rudimentary characteristics, demonstrating their important contribution to the field of environmental crime detection in the Amazon rainforest (Raschio, E., Contreras, C., Allende, F., & Maturana, P., 2021).

This work is organized in 5 sections, where the points related to the research topic are discussed, organized as follows:

– Section 1. Introduction, the focus of the work is presented and the state of the art on works related to image analysis using different artificial intelligence algorithms is presented.

– Section 2. Theoretical foundation, here are presented the necessary concepts on image analysis, development methodology and classification using Artificial Intelligence algorithms.

– Section 3. Development, this section shows the steps to follow to carry out the classification of the different types of ears of mature corn and the identification of their diseases or if they are healthy.

- Section 4. Results: The results obtained based on the experimentation carried out to identify the color of the cob and the type of disease are shown.

- Section 5. Conclusions, the conclusion reached based on the results obtained is presented and the future work that is planned to be carried out is shown.

2. Theoretical background

2.1. Artificial intelligence

Artificial Intelligence (AI) has emerged as a technology with a significant impact on the classification and processing of information in various disciplines. Its machine learning and data processing capabilities have enabled a wide range of applications ranging from image and text categorization to segmentation of complex information in areas such as medicine, fraud detection, customer service automation, and much more.

Artificial intelligence (AI) is the field of computer science dedicated to solving cognitive problems commonly associated with human intelligence, such as learning, problem-solving, and pattern recognition (What Is Artificial Intelligence? - Artificial Intelligence (AI) Explained - AWS, 2023). It refers to systems or machines that mimic human intelligence to perform tasks and can iteratively improve from the information they collect. For example, chatbots to understand problems faster and provide more efficient answers to users are typically hosted within web pages, intelligent assistants are used to analyze critical information from large data sets, and recommendation engines that can provide automated recommendations for TV shows based on users' viewing habits (Oracle, 2022).

There are currently 3 types of artificial intelligence, the first called narrow or weak artificial intelligence which refers to the ability of a computer system to perform a task with better accuracy than a person, the second known as strong general or human-level artificial intelligence which refers to the ability of a computer system to outperform people in any intellectual task and finally artificial super intelligence which is a computer system that has managed to outperform people in almost every field, including scientific creativity and social skills (What Is Artificial Intelligence? | Microsoft Azure, 2023).

Currently, the applications of artificial intelligence are present in many areas of daily life, for example, in the facial detection of people in certain areas, in virtual voice assistants such as Siri or Alexa and in industries such as transport, education, culture, medical services, etc.

Artificial intelligence applications seek to make people's lives easier, for example, with personal assistants we can make use of chatbots, with which we interact to be able to more quickly find products and services within our reach and these choices are stored so that we can later use the chatbot's recommendations and have a better service. The second example can be found in agricultural use, where platforms can be created that carry out a historical analysis of the information stored and can determine what the best yield of the fields will be and it is possible to warn of adverse environmental impacts that may harm production (Iberdrola, 2017).

