EDUCACIÓN
SECRETARÍA DE EDUCACIÓN PÚBLICA

Instituto Politécnico Nacional
"La Técnica al Servicio de la Patria"

Research in Computing Science

ISSN: 1870-4069

Vol. 149 No. 7
July 2020

Research in Computing Science

Research in Computing Science, Año 19, Volumen 149, No. 7, julio de 2020, es una publicación mensual, editada por el Instituto Politécnico Nacional, a través del Centro de Investigación en Computación. Av. Juan de Dios Bátiz S/N, Esq. Av. Miguel Othon de Mendizábal, Col. Nueva Industrial Vallejo, C.P. 07738, Ciudad de México, Tel. 57 29 60 00, ext. 56571. https://www.rcs.cic.ipn.mx. Editor responsable: Dr. Grigori Sidorov. Reserva de Derechos al Uso Exclusivo del Título No. 04-2019-082310242100-203. ISSN: en trámite, ambos otorgados por el Instituto Politécnico Nacional de Derecho de Autor. Responsable de la última actualización de este número: el Centro de Investigación en Computación, Dr. Grigori Sidorov, Av. Juan de Dios Bátiz S/N, Esq. Av. Miguel Othon de Mendizábal, Col. Nueva Industrial Vallejo, C.P. 07738. Fecha de última modificación 01 de junio de 2020.

Research in Computing Science, year 19, Volume 149, No. 7, July 2020, is published monthly by the Center for Computing Research of IPN.

Volume 149(7)

Hybrid Intelligent Systems

Edgar Cossio
Carlos Alberto Ochoa Ortiz Zezzatti
José Alberto Hernández Aguilar
Julio César Ponce Gallegos (eds.)

Instituto Politécnico Nacional, Centro de Investigación en Computación
México 2020

ISSN: in process

Formerly ISSNs: 1870-4069, 1665-9899.

Instituto Politécnico Nacional (IPN)
Centro de Investigación en Computación (CIC)
Av. Juan de Dios Bátiz s/n esq. M. Othón de Mendizábal
Unidad Profesional "Adolfo López Mateos", Zacatenco
07738, México D.F., México

http://www.rcs.cic.ipn.mx
http://www.ipn.mx
http://www.cic.ipn.mx

Indexed in LATINDEX, DBLP and Periodica

Electronic edition

ISSN 1870-4069

Table of Contents

Page

ISSN 1870-4069

Application of Data Mining Techniques and Algorithms for the Detection of Breast Cancer

José E. Zagal Solano[1], Miguel A. Ruiz Jaimes[1], Juan J. Flores Sedano[1], Mayra L. Bonilla Monzón[1], Gloria V. Urquiza Flores[1], Marco A. Valerio Reyes[1], Jorge A. Ruiz Vanoye[2]

[1] Universidad Politécnica del Estado de Morelos, Mexico

[2] Universidad Politécnica de Pachuca, Mexico

{jzagal, mruiz, fsjo161286, bmmo16002, ufgo160163, vrmo161129}@upemor.edu.mx, jorge@ruizvanoye.com

Abstract. Breast cancer is a disease that affects a large part of world society. It is the most diagnosed cancer in women and its prevention although it is not impossible, it seems really difficult since its cause is unknown, so early detection is based on the patient's forecast. The most common form for detection is self-exploration, however this is only detected in more advanced stages. That is why during the article some data mining techniques are presented along with three artificial intelligence algorithms, using data obtained from the University Medical Center, Institute of Oncology, Ljubljana, Yugoslavia and using the algorithms it is possible to identify patients likely to suffer from this disease.

Keywords: Classification algorithms, cancer of mama, k-nn, naïve Bayes, decision trees, machine learning.

1 Introduction

Breast cancer is the most common among women in the world, it represents 16% of all female cancers. It is estimated that in 2004, 519,000 women died from breast cancer.

Survival rates vary greatly, from 80% or more in the USA, Sweden and Japan, approximately 60% in middle-income countries, to figures below 40% in low-income countries (Coleman et al., 2008). Low survival rates can be mainly explained by the lack of early detection programs [2].

In Mexico also since 2006, breast cancer is the leading cause of cancer death in women. An occurrence of 20,444 cases in women is estimated annually, with an incidence of 35.4 cases per 100,000 women. The entities with the highest mortality from breast cancer are Coahuila (24.2), Sonora (22.6) and Nuevo León 22.4) [3].

During this article we will describe the algorithms k-NN, decision trees and Naive Bayes that were used for the detection of patients with the possibility of suffering cancer

based on attributes such as tumor size, menopause, age, etc. Always looking for the highest accuracy range for each algorithm.

2 Related Works

There are currently several works focused on the detection of breast cancer, mainly those with a medical approach, which are based on the analysis of nutrition, lifestyle and interaction with the environment for the prevention of this cancer (Cuaya-Simbro et al., 2017).

On the other hand, in the area of computer science, studies have been carried out in which data mining is applied, which allow the evaluation of different models of prevention and diagnosis of breast cancer; These works make use of databases with information on patients with breast cancer and show the effectiveness of the models to detect or determine if a patient is at risk of suffering from this type of cancer, such as the following works.

1. Breast cancer detection using advanced data mining techniques with neural networks [3].
2. Design and implementation of fuzzy classification algorithms for breast cancer diagnosis [4].
3. Data mining as support in the diagnosis and treatment of breast cancer [6]. Also, there are other works that suggest and implement a solution such as the development of an application that supports the early detection of breast cancer, which is based on the capture of temporary data and its subsequent analysis.
4. Smart mobile application for breast cancer prevention [1].

3 Description of the Technique

3.1 K-NN Algorithm

The algorithm is based on the comparison of an unknown example with the training examples k that are the closest neighbors of the unknown example [7].

Classify a set of examples from others that we already know such as their class and we will call them training set. Calculate the distance of each example to classify with all the examples of the training set and classify the example according to the class to which those closest examples belong to. The variable k is used to determine how many of your closest examples of the training set have to be taken into account to classify it [9].

The main problem of the k-NN algorithm is to find the value of k with which a higher performance is obtained, a technique known as cross validation is generally used.

To calculate the distance, you can use different methods, such as Euclidean distance, Manhattan, Canberra or maximum distance [8].

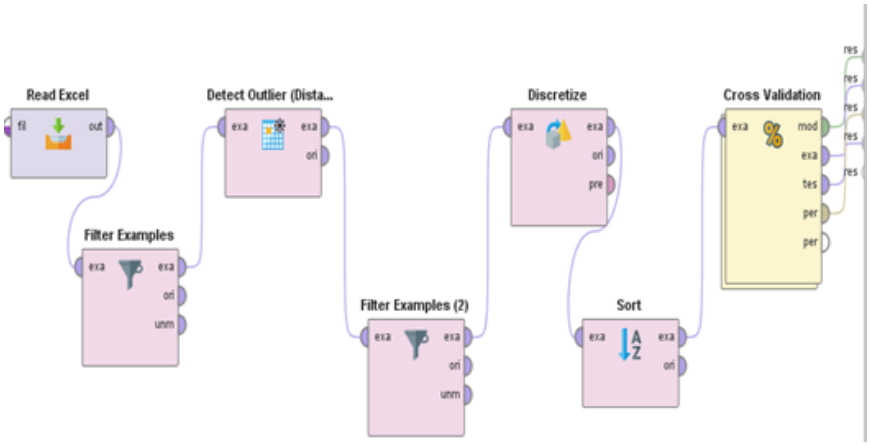


Fig. 1. Final configuration for the K-NN algorithm.

The advantages of this algorithm are the following:

1. **Not parametric**. It does not make explicit assumptions about the functional form of the data.
2. **Simple algorithm.** To explain, understand and interpret.
3. **High precision (relative).** High but not competitive against more supervised models.
4. **Insensitive to atypical values**. Accuracy may be affected by noise or irrelevant characteristics.

The disadvantages of this algorithm are:

1. **Instance based.** Do not explicitly learn a model. Memorize subsequent instances as knowledge for the prediction phase.
2. **Computationally expensive**. Store all training data.
3. **High memory requirement**. Store all (or almost all) training data[8].

The process that is implemented in Rapidminer to apply the algorithm is really very easy. The first step is to have a database, in this case there was a test database that was converted to Excel using the spoon tool. For this to be functional, an attribute such as "label" must be selected, which for this database is the "class" attribute. As shown in Figure 1, some operators were applied so that the accuracy range increased and better results were obtained.

When analyzing the data in the database, it was observed that, in certain attributes, there were missing data, so it was decided not to take them into account and eliminate them. For this, a filter was used as shown in Figure 2, where we can see that it is required that all data containing a "?" Be removed.

On the other hand, to avoid data that could affect the result by having extreme values, the operator that detects outliers was used. As shown in Figure 6, 10 neighbors and 2 outliers were chosen.

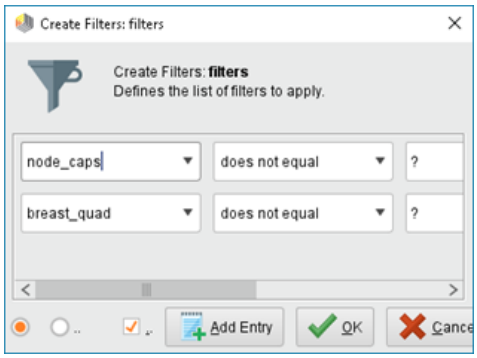


Fig. 2. Filter to eliminate missing data.

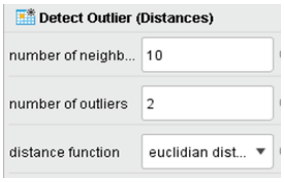


Fig. 3. Filter for outliers.

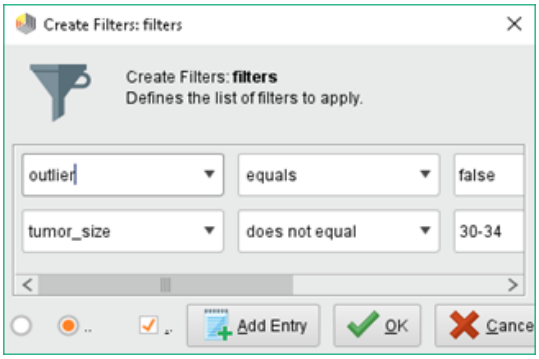


Fig. 4. Filter for outliers.

The following filter, as shown in Figure 4, is used to filter outliers detected in the previous operation, and also filters data whose tumor size is not equal to 30-34.

The next step is discretization, and this is through two bins, the result of this is increasingly ordered by the deg_malig attribute.

Finally, in the cross validation the KNN algorithm is added, which is connected with an “Apply model”, which in turn must be connected with a “Performance”, as is shown in Figure 5.

3.2 Decision Tree

It is a type of supervised learning algorithm (with a predefined target variable), which is used in classification problems. It works for input and output variables both

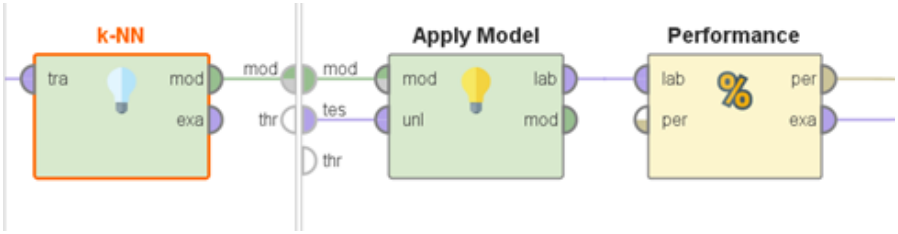


Fig. 5. Final configuration for the k-NN (Cross Validation).

categorical and continuous. They learn and train from given examples and predict for unseen circumstances [12].

Each node represents a division rule for a specific attribute. These can be expressed in a "Yes ... then ..." clause. Each data value or decision forms a clause, such that, for example, "if conditions 1, 2 and 3 are met, then result X will be the definitive result with certainty Y" [12].

The construction of new nodes is repeated until the detention criteria are met. A prediction for the class tag attribute is determined depending on most of the examples that reached this sheet during generation. Then, the tree model can be applied to the new examples using the Apply model operator.

Employing decision trees in machine learning has many advantages:

1. The cost of using the tree to predict the data decreases with each additional data point.
2. It works for numerical or categorical data.
3. The results are easy to explain.
4. Quantifiable reliability and can be tested.