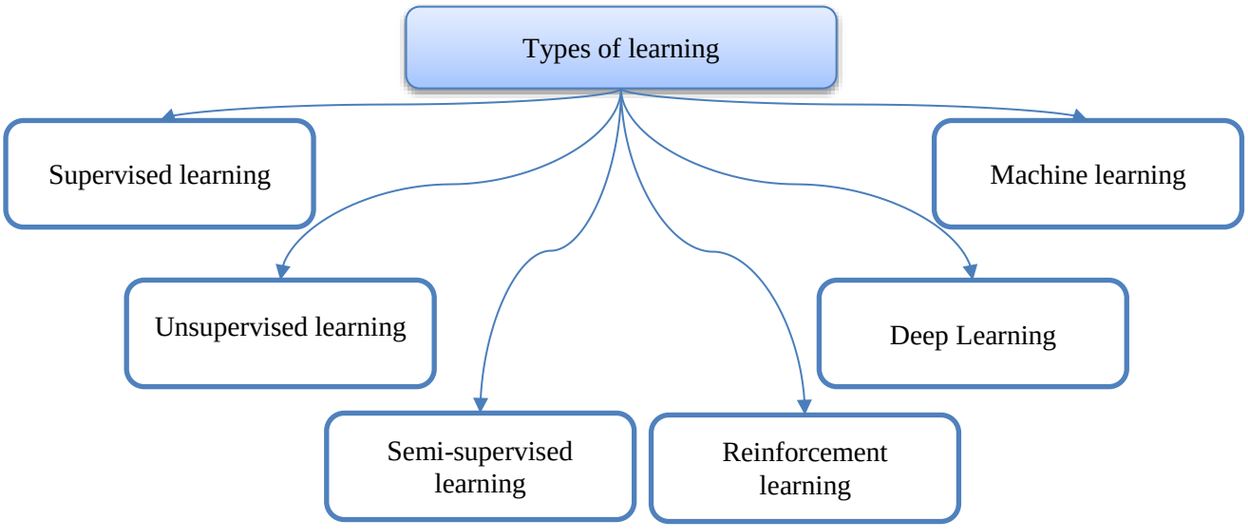
We also find applications of artificial intelligence within finance, since they can help banks detect fraud, predict market patterns and advise what operations customers should carry out within their platforms, for example, apply for loans, credit cards and other transactions, another use is found in education since it allows us to know if a student may be a cause of abandonment, By analyzing the information, we can determine if their learning is optimal or requires some kind of attention so that they can be guided by the corresponding authorities in decision-making.

How these we can list different applications in industries and companies where artificial intelligence has given good answers within the market, however, we must also consider the risk represented by the development of this type of systems, because by automating tasks and improving the performance of operations, jobs are at risk since fewer and fewer personnel are needed to be able to carry out the activities. This means a potential risk for the population despite the benefits that artificial intelligence gives us.

Within the area of artificial intelligence there are several types of learning, these will help us determine how the algorithm works and the way in which we can train the system that is being generated, this classification will depend on the use of each of the applications and the mechanisms of implementation of these, as shown in Figure 1.

In this case, we must make a distinction in terms of the type of learning, since machine learning and deep learning are going to refer more to the application of the different artificial intelligence algorithms that we can find, while supervised, unsupervised, semi-supervised and reinforcement learning are going to refer to the way in which the algorithm is going to be trained.