But it also has some disadvantages:

1. When categorical data with multiple levels are presented, the results are in favor of attributes with more levels.
2. Calculations can become complex with numerous related results.
3. Conjunctions between nodes are limited to AND, while graphics support related nodes using OR.

For the application of this algorithm exactly the same database was used, and the final configuration can be seen in Figure 5. Because it is the same database, the missing data should be omitted, so a filter equal to the one shown in Figure 6 was added.

Similarly, it was decided to add a filter for data whose size of tumors were different from 30-34. The order was by this same attribute in decreasing form.

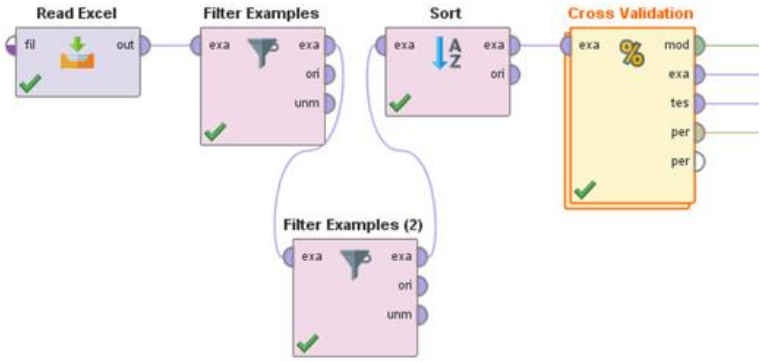


Fig. 6. Final configuration for the decision tree.

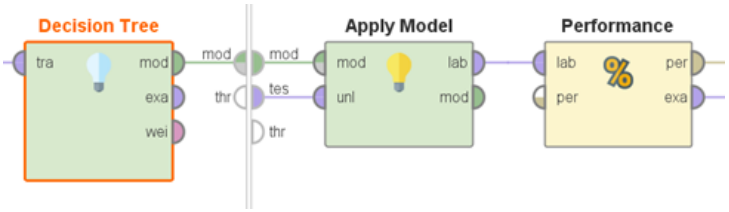


Fig. 7. Cross Validation for decision tree.

Finally, in the "Cross Validation" you must add the "Decision Tree", and for it to work you must apply a model and a performance, as is shown in Figure 7.

4 Problem Statement

4.1 Naive Bayes Classifier

Algorithm based on probabilities conditioned with known data. Its operation is based on calculating probabilities of known data and according to the results and a formula, it can calculate the probability that the entry is of one kind or another. It is based on Bayes' Theorem or conditional probability theorem. The probability that an event will occur having happened another that influences the previous one, is defined with the following formula:

$$P(C|W) = \frac{P(W|C)P(C)}{P(W)}. \quad [10]$$

Finally, the Naive Bayes method classifies document D into one of all existing classes using the formula:

$$Mejor\ clase = \boldsymbol{argmax}_{cjeC}\ P\ (Ci) \prod_{i=1}^{"} P(Wi\,|\,Ci)\,. \quad [11]$$

Advantages of this method are:

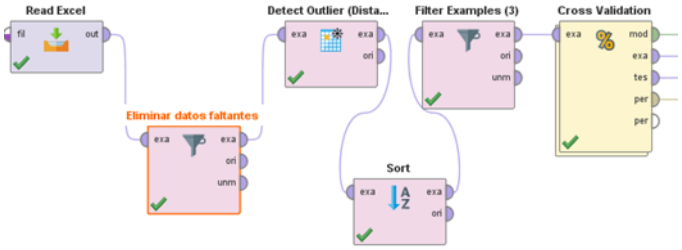


Fig. 8. Final configuration of the Naive Bayes algorithm.

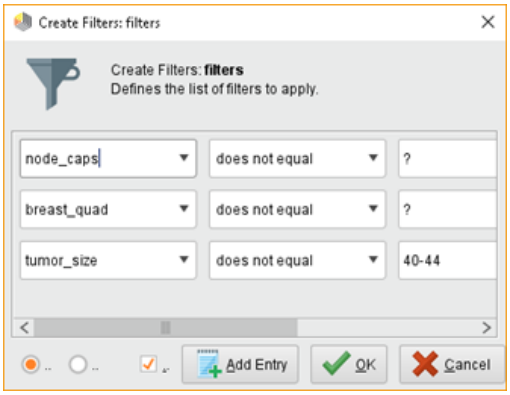


Fig. 9. Filter for missing data and tumor size.

1. Fast and simple to use.
2. Quick to train Quick to sort.
3. It is not sensitive to minor characteristics. Handles discrete and subjective information.
4. No problem handling continuous data streams.

Disadvantages are:

1. Not very accurate.
2. It assumes an independence of the characteristics [13].

The application of the Bayesian classifier is very similar to that of the other two. And the configuration is shown below in Figure 8.

The first step, as mentioned in the previous ones, is to filter the missing data, in addition there is added one more filter that is for the size of the tumor between 40-44 as seen in Figure 9.

On the other hand, it was decided to detect the outliers, and the number of neighbors chosen was 5 to have more proximity and the number of outliers was 2.

This time it was decided that the distance would be calculated with the “cosine distance” as shown in the following Figure 10.

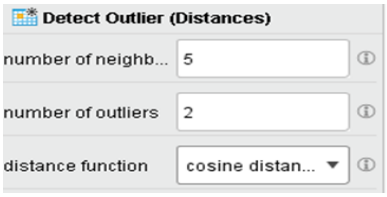


Fig. 10. Outliers Detection.

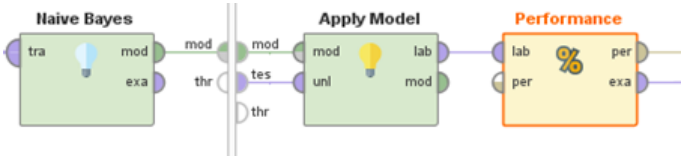


Fig. 11. Naive Bayes (Cross Validation).

Table 1. Data attributes in the database.

Data	
– Class	– Quadruple chest
– Age	– Node caps
– Menopause	– Deg – malig
– Tumor size	– Mama
– Nodes	– Irradiat

The sorting was given by the node_caps tribute in decreasing manner. The last filter was used for outliers.

As in the previous algorithms, in the cross validation the algorithm must be put, which for this case is the "Naive Bayes", applying a model and a performance for its correct operation, as is shown in Figure 11.

5 Analysis of Results

The data obtained as of July 11, 1988 have a number of 286 instances, each with 9 attributes and one attribute class, indicated below (Table 1).

Relevant information about the data set corresponds to 201 instances of the class: no recurrence and 85 instances of the class: recurrence, mentioning a range of precision of 4 systems tested with a result of 68% -73.5%. Subsequently, this data set was prepared to be processed and analyzed, submitting to the K-NN algorithms, decision tree and Bayesian classifier, using within the process operators to have the lowest number of data loss, with the main objective of obtaining the highest possible accuracy in the results of each.

The results obtained are presented below, in each process of the set of training instances.

accuracy: 76.16% +/- 3.92% (micro average: 76.17%)

	true no-recurrence-events	true recurrence-events	class precision
pred. no-recurrence-events	192	62	75.59%
pred. recurrence-events	4	19	82.61%
class recall	97.96%	23.46%	

Fig. 12. Precision of the K-NN algorithm.

accuracy: 77.27% +/- 6.43% (micro average: 77.27%)

	true no-recurrence-events	true recurrence-events	class precision
pred. no-recurrence-events	151	38	79.89%
pred. recurrence-events	12	19	61.29%
class recall	92.64%	33.33%	

Fig. 13. Precision of the Decision tree.

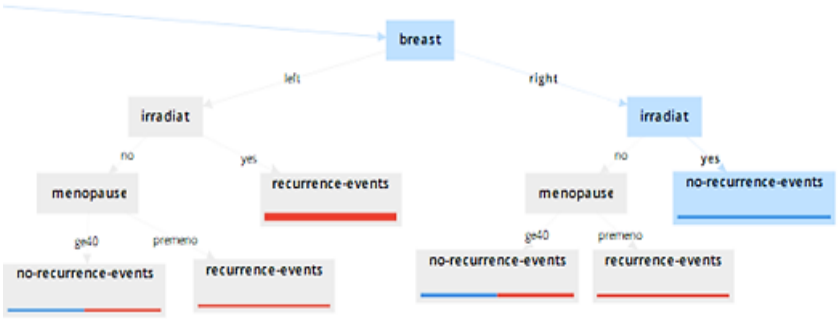


Fig. 14. Result of the Decision tree: Chest.

5.1 K-NN Algorithm

Accuracy result of 76.16%, with an amount of 192 data correctly classified in the "no-recurrence-events" class and 62 data not correctly classified. On the other hand, 19 correct data were classified in the "recurrence-events" class and only 4 were not classified well, as is shown in Figure 12. Exceeding the estimated accuracy of 2.66%, without the greatest loss of data.

5.2 Decision Tree

Accuracy result of 77.27%, obtaining 151 data classified correctly for the first class and 38 misplaced. And in the second class a total of 19 well-classified data and a total of 12 poorly classified, as is shown in Figure 13. Exceeding the estimated accuracy of 3.77%, without the greatest loss of data.

accuracy: 76.42% +/- 8.83% (micro average: 76.28%)

	true no-recurrence-events	true recurrence-events	class precision
pred. no-recurrence-events	149	31	82.78%
pred. recurrence-events	29	44	60.27%
class recall	83.71%	58.67%	

Fig.15. Precision of the Naive Bayes classifier.

The result of this algorithm obtains a graph in which a tree is represented, detailing each of the attributes of the instances, due to being extensive a brief example is shown identifying the attributes, chest, tumor size and quadruple chest. as is shown in Figure 14.

5.3 Naive Bayes Classifier

Distribution model for the tag attribute class:

1. Class without recurring events (0.704).
2. 9 distributions.
3. Class with recurrence events (0.296).
4. 9 distributions.

Accuracy result of 76.42% with 149 data classified correctly for the first class and only 31 data classified in a wrong place. In the second class, 44 data classified in the correct class and 29 in the incorrect class were obtained. The percentage rose 0.02% when changing Euclidean distance to Cosine, so this solution was chosen as the best, as it is shown in Figure 15. Exceeding the estimated accuracy of 2.92%, without the greatest loss of data.

6 Conclusions and Future Research

The development of this research obtained favorable results, by using software and its operators to deal with issues pertaining to data mining, implementing the knowledge acquired throughout the four-month period.

In addition, to understanding and acquiring the knowledge of data analysis, the importance of lost values within the training set was understood, since the loss of data or values have a significant impact on the results obtained, as well as the operators used influence, you should look for the most favorable accuracy percentage, stating that the data is treated properly and implement a smaller number of data lost in the training process.

In the future, learning about tools for data mining, such as those implemented for the development of this work, will allow for the ability to process a large number of instances and submit the set of training instances to the different algorithms they offer, to analyze issues as important as breast cancer, as well as focusing this analysis on the possibility of analyzing relevant information of all kinds, within a wide number of

examples, such as medicine, artificial intelligence, genetics, terrorism, as well as science and technology, etc.

Achieving such an in-depth analysis, will allows us in the future, to analyze patterns and obtain a high percentage of prediction in the events of such topics so relevant at present, not ruling out the possibility that, over the years, the algorithms and their set of training data can give solution to outstanding events in society within each of its areas.