Figure 1 Types of learning



Source: Own Work

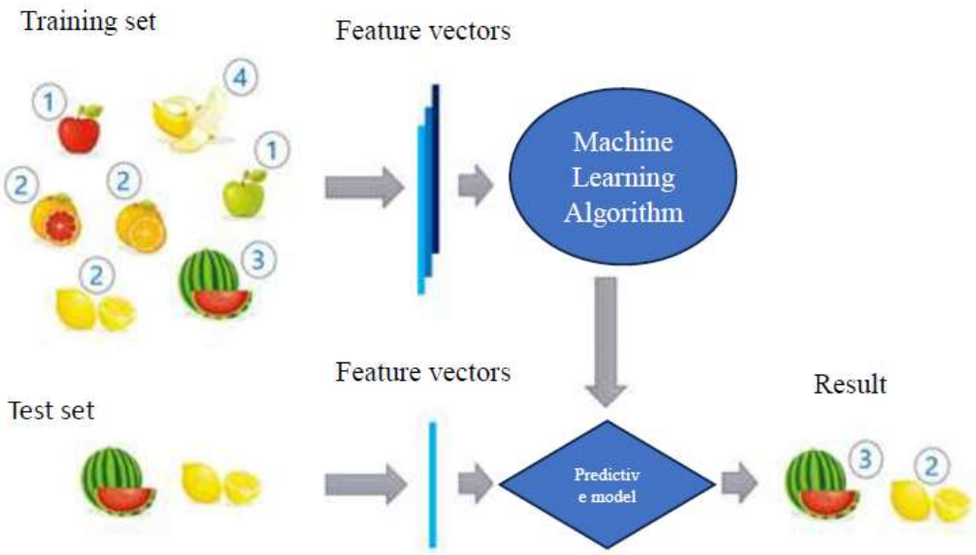
2. 2. Supervised learning

The branches of artificial intelligence are mainly divided into natural language processing, expert systems, computer vision, automatic speech recognition, planning, robotics and machine learning, it is in the latter where we find a sub-classification which is divided into supervised, unsupervised, reinforcement and deep machine learning, for the case study of this work supervised machine learning is used since the label of the class to which the species being tested during training belongs.

Supervised machine learning is where the data is previously labeled to carry out the training of the algorithms that will be in charge of classifying data and predicting results accurately (see figure 1), as the data enters the model, the weights are adjusted until the models perform a classification close to 100% using different types of validation such as hold-out or cross validation (Calvo, 2019).

On the other hand, unsupervised learning learns from the data since it enters without labeling and seeks that the data is understood by itself, in this case the model must learn to adjust the results and the groupings that are made until it finds a relationship of the data and can make a correct classification (What is unsupervised learning? 2020).