References

1. Cuaya-Simbro, G., Ruíz-Hernández, E., Hernández-Hernández, L.Á., Lima-Luna, L.A.: Aplicación móvil inteligente para prevención de cáncer de mama. Revista de Ingeniería Tecnológica (2017)
2. WHO (World Health Organization). Obtenido de: Cáncer de mama: prevención y control (2016)
3. Ortiz-Murillo, J.A., Celaya-Padilla, J.M., López-Hernández, Y.: Detección de cáncer de mama usando técnicas avanzadas. In: Proccedings of the ISSSD (2016)
4. Secretaria de Salud, Gobierno de México. Obtenido de Programa de Acción Específico Prevención y Control del Cáncer de la Mujer 2013-2018 (2015)
5. De la Puente-Marrugo, Y.M., Milena-Rizzo D.R.: Diseño e implementación de algoritmos de clasificación borrosa para diagnóstico de cáncer de mama. Corporación Universitaria Rafael Nuñez (2006)
6. López-Portillo, C.C.: Minería de datos como soporte en el diagnóstico y tratamiento del cáncer de mama. Centro de Investigación Científica y de Educación Superior de Ensenada (2006)
7. Berástegui-Arbeloa, G.: Implementación del algoritmo de los k vecinos más cercanos y estimación del mejor valor local para su cálculo. Pamplona (2018)
8. González, L.: Obtenido de aprendizaje supervisado: K-Nearest Neighbors: http://ligdigonzalez.com/aprendizaje-supervisado-k-nearest-neighbors/ (2018)
9. Rapidminer: https://docs.rapidminer.com/latest/studio/operators/modeling/predictive/lazy/k_nn.html (2006)
10. Blogspot: Algoritmos de Mineria de datos: http://algoritmosmineriadatos.blogspot.com/2009/12/algoritmo-naive-bayes.html (2009)
11. Lucidchart: Que es un diagrama de árbol de decisión. https://www.lucidchart.com/pages/es/que-es-un-diagrama-de-arbol-de-decision (2006)
12. Sloth's Lab: http://www.slothslab.com/python/2015/12/03/clasificador-bayesiano-ingenuo-python.html (2015)

ISSN 1870-4069

JaguarEye: Facial Recognition Web Service for Student Access to ITSCH

Yotziri Paloma Pérez Rios, Marco Julio Franco Mora,
José Iraic Alcántar Alcántar, Mariela Chávez Marcial

Instituto Tecnológico Superior de Ciudad Hidalgo,
Mexico

{ypelekai, darkmarksdoe}@gmail.com,
jiraic@itsch.edu.mx, marielawiroma@hotmail.com

Abstract. Biometric systems play a fundamental role in the processes of recognition of people, on which public security policies are based [5], so within the institutions, security is part of the main point to be addressed for improvement in the quality of services than they offer. The educational institutions of the State of Michoacán, México, nowadays have systems focused on treating this problem through methods that may be ineffective, which presents a clear disadvantage to institutions that handle biometric technologies. The use of biometric systems makes it easier for educational institutions to compete on innovation issues, while creating a better user experience, giving rise to a set of data that can determine the behavior of customers and the institutions itself. JaguarEye emerges as a tool that provides solutions focused on security, when allowing access to students belonging to the ITSCH, making a facial recognition to them, thus avoiding the procedures of generation of student credentials.

Keywords: Machine learning, biometric systems, security, openCV.

1 Introduction

Our society is connected electronically and is increasingly mobile. Representations of our identity as secret codes and cards are not completely reliable to establish the identity of people. During the last years.

Facial recognition has become one of the most studied applications in fields such as biometrics, image processing or pattern recognition.

The main reasons for its use is to promote the creation of systems or applications focused on security and surveillance since they form a very powerful tool for identity management. This is because the biometric features cannot be shared or lost and intrinsically represent the bodily forms of the individual it identifies.

The most important markets for this application are financial, health and government, although in principle any business sector is capable of using it. As for physical access to facilities, the objective is to control the identity of the individuals who access, leave or remain in an area, typically a building or a room. Biometric

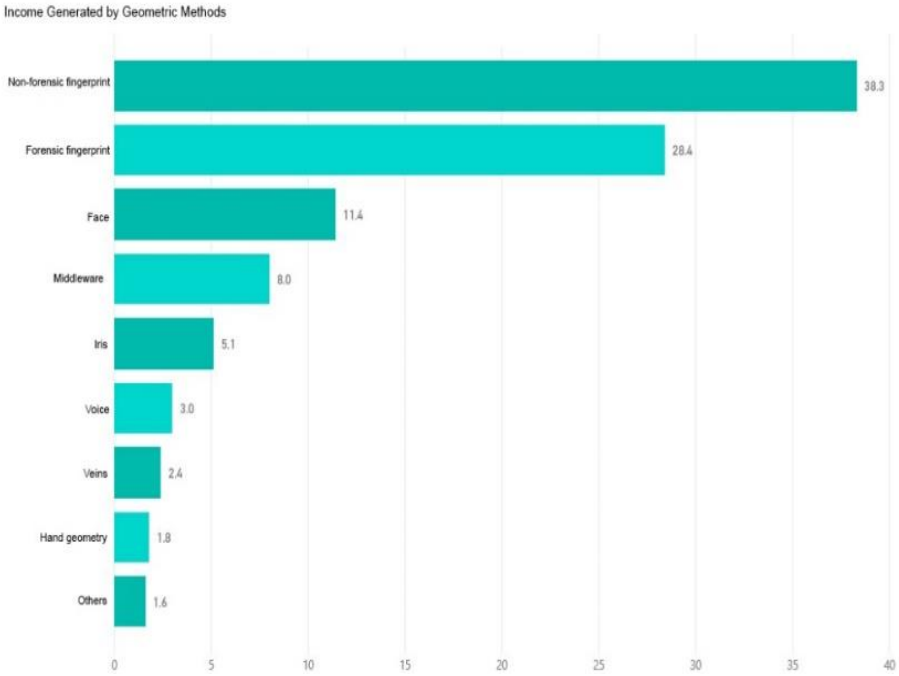


Fig. 1. Percentage of income generated by the different biometric methods.

recognition complements or replaces keys and identification cards, and is often used in certain sensitive rooms or facilities [11], thus indicating the magnitude of the impulse to be used by public and private companies.

2 Analysis and Diagnosis of the Current Situation

The implementation of systems that apply this technology are currently booming with the intention of replacing or optimizing ambiguous tasks related to the identification of people for physical entry to establishments, specifying the above, it should be noted that making use of this type of technology facilitates the manipulation of data in a dynamic way. These types of systems can be used in educational institutions in order to expedite the process of identifying students belonging to it at the time of entry, as a result, the objective of offering more comfortable, safer and faster systems can be achieved.

The increasingly widespread use of biometric technologies has meant that system prices have fallen, components have been miniaturized and more reliable.

And all these facts cause this technology to be used even more (see Figure 1). Figure 1 shows the distribution of biometric features with respect to the income they generate.

The fingerprint is the oldest biometric feature and remains the one that generates the most income. The next biometric feature is the face, which is already a long distance away.

Every day we ask ourselves many questions related to the identity of people. Is this person authorized to enter this building or institution? Can this person be given this information? Is this person wanted for a crime?

In addition to our teams face and solve the same problem: verify if you are who you say you are. The most used tool to get it is the password. However, this is a method that can be stolen or forgotten. Due to the problems that arise with the access codes, it has been essential to develop other systems to verify the identity of the users. The biggest difference between an ordinary password system and a biometric system is that the original sample and the sample to verify never match perfectly. To solve the problem, biometric systems attempt to clean the scanned samples of any element that interferes with the verification process, using only easily recognizable features. However, this "skeleton" must match the original according to mathematical parameters. For a medium security system, a margin of error of a stranger for every 10,000 attempts and the blocking of the legitimate user every 50 cases is assumed as normal. In unstable external environments, light and vibration increase the margin of error and, for this reason, Android's facial recognition, for example, fails in 30 or 40% of cases.

Facial recognition systems can rarely distinguish a real face from a photo. On the other hand, when we use a mechanism with these characteristics, it is really demanding with the lighting conditions and the environment in general, so it will not be necessary to configure additional systems.

In response to providing an agile tool for educational institutions, a web service system called JaguarEye was created, which on this occasion fulfills the specific task of optimizing physical access control for ITSCH students using facial recognition technology, replacing in this way the traditional method of presenting student credentials at the time of entry, in addition to discarding the fact of loss, theft or lost of this and with it the process and properly the payment to generate it again.

3 Research Methodology

3.1 Methodology for Specification of Requirements

Biometric technology is a system that consists of six subsystems: data collection, data transmission, signal processing, data storage, decision making, evaluation and performance [13].

For a certain reason, the development of a web service system integrated to this technology requires an in-depth study of the What? and for what?, it is desired to carry out, with this considered as the principle of innovation the CMMI quality model [2].

To comply with the aforementioned, it was decided to use the agile development model SCRUM [1], since this type of model allows the option of collaborating within reduced development teams (4 members in this case) responsible for development, algorithm, system software logic and engineering, together with a team outside the

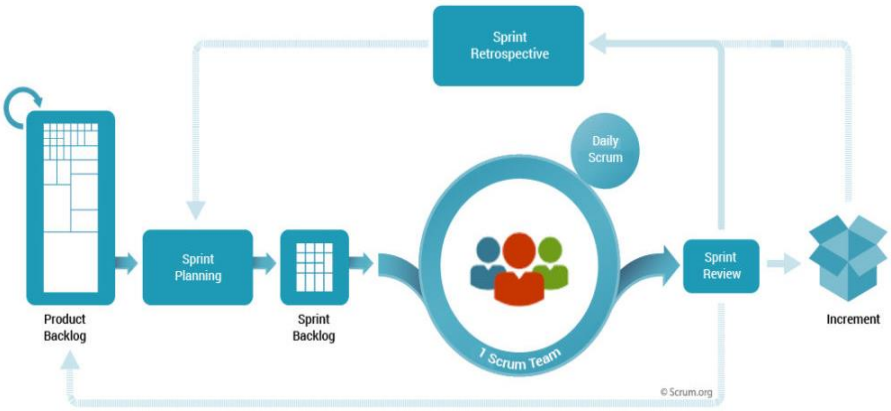


Fig. 2. SCRUM methodology [1].

development area, made up of professionals in the areas of graphic design, user experience and system analysis, with both teams approved in one, the system could be successfully developed without major inconvenience (see Figure 2).

The CMMI Dev v1.3 Model explains the following: "In Agile Environments, the needs and ideas of the client are iteratively educated, elaborated, analyzed and validated. The requirements are documented on forms such as; user history, scenarios, use cases, product backlog and iteration results (code in development in the case of software). What requirements will be addressed in a given iteration are determined by a risk assessment and by the priorities associated with the requirements that are left in the Product Backlog of the product. What details of the requirements (and other artifacts) to be documented are determined by the need for coordination (between team members, teams and subsequent iterations) and the risk of losing what has been learned. When the customer is on the team, there may still be a need to wait for customer and product documentation to allow multiple solutions to be explored.

While the solution arises, the responsibilities of the derived requirements are assigned to the appropriate teams" [3], for this reason, the implementation of agile and simple acquisition techniques is recommended for those development teams that require it.

3.2 Software Requirement Survey Techniques

The Obtaining or Collection of Requirements, is characterized by the identification of Stakeholders, who are all persons interested in the system or in any of its processes for a particular need. The needs of the users with the systems and their expectations are also known.

In the same way, the requirements found from the analyst's perspectives are identified and formalized based on the information collected [9].

In order to provide a quality system focused on security when entering the ITSCH and generate a more user-friendly user experience, it is suggested to use the techniques

listed below, with the objective of achieving results based on creativity and the conceptualization of ideas that generate added value in technological models for modern security systems.

3.2.1 Workshops

It is an effective technique to obtain information quickly between different points of view:

1. It is advisable to have an agenda of activities already predefined of the points to be dealt with in each workshop, in addition to the preselected list of the participants, which will influence in obtaining effective meetings.
2. Make use of a neutral facilitator that performs the function of ensuring that the objectives of the session are met, directing and guiding the participants through proposed dynamics and activities [8].
3. Use visual management (panels, posters, diagrams), and available spaces. Which will help to maintain interest in the session [8].

This technique can be combined in turn with others such as interviews and questionnaires.

3.2.2 Observation

This technique can be combined in turn with others such as interviews and questionnaires:

1. The observation is based on directly identifying the tasks that users usually perform in the organization. The practices of the organization that are carried out with high frequency or that present some complexity in its execution must be selected [10].
2. This technique is based on the observation of physical information of documents in which only specific explanations of the Stakeholders will be requested by the analyst [9].
3. It can be of two types, passive or active.
4. In passive observation, the observer does not ask questions, being limited only to taking notes and not interfering with the normal performance of operations.
5. In active observation, the observer can talk with the user [4].

3.2.3 Brainstorming

It is a group technique to generate original ideas within a relaxed environment:

1. Technique used in various areas and basically based on stimulating the creativity of the team participating in a project.

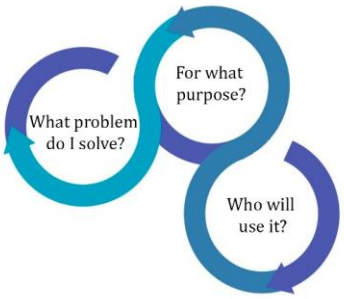


Fig. 3. Purpose delimitation model.

2. Everyone must contribute ideas, which should not be prosecuted until the end of the process, when no one else brings new ideas [7].
3. The technique allows generating different views of the problem, especially at the beginning of the phase of taking requirements, where the views of the problem are still diffuse [6].

3.2.4 Existing Systems

It is a technique used in requirements management. It consists in the search and analysis of systems that have been developed and that have characteristics similar to those of the proposed system:

1. From the documents of requirements of old systems, information can be obtained regarding the domain of the problem, characteristics, turn, nature of the institution, the type of user interfaces can be defined. It is also useful for validating new information that is extracted, information that has probably been omitted [6].

3.3 Proposed Model

In previous lines, the axes that supported the development of the system were mentioned: What? and for what? Which represents a challenge when generating the means for the development and training of requirements, especially in a security system focused on facial recognition that is sought to be implemented within a community where this type of technology is not the determining factor in business models, representing the challenge when generating a new level of innovation, creativity, disruptivity and that they are optimal candidates to generate a new experience scheme in addition to facilitating the observation of the behavior of the agents that are part of the user experience. In the case of the system, the following models were generated that met the expectations of the project see Figure 3.

The fulfillment of the For what?, was given by implementing a model where the needs of the institution are functional and satisfied through the use of the student security system. The points to be resolved by using this method are the validity and verification of the end user, as well as the capacity for technological adoption by the

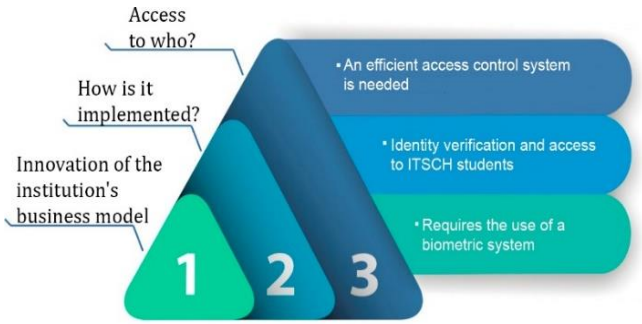


Fig. 4. Model for what? (Verification and Validation).

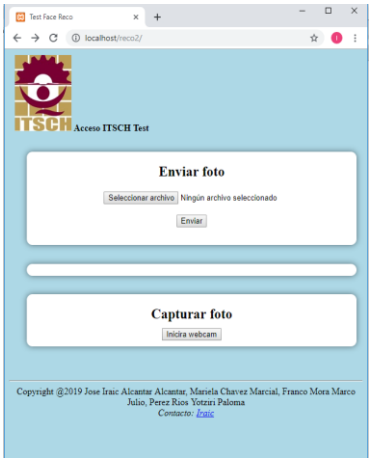


Fig. 5. Web test interface.

institution; where the safety factor plays the most important role in order to assimilate the idea that a profitable, sustainable and scalable facial recognition system to new technologies facilitate the empowerment and quality of service of the institution (see Figure 4).

The key in this product is to ask if the objective set by the users, institution and the development team is satisfactory for all those involved, generating a harmony between the security, technological and commercial aspects.

When talking about the development of the system, technologies were used for the creation of the web service that allowed to speed up the process in order to be able to focus on the conceptualization and engineering of project requirements, therefore technologies such as OpenCV (open source library owned by Intel), PyCharm and Visual Studio Code for the coding of the project, with respect to programming languages Python was used.

MySQL was adopted as a backend system, which is a real-time relational database system, multi-threaded work, API's availability, great level of security, among other services that were not used at the moment.

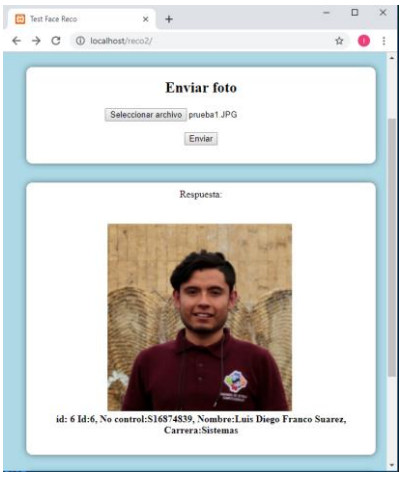


Fig. 6. Recognized face.

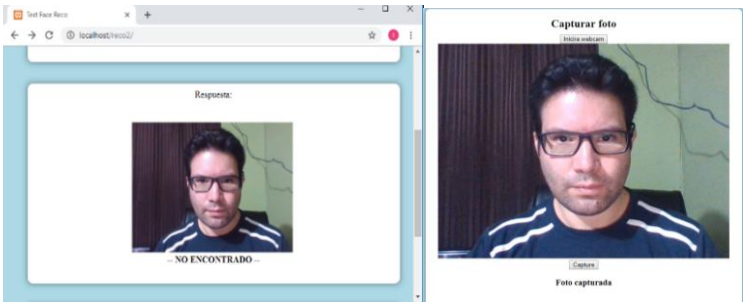


Fig. 7. Unrecognized face.

4 Results

To carry out the tests, a simple web interface was developed, which allows both uploading photographs and capturing from the webcam, which is shown in the following figure (see Figure 5).

The initial tests were carried out with 17 photographs of different students, of which a training was carried out and the characteristics (sample points of the face) were uploaded to a file, subsequently tests were carried out with photos in different positions.

The detection was successfully detected in approximately seventy percent, however, in some situations the faces were not recognized, mainly due to the amount of light on the face and the direction of the shot, which must be front to increase accuracy (see Figure 6-7).

The recognition time is very fast, because the most relevant data of the faces are in a single file, so when applying it to the identification for access the times will be relatively short, however, training will have to be done every time it is required to allow recognition of new people.

Fig. 8. Haar type features.

4.1 Biometric System Performance

By using the Viola-Jones algorithm we focus on performing facial recognition; algorithm that is based on three concepts:

The first of these is the "integral image" [15] that allows the "haar" characteristics used by this detector to be calculated very quickly. This facial detection algorithm will look for specific characteristics that are common in a human face. These "features" are basically black and white rectangles (see Figure 8).

Paul Viola and Michael Jones used the term "Integral Image" within their object detection structure, to refer to a fast and efficient method to calculate the sum of pixel values in any rectangular area of a given image.

The second is a machine learning algorithm, "Adaboost", which selects only the important characteristics of the whole set. The main idea is to combine the output of some weak classifiers in a weighted sum, thus creating a strong final classifier, whose error is exponentially zero.

The third concept is the creation of a “cascade” structure, that is, the combination of complex classifiers, which rejects the background of the input image by spending more calculation time in the areas that may contain the object of interest. The Viola-Jones detector uses the Adaboost technique, but organize the classifiers as a cascade of rejection nodes. Only the candidate who manages to cross the entire waterfall will be classified as a face. In this way the computational cost is significantly reduced [14].

4.2 Algorithm Used for Facial Recognition

The LBPH (Local Binary Patterns Histograms) algorithm was used, where the main idea of the LBPH is not to look at the entire image as a vector, but to describe only local characteristics of an object. The basic idea of local binary patterns is to summarize the local structure in an image by comparing each pixel with its neighbors.

Taking a pixel as the center, if the intensity of the central pixel is greater than or equal to its neighbor, then it will be denoted with 1 and 0 if not. In the end we will end with a binary number for each pixel. So with 8 surrounding pixels we will have 2^8 possible combinations, called local binary patterns or LBP codes (see Figure 9) [16].

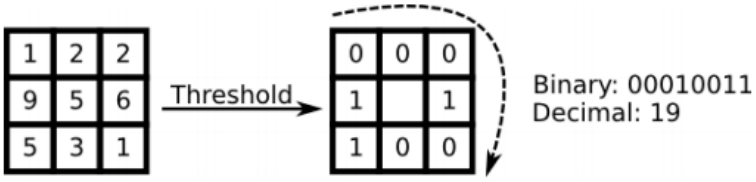


Fig. 9. LBP code.

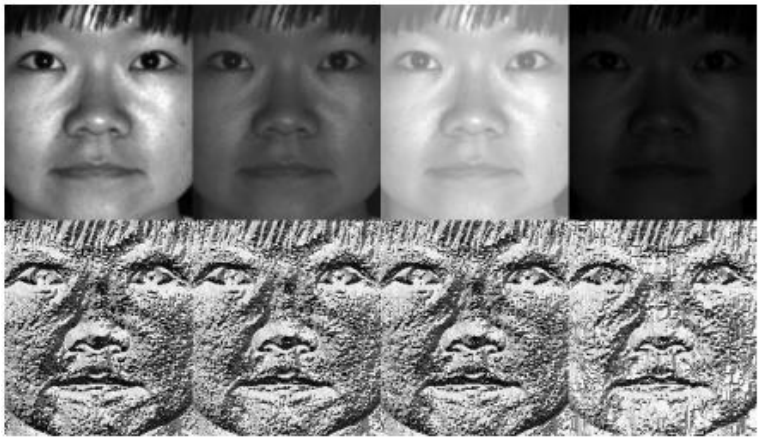


Fig. 10. LBP transformations.

By definition, the LBP operator is robust against monotonic grayscale transformations. An image can be represented in different ways, be it grayscale, filters such as cyan, magenta. In the case of grayscale, each pixel in the image is represented as a number from 0 to 255, the number is saved in one byte, where 0 represents the color black and 255 the color white. Grayscale is used in computational vision to facilitate the treatment of images, when color is not relevant. We can easily verify this by looking at the LBP image of an artificially modified image (see Figure 10).

4.3 Machine Learning Performance

At the beginning there was a series of sample images taken from The Yale Face Database [17] to later use photographs of students belonging to the ITSCH, which had to be the same size to match the dimensional spaces.

That is, for facial recognition to work, it must be divided into two phases, one for training and one for recognition. In the first phase, the training phase, images were collected and their data was extracted in order to apply the algorithms.

To do this every time an image is collected, we will detect the face in it, and a new image containing the face will be saved in a grayscale and resized to a specific size so that they are all the same.

But you don't have to analyze all the images every time you want to make the recognition. When we apply the algorithm to the images, the eigenvalues and the eigenvectors of each one.

They can be saved in an XML / YML file. We will change this file when there are new images. In the second phase, the one corresponding to the recognition phase, a new image will be collected, the face will be detected and it will be grayscale.

Then with the methods that OpenCV provides us, the data extracted from this new image will be compared with those saved in the XML / YML file and you must tell us which image of the training has the greatest coincidence, once this is confirmed, take the id assigned during the training and link to the database to obtain the student's data [14].

5 Discussion

With the development of the system, it allowed, among other things, the following:

1. Identification of students and ITSCH staff.
2. Precave in waste of time for the end user when entering the institution.
3. Bypass procedures in the generation of new student credentials in case of theft or loss.

6 Future Work

With the advantage of mastery of facial recognition and its background, it is suggested to expand the system to new areas within the institution, for example, in order to contemplate a vehicle entry and exit registration by both students and teachers and managers, take the initiative to propose and carry out a security system focused on the aforementioned, preventing any incidents, theft or unauthorized entry of vehicles to the Higher Technological Institute of Ciudad Hidalgo, thus contributing to the community by offering a comfortable system, stable and reliable for the end user.

In the final idea we have the proposal to mount the system on the physical server of the institution that runs on a Linux distribution (Cent Os) offering an expert system for the analysis of user behavior (inputs, outputs, schedules).

Likewise, parallel coding will be analyzed and compared by implementing libraries such as TensorFlow + Keras, CUDA, OpenCL, to look for the best performance when doing facial recognition.

If necessary, to avoid server stress, it’s planned to mount it on hardware architectures such as Intel *Movidius* Neural Compute Stick *(NCS),* Nvidia Jetson, including RaspBerry Pie, always looking for the best possible performance.