Figure 2 Supervised learning

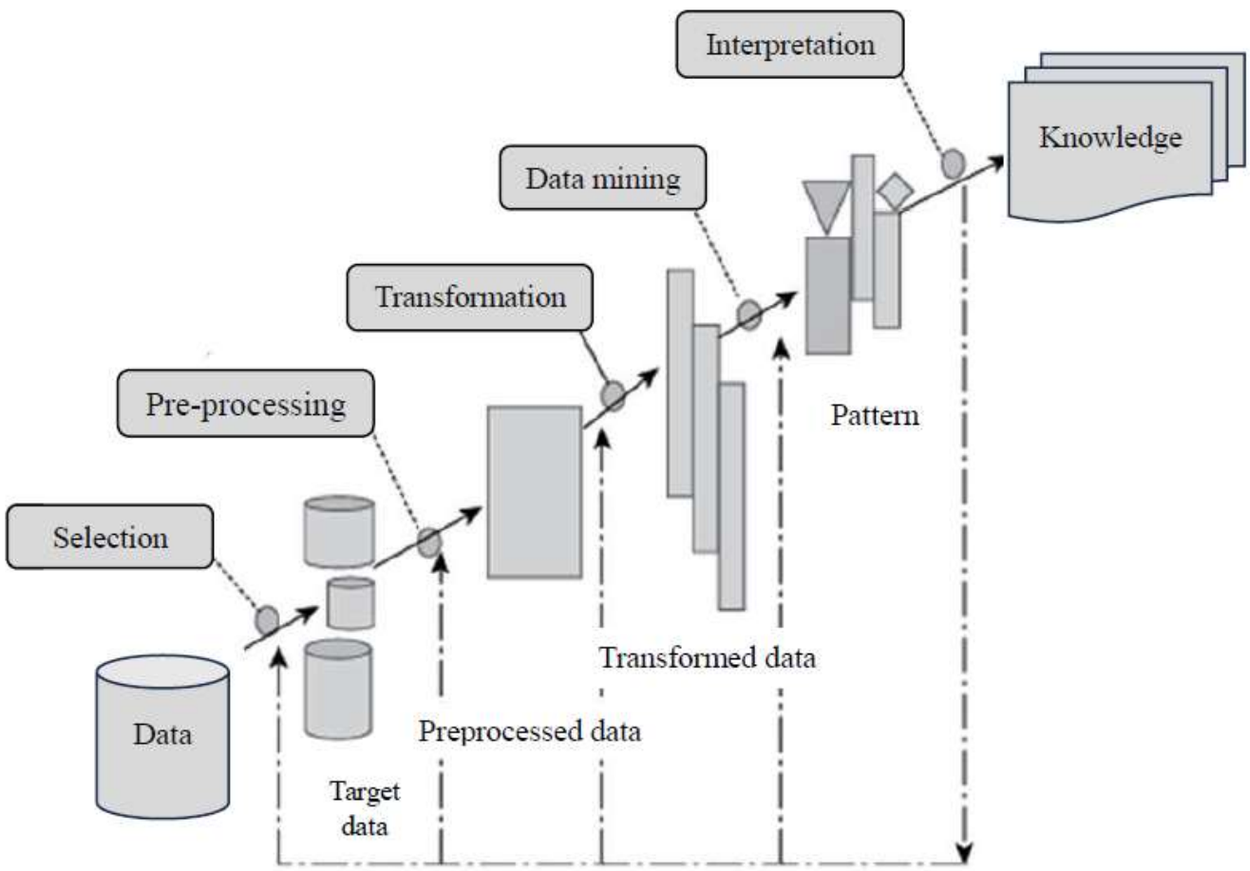


Source: obtained from (Calvo, 2019)

2. 3. KDD (Knowledge Discovery in Databases)

The process that is followed to obtain knowledge of a database through the application of data mining algorithms is shown in figure 1.1, this process is known as KDD (Knowledge Discovery in Databases), it refers to the analysis of large databases using different algorithms to obtain useful information for the organization (Tangarife Morales, 2016).

Figure 3 Stages of the KDD process



Source: Obtained from (Timarán-Pereira, S. R., et al, 2016)

The description of the stages of the knowledge extraction process according to (Timarán-Pereira, S. R., *et al*, 2016) are:

– Selection: Once the relevant and priority knowledge has been identified and the goals of the kdd process have been defined, from the point of view of the end user, an objective dataset is created, selecting the entire dataset or a representative sample of it, on which the discovery process is carried out.

– Pre-processing: data quality is analyzed, basic operations such as noisy data removal are applied, strategies are selected for handling unknown data (missing and empty), null data, duplicate data, and statistical techniques for their replacement.

– Transformation: useful features are sought to represent the data depending on the goal of the process. Dimension reduction or transformation methods are used to decrease the effective number of variables under consideration or to find invariant representations of the data.

– Data mining: it is the search and discovery of unsuspected and interesting patterns, applying discovery tasks such as classification.

– Interpretation: the patterns discovered are interpreted and the classification is made.

3. Development

In this stage, the application of the KDD process is presented, through which the analysis and classification of ears is carried out in real time through video analysis, considering the training stage of the algorithm based on a deep neural network with previously identified images according to the type of ear to which they belong.

3.1. Data selection and pre-processing.

The first stage of the work consisted of collecting the dataset of images of different cob samples of the 4 types of corn that will be analyzed, having a total of 200 images of ears between white (see figure 1), black (see figure 2), yellow (see figure 3) and pink (see figure 4), the latter is one of the least common to find so it becomes more complicated to identify its variations and In addition to having 50 images with ears of the 4 diseases that will be identified among the 4 colors of cobs (see Figure 5), it is important to mention that diseases are usually present in white and yellow cobs since they are the most predominant species.

Figure 4 Specimens of white maize

Source: Own Work

Figure 5 Black maize specimens

Source: Own Work

Figure 6 Specimens of yellow maize

Source: Own Work

Figure 7 Specimens of pink corn

Source: Own Work

Figure 8 Specimens of diseased maize

Source: Own Work

To determine what kind of disease the ear has, the following aspects should be considered according to (Taba, S., 2004 and Varón de Agudelo, F., & Sarria Villa, G. A., 2007):

– Aspergillus: occurs when infected ears are stored with high moisture content, it may contain yellow-green, ivy-green or black masses on the grain or on the olote.
– Gibberella: This is most common in cold, moist areas. The first signs of the infection are the formation of white mycelia, which descend from the tip of the cob and give a reddish and pink coloration to the infected grains, this type of infection can be poisonous to some species of animals.
– Fusarium: This is the most common disease, causes infected grains to develop a cottony mold and can be toxic to animals.
– Common Carbon: this disease can be detected in the young plant from the germination of the corn when it is produced in the "huitlacoche" fungus consumed by some people, when it reaches the state of maturity it produces a black color similar to coal dust, hence its name.