References

1. Schwaber, K., Sutherland, J.: The Scrum Guide™ (2017)

2. International Institute of Business Analysis: Babok a guide to the business analysis body of knowledge, IIBA (2015)
3. Equipo del Producto CMMI: CMMI para Desarrollo, Versión 1.3 CMMI DEV, V1.3, Software Engineering Institute (2010)
4. Sarmiento, P., Hernández, D.C.: Metodología para la optimización de los procesos de recolección de información y análisis en la etapa de especificación de requerimientos de software (2017)
5. Etchart, G., Luna, L., Leal, C., Benedetto, M., Alvez, C.: Sistemas de reconocimiento biométricos, importancia del uso de estándares en entes estatales. Facultad de Ciencias de la Administración (2011)
6. Gallardo, J.A., Meneses, C.J.: Un modelo de proceso para educación de requisitos en proyectos de data mining. In: VI Jornadas Iberoamericanas de Ingeniería del Software e Ingeniería del Conocimiento (JIISIC'07) (2007)
7. Gause, D.C., Weinberg, G.M.: Exploring requirements: quality before design. Dorset House (1989)
8. Rodríguez, M.: Inception workshop: Cómo abordar un proyecto ágil (2016)
9. Mera, C.A.: Guía para estructurar con stakeholders en el proceso de ingeniería. Pontificia Universidad Javeriana (2010)
10. Atará, C.A., Liberato, M.C., Sierra, D.A., Vargas, A.J.: Key concepts for the management of technological projects (2016)
11. Ortega, J., Fernández, F.A.: Biometría y seguridad. Grupo de Reconocimiento Biométrico-ATVS (2008)
12. Serratosa, F.: La biometría para la identificación de personas. Universidad Oberta de Catalunya (2012)
13. Luzmilla, M.G., Gonzáles, J.C., Contreras W., Yañez, C.: Tecnologías biométricas aplicadas a la seguridad en las organizaciones. Revista de Ingeniería de Sistemas e Informática, 6(2) (2009)
14. Santamaria, F.J.: Módulo biométrico de imágenes para reconocimiento facial de los usuarios. Universidad de Rioja (2017)
15. Viola, P., Jones, M.: Robust real-time object detection. In: International Workshop on Statistical and Computational Theories of Vision, Modeling Learning, Computing and Sampling (2001)
16. Delbiaggio, N.: A comparison of facial recognition's algorithms. Haaga-Helia University of Applied Sciences (2017)
17. Yale University: Computer Science. https://cvc.cs.yale.edu (2006)

ISSN 1870-4069

Characterization of Dating in University Students through Grouping Techniques

María Arely López Garrido[1], Erika Yunuen Morales Mateos[1], Diana López Hernández[2], María Isabel González Hernández[3], Carolina González Constantino[2], José Alberto Hernández Aguilar[4], Carlos Alberto Ochoa Ortiz[5]

[1] Universidad Juárez Autónoma de Tabasco Cunduacán, Mexico

[2] Universidad Juárez Autónoma de Tabasco Villahermosa, Mexico

[3] Empresa Consultoría Género y Desarrollo, Mexico

[4] Universidad Autónoma del Estado de Morelos, Mexico

[5] Universidad Autónoma de Ciudad Juárez, Mexico

{arely.lopez,erika.morales}@ujat.mx, {dianalphe, isago73}@gmail.com, jose_hernandez@uaem.mx, alberto.ochoa@uacj.mx

Abstract. The present investigation has the purpose of knowing if in the relations of dating in students of a university of the south of Mexico present situations of violence, to be able to identify them and establish plans and programs that help to diminish them; as well as to characterize the types of violence in dating relationships. An online questionnaire was applied in which one of the sections is about dating, the descriptive clustering technique of data mining was applied to create groups with the characteristics of dating relationships in terms of what they would most allow, that they seek and what situations of violence they have lived within their dating. Four groups were formed, two formed by men and two by women, in which only one, formed by women from the Architecture degree, presented the situation of prohibiting and monitoring work or school friendships. It is concluded that it is necessary to conduct these types of studies in other faculties to also characterize these relationships in dating among students and implement actions according to the situations they present.

Keywords: Dating, data mining, grouping, violence.

1 Introduction

The Constitution of the World Health Organization establishes that health is a complete state of physical, mental and social well-being combined with this principle, the Universidad Juárez Autónoma de Tabasco in its 2016-2020 Institutional Development Plan establishes itself a promoter of health to favor the overcoming of the individual in all its human dimensions [1], this study is carried out with the objective of knowing the characteristics of their relationships such as what they would most allow and what they seek in their relationship and if there is some kind of violence in dating relationships; with the purpose of developing plans and programs to prevent and reduce situations of violence.

There have been several studies about dating violence. One of them was to know the factors and variables associated with this phenomenon, for this a questionnaire was applied to 376 students of different careers; they conclude that the factors that can affect situations of Violence in dating relationships are low self-esteem, parenting style. It is also stated that there are risk situations that raise the probability of present or future physical or emotional violent behaviors [2].

At the UAEM Zumpango University Center of the Autonomous University of the State of Mexico, an investigation was carried out to identify if there was violence in dating relationships among students, the sample consisted of 100 students, the instrument applied measured violence in four areas: economic , psychological, physical and sexual. As a result, they obtained that psychological violence shows in 92% in the immediate previous or current relationships. They point out that psychological violence is usually combined with some other type of violence [3].

At the University of Salamanca, a study was carried out to verify the relationship of sexist attitudes variables in the appearance and maintenance of violent behavior in couples and in this way to design prevention and intervention plans. The sample was composed of students from different careers, between the ages of 18 and 36 who had or had a relationship; the results showed that men report having committed more sexual aggressions and women more emotional verbal aggressions and there are no significant differences in the practice of physical aggressions. They conclude that it is necessary to investigate about ambivalent sexism towards men, more investigations of bidirectional violence in relationships of young people for the understanding, prevention and intervention in violence of young couples [4].

Another study to analyze the occurrence of aggressive behaviors in the dating of university students, was carried out at the Universidad de los Andes, in Mérida, Venezuela. They used Neidig's (1986) Modified Conflict Tactics Scale (M-CTS) instrument on psychological and physical aggression / victimization; which applied to 616 young people and their respective partners. The results indicate that the predominant tendency is psychological, reciprocal aggression, in relation to the gender perspective the indicators behave statistically the same in men and women, there is a significant difference in the prevalence of victimization due to mild physical abuse, it is men who suffer most from this type of abuse and women use physical and psychological aggression more frequently [5]. Other previous works have been developed using other techniques, such as association rules, GGE Biplots and Star Graphics [6-7].

2 Materials and Methods

The methodology used in the present study is qualitative and descriptive because it seeks to specify properties, characteristics and profile of groups [8]. In this case, violence in the dating of university students will be described by means of the data mining technique of the grouping with the objective of subsequently developing and implementing strategies to promote self-improvement, health and physical integrity [1]. The study population are the students of a university in southern Mexico of the Faculty of Engineering and Architecture enrolled in the August 2018 - January 2019 school period, which were 3,498. The sample was for non-probabilistic convenience, 574 students were chosen who had a year studied at the university, for this investigation 218 data of students and students who answered they currently have a girlfriend or boyfriend were selected.

2.1 Model KDD

Four variables were used to know the reasons why university students selected their careers, later these variables were related to student engagement. These four variables of the choice of studies are: the educational value, academic quality of the career, aptitudes for studies and the possibility of work. For this, four questions that measure these variables were taken as a basis and are integrated in an answer where 0 means nothing, 2 equals very little, 3 means little, 4 equals medium, 5 corresponds to enough, and 6 means a lot [10]:

- Integration and data collection: The sources of information that could be useful are identified and selected and their origin is determined. Then all the data is transformed to a common format, inconsistency in the data is eliminated, the data considered interesting is explored and identified.
- Selection, cleaning and transformation: The data is reviewed, the incorrect data is corrected or deleted, and it is determined the data or attribute relevant to the investigation.
- Data mining: In this phase the method, model and algorithm of the data mining to be used is selected and applied.
- Evaluation and interpretation: Evaluation and analysis of the obtained models, which may involve returning to the previous phases.
- Dissemination: The new knowledge is used and shared to potential users.

2.2 Data Mining

Data mining is the extraction of knowledge of large amounts of information using specialized techniques supported by technology and information technology; it involves the application of specialized techniques for the discovery of knowledge in large amounts of data to analyze behaviors, patterns, trends and associations [10]. According to Hernández, Ramírez and Ferri [11], data mining is understood as the process of extracting useful and understandable knowledge, from large amounts of data

stored in different formats. This knowledge can follow two types of models: Predictive or Descriptive.

Predictive models attempt to estimate future or unknown values from variables or fields in the database. Descriptive models identify patterns that explain or summarize data and serve to explore their properties. In this investigation, the descriptive clustering technic will be used [11].

2.3 Clustering

Clustering is a descriptive task of data mining that involves analyzing data and grouping it so that the elements of one group are similar with each other and very different from the objects of the other groups [11].

One of the techniques for clustering is the K means algorithm, this is a proximity-based method, it is based on a certain number of prototypes and a set of examples to be grouped, without labeling. K means places prototypes or centers in space, and thus includes data belonging to the same prototype with similar characteristics. The procedure of K means is as follows [11]:

- For each example x_k, the closest prototype A_g is calculated and included in the list of examples of that prototype.
- After having placed all the examples, each prototype A_k will have a set of data that it represents.
- The prototype moves towards the center of mass of the set it represents.
- Repeat the procedure until the prototypes no longer move.

2.4 Weka Software

WEKA (Waikato Environment for Knowledge Analysis) is an open source data mining software issued under the GNU General Public License is developed in Java. It is composed of a set of open source packages, including tools for preprocessing, classification, grouping, association and visualization. It includes a graphical interface that facilitates its use [12]. This software was selected to apply the grouping technique.

3 Development of Data Analysis to Obtain Clusters of Violence in Dating

The data set of this research consists of 218 students, of which 91 are women and 127 are men, from the Faculty of Engineering and Architecture of a university in southern Mexico, after applying online surveys to obtain general data and violence in dating. The sample has a minimum age of 18 years of age and a maximum age of 33, the average is 20,794 years of age and the standard deviation is 2,125, as for who solves the students' tuition 49% is the father, 22% both parents, 21% the mother, 9.70% the same student supports their tuition. 60.55% of the couples are dedicated to study, 20.64% work and 15.60% of the couples are dedicated to study and work.

Table 1. Characteristics of the population study sample.

Variable	Woman Yes	No	Man No	No
Kisses and Hugs	83	8	93	34
Caresses without Sexual intercourse	20	71	41	86
Sexual Intercourse	25	66	58	69

Table 2. Frequencies that seek in a dating relationship. Own elaboration.

Variable	Woman Yes	No	Man Yes	No
Preparing for starting a family	26	65	48	79
A way to getting to know someone before marriage	13	78	39	88
Somebody to have sexual a relationship with	13	78	39	88
Somebody to love and share mutual feelings	70	21	100	27
Company to go out and have fun	29	62	63	64

Table 3. Frequencies of aspects of violence presented in dating. Own elaboration.

Variable	Woman Yes	No	Man Yes	No
Insults and threatens of physical violence	8	83	13	114
Prohibition, surveillance or control of activities and friendships.	26	65	28	99
Monetary and spending control.	3	88	9	118
Physical aggressions with or without a weapon	3	88	5	122

Table 1 shows the frequency of responses to what they would most allow during dating, both women and men more frequently indicated kisses and hugs, followed by caresses without sexual intercourse, although in sexual relations Men are the ones who would allow it the most.

Table 2 shows the frequencies of what they are looking for in a dating relationship, showing that what they are most looking for is someone to love and with whom to share feelings, followed by company to go out and have fun.

Table 3 shows the frequencies of the aspects of violence presented in the dating; it is observed that the aspect that has been most presented is the prohibition, surveillance or control of activities or friendships.

Table 4. Grouping obtained with Weka software.

		Clusters			
Attribute	Full Data	0	1	2	3
	(143.0)	(70.0)	(27.0)	(11.0)	(35.0)
Sex	Man	Man	Man	Woman	Woman
Program	Bachelor of Architecture	Bachelor of Civil Engineering	Bachelor of Electromechanical Engineering	Bachelor of Architecture	Bachelor of Chemical Engineering
Who pays tuition	The father	The father	The father	The father	Both parents
Has worked before	Si	Si	Si	Si	Si
Live with	Parents	Parents	Parents	Parents	Parents
Preparing for starting a family	No	No	Yes	Yes	No
A way to getting to know someone before marriage	No	No	yes	Yes	No
Someone to have a sexual relationship with	No	No	Yes	Yes	No
Somebody to love an to share mutual feelings	Yes	Yes	Yes	Yes	Yes
Company for going out and have	No	No	Yes	Yes	No
I would allow kisses and hugs	Yes	Yes	Yes	Yes	Yes
I would allow caresses without sexual intercourse	No	No	Si	No	No
I would allow sexual intercourse	No	No	Yes	No	No
Insults or threatens of physical violence	No	No	No	No	No
Prohibition, vigilance or control of activities or friendships	No	No	No	Si	No
Monetary and spending control	No	No	No	No	No
Physical violence with or without a weapon	No	No	No	No	No

Phases of KDD

The KDD process was used to develop clustering, which is described below:

Integration and Data Collection

The data was obtained from a questionnaire applied online, exported to a spreadsheet, organized and passed into a pro-delimited CVS format that is recognized by Weka.

Cleaning and Transformation Selection

At this stage of the study, the data is reviewed, selecting those with characteristics that are relevant to the investigation.

Evaluation and Interpretation

For the validation of this technique given the number of records in the data set, Weka's 66% percentage split option was applied, the software automatically selects 66% of the data set for training and 34% for tests.

Results Obtained from the Group

The groups obtained through the clustering technique using the Simple K-means algorithm are show in Table 4. The Weka data mining tool was used for this technic.

In total, four groups were formed, two formed by men from Civil Engineering and Electrical Mechanical Engineering degree respectively and the other two formed by Women from the Architecture and Chemical Engineering programs.

Group 0 is made up of men from Civil Engineering program whose fathers solve their studies and live with both parents, they have worked; They seek in their dating relationship someone to love and share feelings and what they would most allow are kisses and hugs, this group does not present any situation of violence in their dating.

Group 1 is formed by men from the Electromechanical Engineering program whose father solves their studies, they live with both parents, this group seeks in their relationship: preparing to start a family, a way to getting to know someone before marriage, someone to have sex with, company to have fun; allowing kisses and hugs, caresses without sexual intercourse and sexual relationships, this group does not present having experienced any situation of violence in their dating.

Group 2 is composed of women from the Architecture program, their father is the one who solves their studies and they live with both parents, they seek in their relationship to prepare to start a family, a way to getting to know someone before marriage, someone to have sex with, someone to love and share feelings and company to go out to have fun. The most that they would allow in a dating relationship are kisses and hugs, this group indicated having lived prohibition, surveillance or control of activities or friendships.

Group 3 is formed by women of the Chemical Engineering program whose both parents pay their tuition, seek in a dating relationship someone to love and share feeling and what they would be more willing to allow are kisses and hugs; and they have not experienced situations of violence in their dating.

4 Conclusions

Men predominate in this population sample due to the nature of the programs, of the four groups, two consisted of men and two by women, the groups formed by men did not show situations of any type of violence: psychological or physical, however, of the groups formed by women the one of the Architecture program stated to have lived situations of violence from partners when prohibiting, monitoring or controlling activities or friendships.

Although three of the four groups formed, have not experienced a situation of violence in their dating, analyzing the frequencies of those who answered having experienced a situation of violence, it is that for both men and women the most presented situation was to prohibit, monitor friendship with classmates from school or work, followed by criticizing the way of being, and insults. For women, the next situation of violence they have experienced with their boyfriend is that they have criticized their way of dressing, for men it is that they told them silly before other people.

Likewise, it is observed that the men reported a greater frequency regarding the following situations of violence; He has pushed you; He has slapped you and He has scratched you.

Comparing these results with those obtained by Olvera, Arias and López [3], a similarity is observed in that they mention that the type of violence that occurs most is the psychological one, followed by some other type.

Regarding the results obtained by Rodríguez [5], it can be concluded that it is also agreed that both men and women have lived in their relationships of psychological violence, and that men report more psychological and physical aggression than women.

It is concluded that these types of studies should continue to be carried out in the other faculties of the University, to compare the results between the different populations, and in this way the plans and programs to prevent and reduce situations of violence during dating are the most appropriate to those required by the students.

References

1. Universidad Juárez Autónoma de Tabasco: Plan de desarrollo institucional 2016–2020 (2016)
2. Ramírez-Rivera, C.A., Núñez-Luna, D. A.: Violencia en la relación de noviazgo en jóvenes universitarios: Un estudio exploratorio. Revista Enseñanza e Investigación en Psicología, 15(2), pp. 273–283 (2010)
3. Olvera-Rodríguez, J.A., Arias-López, J., Amador-Velázquez, R.: Tipos de violencia en el noviazgo: estudiantes universitarias de la UAEM, Zumpango. Revista Electrónica de Psicología Iztacala, 15(1), pp. 150–171 (2012)
4. Rojas-Solís, L., Carpintero-Raimúndez, E.: Sexismo y agresiones físicas, sexuales y verbales-emocionales en relaciones de noviazgo en estudiantes universitarios. Electronic Journal of Research in Educational Psychology, 9(2), pp. 541–564 (2011)
5. Rodríguez, J.A.: Violencia en el noviazgo de estudiantes universitarios venezolanos. Archivos de Criminología, Seguridad Privada y Criminalística, 6(12), pp. 4–20 (2014)
6. López, M.A, Morales, E.Y., Hernández, J.A., Ochoa, C.A., González, C., González, O.A.: Patterns of motivational orientation and its relationship with academic performance in university students. Research in Computing Science, 148(6), pp. 197–203 (2019)
7. López, M.A, Morales, E.Y., Hernández, J.A., Ochoa, C.A., González, C.: Representation of learning strategies through visual techniques of multivariate analysis in university students. Research in Computing Science, 147(2), pp. 89–98 (2018)
8. Hernández-Sampieri, R., Fernández-Collado, C., Baptista-Lucio, P.: Metodología de la investigación. Editorial Mc Graw Hill (2010)
9. Fayyad, U., Piatetsky-Shapiro, G., Smyth, P.: From data mining to knowledge discovery in databases. AI magazine, 17(3) (1996)

10. Pérez-Marqués, M.: Minería de datos a través de ejemplos. Editorial Alfa y Omega (2014)
11. Hernández, J., Ramírez, M.J., Ferri, C.: Introducción a la Minería de Datos. Pearson (2004)
12. Weka.: Weka 3: Software de aprendizaje automático en Java. https://www.cs.waikato.ac.nz/~ml/weka/index.html (2019)

ISSN 1870-4069

Design of Material Delivery Routes with Towing Equipment for the Automotive Sector Using a Von Neumann Topology of PSO under the Logistics 4.0 Paradigm

Alma Luévano[1], Alberto Ochoa[2], Elías Carrum[1], Darwin Young[1], Pedro Pérez[1], Denisse Barzaga[1]

[1] Corporación Mexicana de Investigación en Materiales−CONACYT, Mexico

[2] Universidad Autónoma de Ciudad Juárez, Doctorado en Tecnología, Mexico

alberto.ochoa@uacj.mx

Abstract. The supply chain increases its importance in the automotive sector continuously. Therefore, manufacturing systems such as Just in Time, entail a complex implementation, due to the ascending variety of models and components of the vehicles, since currently, the implementations of expert systems within the Logistics 4.0 concept, seek to accelerate the flow synchronized materials in the production lines, using technological tools of the environment Industry 4.0. This project was located in an engine production plant, in the material assortment part from the supermarket (decentralized warehouse of a plant) to the assembly line. A mathematical model of the process was made, and a genetic algorithm programmed in Matlab was used to optimize it, seeking to reduce line stoppages caused by lack of material. The experimentation shown focused on five of the currently implemented assortment routes, which provide 29 different part numbers to 25 workstations. The performance of the current routes and that of the optimization were validated by means of a simulation model.

Keywods: PSO algorithm, material delivery routes, logistics 4.0.

1 Introduction

In recent years, in the operational logistics stage, decision problems have been increasing due to a growing trend of mass customization, which has generated a continuous increase in the variety of vehicles and their components.

As a result of this situation, implementing the most used manufacturing methodologies such as "Just in Time" and "Just in Sequence", has become one of the biggest challenges of the current automobile production (Boysen et al., 2015). One of the steps that have been the most reason for study, due to the problems that arise in it,

is the delivery of productive parts to the assembly line (Boysen et al., 2015).In addition, due to its complexity and the adoption of production system methodologies such as "World Class Manufacturing WCM" (World Class Manufacturing), used by leading companies in the automotive sector, which does not allow forklifts to enter the stations of work and limits the level of inventory in each station according to the classification that gives the part numbers, that the problems that involve the towing equipment as a means of transport are among the most studied.

For all the above, it is precisely the assortment of parts to the assembly line by means of towing equipment, the study area chosen for this project, since to allow a reliable supply of parts with the principle "JIT" (Just in time), the interdependent routing and programming problems need to be solved, being the routing, the assignment of the stations that will be supplied between the towing equipment and the programming, deciding the start times of the trips of each team through its assigned stations. With regard to the resolution of these types of problems, recently in the state of the art it has begun to mention the use of tools of Industry 4.0, mainly the use of simulation. The fourth industrial revolution, better known as Industry 4.0, is currently underway, which was named in 2011 at the Hannover Messe fair in Germany, and is characterized by the integration of digital and physical. The concept of logistics 4.0 starts from these same bases.

2 Formalization of the Problem

Based on the existing literature, we can mention that the most common problems when transporting material with towing equipment are:

1. Assign a subset of stations to each towing equipment.
2. Determine the number and types of parts to be loaded per trip of the towing equipment.
3. Determine a delivery schedule, for each towing equipment and its associated route. (Boysen et al., 2015).

In the present project, the first two problems mentioned above are studied in a real context, in a plant dedicated to engine machining and assembly, located in Saltillo, Coahuila, Mexico, which produces a 3.6-liter, 6-cylinder engine, which It has 4 different models.

In the plant there are three types of routes responsible for supplying the productive parts to the assembly line, which are differentiated by the means of transport used and the method of loading and unloading containers with empty material and containers. The first two types use towing equipment as a means of transport, while for the third type of route the main means of transport is the forklift.

There are two subdivisions of the routes used as a means of transport for the towing equipment. The first supplies part numbers with classification of material that allows you to have in stock in process, at each station where they are stocked, enough parts to assemble the engines produced in two hours or more. The part numbers supplied by these routes have among their main characteristics, a high number of pieces per unit container, these are thus sent from the supplier. The cycle time of these routes, that is, the frequency with which they supply material to the line, is two hours.

Another important feature is that the loading and unloading of containers with empty material and containers in the warehouse and in the assembly line is done manually by the equipment operator. The project is focused on the following subdivision, which covers the material assortment routes through towing equipment, in which the loading and unloading of material containers and empty containers is done automatically.

The process of this type of routes begins in two different material stores, in the first one the material is placed in such a way that the route operators can take the unit containers manually for their subsequent transfer. The second is the area where the complete pallets of material are located, that is, the material loading units (unit containers of material arranged on pallets, commonly protected with rubber and strapping), just as received from the supplier.

The material is transported from the warehouses already described to a supermarket area, which is also a warehouse, but decentralized located within the plant and closer to the assembly line, in which the material is placed in such a way that the Person responsible for this area, can take individual containers and place them manually in the supermarket facilities. These facilities are racks specially manufactured for each assortment route, adapted with pneumatic mechanisms so that the material placed in them is automatically transferred to special delivery trucks used for this type of route.

These cars are structures made of aluminum profiles and rails, designed and built to load and unload only certain sizes and quantities of material and empty containers. Each structure is fixed to a platform with tires which is anchored to a towing equipment, to be able to transfer it from the supermarket area to the work stations and vice versa. Each towing equipment pulls up to two cars at a time, for which the allocation of material that each one carries was made from the design stage of the routes, currently already implemented in the plant. The transfer of full containers from the supermarket facilities to the cars and the transfer of empty containers from the cars to these facilities, is done at the moment when each car is aligned with its corresponding facility, however, the loading of material to The facilities are done in advance of that time.

Each towing equipment is driven by an operator to the workstations corresponding to its route, where the transfer of material to the station and the transfer of empty containers to the cart are also carried out automatically. In each station where material is supplied, the empty containers accumulated up to that point must be loaded. In both the supermarket area and the assembly line, the loading and unloading of empty material and containers is done for some routes in a single step and for others in two steps for each carriage. It is important to mention that the carriage limit that each towing equipment can pull was given based on its ability to drag and make the necessary turns through the route assigned to each route. Currently, of this type of routes, 5 are implemented and are identified by colors, for reasons of practicality in this work will be identified by numbers.

For the design of the routes already implemented, the following variables were mainly considered: production speed of the assembly line (demand for material on each workstation in a given time frame), loading times and unloading of empty material and containers, permitted speed of towing equipment, cargo capacity of delivery carts, number of carts that can be used for each route, whose decision is given mainly based on the possibility of turning in aisles narrow without difficulty.

The production speed considered to perform the allocation and scheduling of the routes already implemented, was taken as a constant data of 105 engines per hour. In the plant you have a production time per shift of 11.5 hours, so when multiplied by the two daily shifts you have a total of 23 hours of production per day. If the 23 hours per day of production is multiplied by the 105 engines per hour, we would have a total production of 2415 engines per day, however, the current daily production target is 1840 engines. Based on this, it would be thought that producing at a rate of 80 engines per hour could reach the daily goal of 1840 engines, so the question arises: What is the reason for assembling the engines at a speed of 105 per hour?