3.2. Transformation and Data Mining

In this stage, the application of the first phase of the convolutional network is carried out, since the characteristics of the images are extracted, resized and scaled to be able to make simpler images and later convert them to vectors, so that the multilayer perceptron that is in charge of the analysis to determine to which class they belong can obtain the necessary data and make the correct classification of them.

For example, Figure 9 shows the code snippet where the image is readjusted to be analyzed, after this step comes the whole process of extracting data and features.

Figure 9 Resizing the Image

```
private var imageRotationDegrees: Int = 0
private val tfImageProcessor by lazy {
    ImageProcessor.Builder()
        .add(ResizeOp(IMG_SIZE_X, IMG_SIZE_Y, ResizeOp.ResizeMethod.BILINEAR)) // Cambiar el tamaño
        .add(Rot90Op(-imageRotationDegrees / 90)) // El proxy de imagen que fluye se gira 90 grados
        .add(NormalizeOp(NORMALIZE_MEAN, NORMALIZE_STD)) // Relacionado con la normalización
        .build()
}
```

Source: Own Work

At this stage, in order to determine how the algorithm works to evaluate the result of the image analysis, the process of converting the image to a YUV format is carried out, then to an RGB bitmap, it is converted into tensorflowImage and finally it is passed to the tensorflowBuffer, so that the result of the analysis can be interpreted in the form of a list. This allows the detection to be more accurate since the model's inferences are carried out in this step.

Figure 10 YUVTo RgbConverter Class

```
class YuvToRgbConverter(context: Context) {
    private val rs = RenderScript.create(context)
    private val scriptYuvToRgb = ScriptIntrinsicYuvToRGB.create(rs, Element.U8_4(rs))

    private var pixelCount: Int = -1
    private lateinit var yuvBuffer: ByteArray
    private lateinit var inputAllocation: Allocation
    private lateinit var outputAllocation: Allocation
```

Source: Own Work

3.3. Interpretation and knowledge

Once the entire process of transformation and processing of the images is completed, the validation stage of the system is carried out, for this the result of the analysis is arranged in the form of a list to determine what the results will be from the training carried out as shown in image 11.

Figure 11 Detection process

```
// Convierta la imagen a YUV-> mapa de bits RGB-> tensorflowImage-> tensorflowBuffer,
// infiera y envíe el resultado como una lista
private fun detect(targetImage: Image): List<DetectionObject> {
    val targetBitmap = Bitmap.createBitmap(targetImage.width, targetImage.height, Bitmap.Config.ARGB_8888)
    yuvToRgbConverter.yuvToRgb(targetImage, targetBitmap) // conversion a rgb
    tfImageBuffer.load(targetBitmap)
    val tensorImage = tfImageProcessor.process(tfImageBuffer)

    //tflite Realización de inferencias en el modelo
    interpreter.runForMultipleInputsOutputs(arrayOf(tensorImage.buffer), outputMap)

    // Dar formato al resultado de la inferencia y devolverlo como una lista
    val detectedObjectList = arrayListOf<DetectionObject>()
    loop@ for (i in 0 until outputDetectionNum[0].toInt()) {
        val score = outputScores[0][i]
        val label = labels[outputLabels[0][i].toInt()]
        val boundingBox = RectF(
            outputBoundingBoxes[0][i][1] * resultViewSize.width,
            outputBoundingBoxes[0][i][0] * resultViewSize.height,
            outputBoundingBoxes[0][i][3] * resultViewSize.width,
            outputBoundingBoxes[0][i][2] * resultViewSize.height
        )
```

Source: Own Work

4. Results

Once the entire process of algorithm design, training and validation for each of the cob species was carried out, the results were obtained as shown in the table below. In the analysis of these results it is important to mention the type of validation that was used for the evaluation of the algorithm, in this case a hold out validation of 70% of samples for training and 30% of samples for testing was used, this data partition was performed 5 times and the accuracy shown is the average of these data. It is important to clarify that the experimentation is in an initial phase, so it is considered that in order to obtain better results it is necessary to increase the number of samples and the number of times of training to apply a cross-validation type.