On the production line there are several unexpected events, such as quality problems in the production parts, lack of parts due to delays in the delivery time of some supplier, failures in the machines, to name a few, which could cause delays in scheduled production. Because of this, there is a safety margin of 25 engines per hour, to ensure compliance with the daily production target. The problems that affect engine production are so unpredictable and have so many possible causes, that maintaining an invariable production per hour for a day is something that has not been achieved. As examples, it could be that in the early hours of the day engines were produced at a rate of 80 per hour, and that, due to engines rejected in the final quality review, by the middle of the shift the amount of production per hour would increase with the aim of reaching the Goal.

On the other hand, it could be the case that, during the first shift due to the absence of problems, they approached the target of 1840 engines per day and therefore, in the last shift the rate of production should be reduced to avoid exceeding the scheduled target, which would also not be suitable for the plant. This point is very important, since one of the main variables to consider for the design of the routes, is precisely the pace of production of the plant. Right after the implementation of the current routes, some issues began to arise. The most serious were line arrests caused by lack of material at workstations. These shutdowns decreased as the learning curve of the towing equipment operators advanced, but unfortunately they continued to occur.

In addition to this, since the implementation to this day, modifications have been made to the design of some tanks of the initial routes, due to the detection of waste in their volumetric capacity. In line with the above, as the learning curve of the operators progressed, downtimes were detected in some of them, contradicting the first recorded observations in which it was described, which due to the cycle time of the assortment process of the routes could not be reached to fill the material in time. In addition, the following observations were made to the assortment process:

1. Existence of routes of towing equipment to workstations without unloading material, by decreasing the demand for parts on the production line.
2. Problems with automatic transfers, when towing equipment again arrives to supply material to a workstation, before the material that occurred in the previous delivery cycle had been consumed.

Another situation that added difficulty to the design of the routes, is the existence of a narrow corridor (where it is not possible to pass) through which four different material assortment routes have their route, three of them of the type studied in this project.

Due to this situation, there have been problems of blockages between material delivery carts, generating the risk of stoppages due to lack of material derived from this condition.

Based on all the features of the problem listed above, it was classified as a routing problem for trained vehicles with time windows. This conclusion is based on the description given in the literature to such problems, which, in order to be classified within this category must meet the following characteristics:

1. Have a fleet of vehicles with limited and constant capacity.
2. The function of delivering various assigned goods according to customer demand.
3. They include the restriction that each customer is only willing to receive orders in the course of a defined time window (Sanches et al., 2016).

In addition to these characteristics, due to the aforementioned WCM philosophy followed by the plant, it is necessary to consider an additional restriction, which states that each workstation has a maximum WPI (Work in process) work inventory allowed, which depends on the classification of the part that is provided in that station, which directly affects the scheduling of the routes.

3 Proposed Methodology

3.1 Particle Swarm Optimization (PSO)

This method was described around 1995 by James Kennedy and Russell C. Particle Swarm Optimization (PSO) is an optimization/search technique typically used in large-ranging search spaces. This method is inspired by the behavior of insect swarms in the wild. You can think of a swarm of bees because they when looking for pollen look for the region of space where there is more density of flowers, because the probability of pollen is higher. The same idea was moved to the field of computing in the form of an algorithm and is currently used in the optimization of different types of systems. Formally speaking, it is assumed that you have an unknown function f(x,y), which can be evaluated at the points you want but as a black box, so you cannot know its expression.

The objective is the usual in optimization, to find values of x and y for which the function f(x,y) is maximum or minimum. F(x,y) is often called a "fitness" function, as it will determine how good the current position is for each particle. The idea that follows in PSO begins by placing particles randomly in the search space, but giving them the possibility of moving through it according to rules that take into account the personal knowledge of each particle and the global knowledge of the swarm.

Providing you with a simple ability to move through the landscape (fitness function) and communication between them, you can discover particularly high values for f(x,y), spending few computational resources (calculations, memory and time) (Sancho Caparrini, 2016). A leader can be global from the entire swarm, or local to a swarm neighborhood. Swarm neighborhoods have a structure that defines how information is concentrated and then distributed through their members.

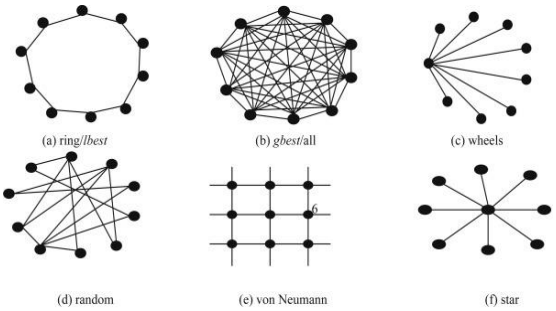


Fig. 1. Topologies used in PSO.

The most common organizations and swarms are: Star neighborhood structure, ring neighborhood structure, wheel neighborhood structure, Von Neumann neighborhood structure, and four-cluster neighborhood structure. The organization of the swarm affects search ability and convergence (Ochoa et al., 2009). 1. The pseudocode is shown below:

1. N: Number of particles,
2. w: Weight of inertia,,
3. c: Cognitive value,
4. pi: Best initial singles,
5. pg: Best Initial Global,
6. x,v' Assign initial random positions and speeds to the particles (N),
7. Start Cycle:
8. For each particle
   - Update Speed (w,c,pi,pg)
9. x-Update Position (v)
10. Calculate new position fitness value (x)
11. "Upgrade Best Singles"
12. pg-Update Best Global
13. The end.

4 Experimentation with the Proposed Model

Four years later, in 2011, Nils Boysen and Stefan Bock in the article Programming for the Supply of Fair-to-Time Parts for Mixed Model Assembly Lines (Boysen & Bock, 2011), raise the problem of finding sequences, according to the philosophy "Just a Time" of boxes of material delivered from a central storage facility. In this case study, the distribution of parts by means of a forklift is bottleneck. Its objective was to improve the efficiency of supply handling for mixed model assembly lines, as well as to minimize the maximum weighted partial inventory that had to be stored near the assembly line of all stations and production cycles. The solution method used was limited dynamic programming and simulated annealed.

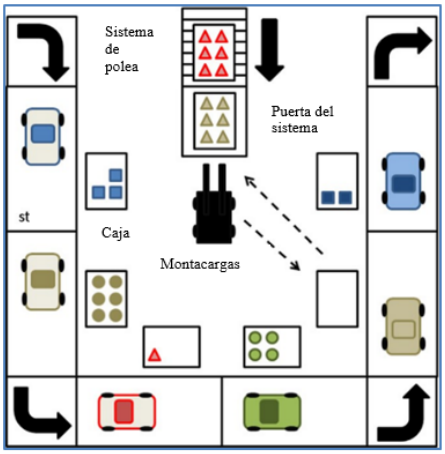


Fig. 2. Problem 2 Scheme. Source: Boysen 2011.

$$(HSP) \qquad Minimizar\ Z(\pi) = \max_{m \in M;\, t = 1, \ldots, T} \{w_m \cdot L_{m,t}\},$$

$$t^{\pi}_{\pi(s)} = p_{\zeta_{\pi(s)}} + \sum_{s'=1}^{s-1} 2 \cdot p_{\zeta_{\pi(s')}} + s \cdot p' \qquad \forall s = 1, \ldots, |B|.$$

Point in time where a box will be available at the workstation:

$$\Gamma_{m,t} = \{p \epsilon B_m | t^{\pi}_{p} \leq t\} \qquad \forall m \in M, t = 1, \ldots, T.$$

Part boxes delivered on time at your station:

$$L_{m,t} = A_m + \sum_{p \in \Gamma_{m,t}} a_p - D_{m,t} \qquad \forall m \in M, t = 1, \ldots, T.$$

Inventory placed near each station on the assembly line. Fig. 3 Mathematical Model.

2. Source: Boysen, 2011. The restrictions considered were:

a) Variable demand.
b) The assortment of a single station per trip.
c) Point-to-point deliveries for a single vehicle.
d) Each box with a variable number of parts.
e) No idle time was allowed between two consecutive deliveries.
f) Fixed and determined travel times and forklift manoeuvres.
g) Time units normalized to the equidistant length of a production cycle.
h) Each box with a predetermined number of single-type units.
i) One-part assembly in each station.
j) Parts ready to be assembled right after the forklift positioned the box on the workstation.

k) The return of empty boxes was not considered in the problem.
l) The safety stock was not explicitly considered, but could be included to the demand of the first period.

Nils Boysen and Stefan Bock concluded that limited dynamic programming provided optimal solutions for moderate and medium sized cases (with up to 20 boxes). On the other hand, using simulated annealing, optimal solutions were produced for large cases (with up to 80 boxes). An important feature considered in this investigation was the variable demand of the material.

In the same year, 2011, Nils Boysen but now with Simon Emde in the article Optimal routing and programming of towing equipment for the just-in-time assortment of mixed model assembly lines (Emde & Boysen, 2012), propose to solve two problems simultaneously:

On the one hand, the routing problem, which is to determine the size of the towing equipment fleet that will be used for the assortment of parts and the distribution of stations among towing equipment (commonly known in the automotive industry as " tuggers"). In addition, the sequence of stops must be decided.

The second problem raised is the programming problem, in which a number of tours have to be determined for each towing equipment, where each tour comprises the loading operation in the supermarket (decentralized storage area within a plant), the cycle through all of its assigned stations, and the arrival time at each stop:

$\alpha_i = \beta_i - (CP_i - PD_i + dp_i)$ Current inventory,

$\delta_i min\left(\frac{K}{D_i},\right) 1$ Filling Capacity Rate,

$\delta = \prod_{i=1}^{T} \delta_i$ Filling rate for current and previous routes if early loads are used,

$K \geq F^{-1}(\delta_{EL}, \sum_{i=1}^{N} d_i) \quad K \gg D$ Estimate the number of stations supplied by the same towing equipment:

$$\min w_i \sum_{i=1}^{TSC-MC} \sum_{j=1+MC}^{TSC} y_{ij}^{+} + w_2 \sum_{i=1}^{TSC-MC} \sum_{j=1+MC}^{TSC} x_{ij} + w_3 \sum_{i=1}^{TSC-MC} \sum_{j=1+MC}^{TSC} x_{ij} \sum_{K=1}^{N} \sum_{i=1}^{j} d_{ku}.$$

Minimize the number of towing equipment cycles and the possibility of early deliveries:

$$x_{ij} = \begin{cases} 1, \\ 0, \end{cases}.$$

1, If there is a towing equipment cycle that covers the cycles of stations from 1 to j
0, If not $min \sum_{s=1}^{N} \sum_{t=1}^{T} |\varepsilon_{st}|$.

Maximize the deviation between line inventory and ideal security stock levels figure 4 Mathematical Model 5. Source: Alnahhal and Night, 2015.

Continuing with the solution of problems within a line of assembly and / or production, in recent years several authors have continued to work in their study, but now using tools typical of manufacturing 4.0, as are simulation.

One of the most relevant advantages of simulation is that it allows for a simpler method of solution when mathematical procedures are complex and difficult.

In addition to this, analytical methods are almost always developed relatively straightforward, where a large number of assumptions are made, while in simulation methods it is possible to analyze systems of greater complexity including a better level of Detail. Below are several studies carried out within the area of interest of this project, but with a solution approach more oriented towards the use of simulation. Objective function is:

$$Maximizar \sum_{t=1}^{N} CWT_t ,$$

where (t) Time measured in the number of engines produced.

N - Number of engines required to be manufactured in a productive day:

a) CWT_t: Inventory in process for all part numbers, at all stations, which will be assorted by towing equipment over time t.

b) Calculating the "CWT_t" as follows:

a. $CWT_t = \sum_{i=1}^{NV}(CWI_i - (s * ups_i)) + \sum_{j=1}^{PT}\sum_{i=1}^{NV}\Big(CWp_{ji} - \big((dt_{ji} + rt_{ji} + at_{ji} + tll_{ji}) * ups_{ji}\big) + x_{ji} - \big(dif_{ji} * ups_{ji}\big)\Big) + \sum_{i=1}^{NV}(CWp_i - (MV * ups_i))$,

c) $\mathrm{CWI}x_{ji} = \begin{cases} \text{(Valor de x\_ji, Si se llena el número de parte i en la estación j.} \\ -0 \text{ si no se llena el número de parte i en la estación j)} \end{cases}$

d) $0 \le x_{ji} \le WSL_i$.