In the same way, the result of 5 classes of cob species is considered, since the diseases that were previously explained are all included in a single category so that a simpler analysis of each of them is carried out.

Table 1 Accuracy of analysis

Species of cob	Precision
White Corn	0.87
Black Corn	0.89
Yellow corn	0.76
Pink Corn	0.72
Diseased corn	0.70

5. Conclusions

Based on the results presented, it can be concluded that the development of this system to classify mature corn cobs of different species is a complex issue, since the characteristics of each of the elements have to be evaluated and the conditions in which the photographs were taken and the different factors that influence them must also be considered. for example, the brightness, the background of the image, and the quality of the image.

The accuracy achieved by the algorithm in the best of cases reached 87% of correct classification, that is, at least 8 out of 10 ears will be classified according to the class to which they belong, however, this percentage is not enough so it is sought to have an accuracy of at least 90% classification, in order to reach this percentage, it is necessary to take the following actions:

- Expand the data set with which you are working to be able to do a more exhaustive training and thus make the system learn in a more effective way.
- Have better control of the environmental conditions in which photographs of the samples to be analyzed are taken.
- Try another type of validation to compare the results.
- Experiment with another algorithm and do an additional feature extraction process to compare the results and determine which algorithm works more accurately.

As a future work, it is planned to carry out the implementation of the physical mechanism that is responsible for classifying the cob species in real time through video analysis, thus achieving a better quality in the product and improving the separation times of the producers, since currently this task is carried out manually by a group of people who are hired only for this purpose.

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Variable	Descripción	Valor
V_V	Volumen de Venta	20000
P_V	Postura de venta	490.61
V_C	Volumen de Compra	20000
P_c	Postura de Compra	485.39
P^{Uh}	Precio último Hecho	491.61
V_o	Volumen Operado	1241979
P_u	Precio/Utilidad	0
P^{VL}	Precio/Valor Libro	0
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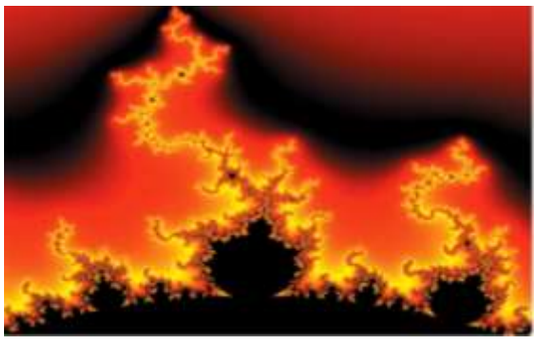

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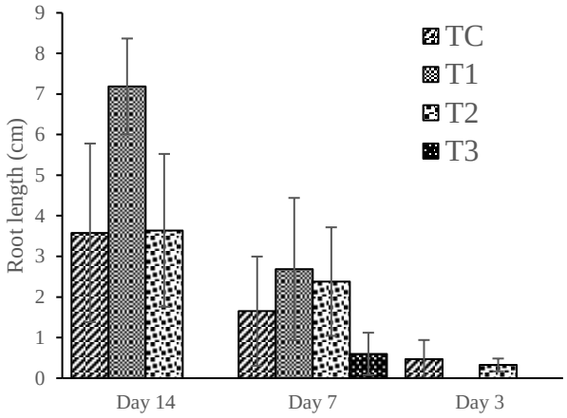

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ISBN 978-607-8948-20-8