Variable that regulates the material consumption of each part number i:

1. Amount of inventory on workstations, part number i, from which the first part number is filled.
2. at-ji - Time it takes to align the towing equipment to fill the part number i at station j.

The time it takes to download part number i on workstation j.

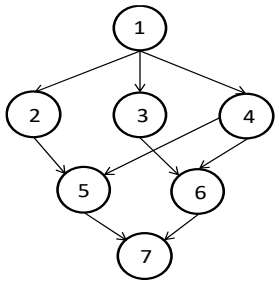
Time to load empty empty containers of part number i at station j.

The time it takes for towing equipment to reach the assortment point of part number (i) at station j, considering only distance traveled:

1. x_ji - Amount of material of part number i to be supplied by the towing equipment at station j:
2. dif_ji - Excess of the quantity of the part number i filled in the workstation j relative to its upper limit of inventory in process allowed.

MV - Number of engines produced in the time the towing equipment comes out of supplying the last part number on the last workstation, returns to the supermarket and reloads material.

PT - Total workstations filled by towing equipment.



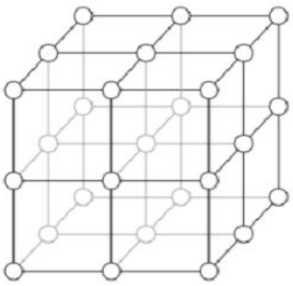
a) Von Newman PSO Model.

a1	a2	a3	a4
a5	a6	a7	a8
a9	a10	a11	a12

b) Area to explore.

Material Resurshyent Car

MRC	a1	a2	a3	a4	a5	a6	a7	a8	a9	a10	a11	12
1	7	3	9	4	9	4	3	3	1	2	9	9
2	4	7	18	3	2	7	7	2	7	8	7	5
3	8	2	19	4	7	1	2	8	4	4	4	1
4	9	9	17	3	2	7	9	1	2	2	3	5
5	4	8	10	5	9	9	8	8	9	1	4	9
6	5	5	9	8	2	3	5	4	5	8	8	4
7	2	3	11	2	3	3	3	7	3	2	7	3
8	7	5	14	4	7	5	5	5	5	3	3	4
9	3	4	20	3	4	4	4	4	2	4	1	4
10	1	5	2	7	2	5	5	5	10	7	3	2



c) Design of experiments using our model.

Fig. 5. Process of implementation of our solution.

NV - Number of part and total numbers, assorted by towing equipment.

WSL_i - Maximum inventory capacity in process of part number i.

4.1 Particle Swarm Optimization

The next technique experimented with was particle swarm optimization, better known by its acronym PSO.

The code was programmed in MATLAB, using the same evaluation function as in the genetic algorithm, but making some adaptations required by the algorithm itself.

Table 1. Experimentation PSO Algorithm, 105 MH. Source: Own elaboration.

PSO Tabla Comparativa 105 MH											
Número de Experimento	Número de iteraciones (MaxIt)	Tamaño del enjambre (nPop)	Peso de Inercia (w)	Radio de expansión del peso de inercia (wdamp)	Coeficiente de aprendizaje individual (c1)	Coeficiente de aprendizaje global (c2)	Valor de función objetivo	Tiempo CPU (seg)	Tiempo Real (seg)	MH	Equipos de remolque
Basal	NA	NA	NA	NA	NA	NA	-1737237.707	NA	NA	105	5
1	500	100	1	0.99	1.5	2	-40999420.47	1.23E+03	1.23E+03	105	3
2	1000	100	1	0.99	1.5	2	-10063176.81	3.12E+03	3.08E+03	105	4
3	2000	100	1	0.99	1.5	2	-261367.8381	7.17E+03	7.14E+03	105	4
4	3000	100	1	0.99	1.5	2	-51059131.31	1.03E+04	1.03E+04	105	5
5	500	200	1	0.99	1.5	2	-52025743.05	3.53E+03	3.53E+03	105	4
6	1000	200	1	0.99	1.5	2	-51025756.56	7.73E+03	7.71E+03	105	4
7	2000	200	1	0.99	1.5	2	-50003199.68	7.88E+03	7.87E+03	105	3
8	3000	200	1	0.99	1.5	2	-12085673.52	2.49E+04	7.07E+04	105	5
9	500	100	1	1	2	3	-42322031.29	1.29E+03	1.29E+03	105	5
10	1000	100	1	1	2	3	-15250043.68	1.66E+03	1.65E+03	105	4
11	2000	100	1	1	2	3	-42398393.92	5.13E+03	5.10E+03	105	5
12	3000	100	1	1	2	3	-10632227.33	4.42E+03	4.38E+03	105	5
13	500	200	1	1	2	3	-9369976.68	2.04E+03	2.04E+03	105	5
14	1000	200	1	1	2	3	-1823862.003	7.83E+03	1.06E+04	105	6
15	2000	200	1	1	2	3	-50015404.96	1.56E+03	1.55E+03	105	3
16	3000	200	1	1	2	3	-18177578.49	1.39E+04	1.38E+04	105	5

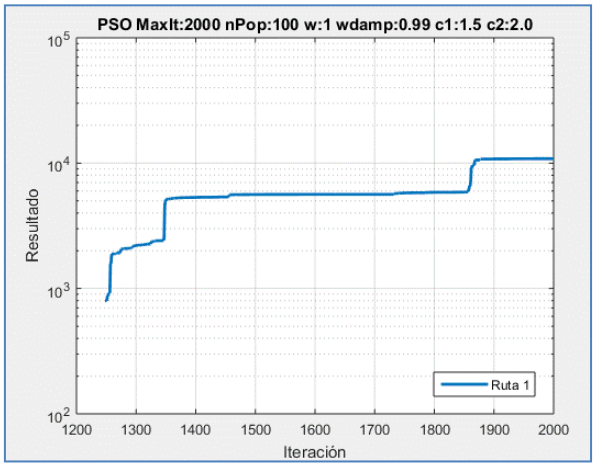


Fig. 6. Convergence Graph, PSO Experimentation, 105 MH, Experiment 3, Route1. Source: Own elaboration.

The topology used for this algorithm was wheel neighborhood structure, which was mentioned in the theoretical framework. The main code is attached in the annexes section. Tables 1 shows the results of the experimentation performed with PSO varying in the algorithm the parameters of, number of iterations (MaxIt), swarm size (nPop), inertia weight (W), radius of expansion of the weight of inertia (wdamp), these two most recently used to get the feed rate in the algorithm.

In addition, variations were made in the individual learning coefficient (c1) and global learning coefficient (c2) parameters. The experimentation was carried out considering a production speed of 105, 90 and 80 engines per hour.

The experiments were conducted based on a custom orthogonal design with 16 runs. The results are shown below and highlighted in green in each table, the best result of each experiment group, corresponding to a different production speed.

5 Conclusions and Future Research

The maximum value of the target function, for the material assortment process with a production speed of 105 engines per hour, was found using a Genetic Algorithm with general crossover type, population of 200 individuals, 300 generations. The time it took to run the algorithm was 22.28 minutes.

The maximum value of the target function, for the material assortment process with a production speed of 90 engines per hour, was found using a Genetic Algorithm with general crossover type, population of 200 individuals and 100 generations. The time it took to run the algorithm was 5.13 minutes.

The maximum value of the target function, for the material assortment process with a production speed of 80 engines per hour, was found using a Genetic Algorithm with general crossover type, population of 200 individuals and 200 generations. The time it took to run the algorithm was 9.49 minutes.

It could therefore be concluded that the best optimization technique for the mathematical model developed was Genetic Algorithm.

Validation by means of simulation, of the results obtained when performing the optimization, considering a production speed of 105 engines per hour, showed a reduction of line stops from 2.42% to 1.30%, using the same 5 towing equipment, but decreasing the total number of kilometers travelled over a 23-hour period, from 448.8 to 410.71 kilometers.

In the current process the amount of material that is sent to the assembly line remains fixed, even if the production speed of 105 motors per hour decreases, so it was expected that in experiments where production speeds of 90 and 80 mots are considered you decrease the amount of material that is sent per cycle, the impact of optimization was greater. However, although the optimization results for lower speeds decreased the use of 1 towing equipment, the validation by means of the simulation did not show good statistics, since, although the value of the target function increased with compared to baseline, a higher percentage of line stops than the current process was obtained in the simulation at the same speeds.

An important detail observed when simulating, was that the solution generated, gave a part number a low amount of material to be sent per cycle (see Figure 93 and 98), which affected the total result of the percentage of line stops of all workstations considered in this study. The above gives rise to consider continuing experimentation with other optimization techniques, or even with it, but with a variety of different parameters, in a future work.

The implementation of the results obtained would require changes in the structure of the facilities of the supermarket area, delivery carts, and special facilities for automatic transfers found at the workstations, for which they are would have to do a cost-benefit analysis that would justify the change considering the cost of the changes.

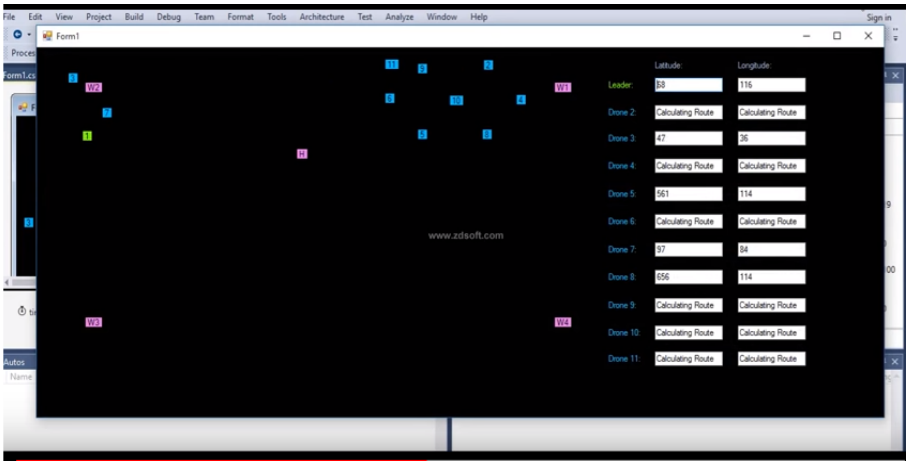


Fig. 7. Simulation software proposed.

Simulation of individual assortment routes showed no greater difficulty. The problem arose when testing all the routes running at the same time, since the interference of each other in corridors where it is not possible to go over, cause the simulation of the 5 routes, in the simulation of the process with waits, to stop 2 hours with 52 minutes. The complexity was found in representing the decisions that towing route operators make so as not to block each other.

Another practice they perform to avoid these blockages is to return to the supermarket area with the material that was loaded at the beginning of the cycle without unloading it at the workstation, seeing that the material from the previous cycle has not yet been consumed, which occurs when the Production speed decreases, this causes unnecessary material handling and is a very bad practice carried out in the current process.

5.1 Future Research

Perform the optimization of material assortment routes using the simulation model. Develop in the Plant Simulation software a graphical interface to facilitate the use of the simulation model of the current process and subsequently perform the optimization of that model.

Improvement of the developed mathematical model, adding considerations such as, the percentage of material damaged by part number present in the workstations, storage capacity of supermarket facilities or loading times and different download per workstation, to name a few.

Experiment incasing with optimization techniques other than those studied in this research, such as ant colony, simulated annealing or dynamic programming, to mention some of the most outstanding techniques in the study of state of the art.

Perform in Matlab a graphical interface, in order to facilitate the use of the programmed genetic algorithm, to obtain the routes of assortment of material.

5.2. Simulation

This research still needs to be complemented with simulation and testing prior to implement it in a real environment. Beside the engineering challenges of a physical Material Resurshyent Cars, the developed algorithm described in section 4 will be simulated for fine tuning and validation. For this, the above is why in the mathematical model wait times are sanctioned, so that the solution that searches for the algorithm avoids them.

References

1. Boysen, N., Emde, S., Hoeck, M., Kauderer, M.: Part logistics in the automotive industry: Decision problems, literature review and research agenda. In: European Journal of Operational Research, pp. 107−120 (2015)
2. Boysen, N., Bock, S.: Scheduling just-in-time part supply for mixed-model assembly lines. In: European Journal of Operational Research, 211, pp. 15−25 (2011)
3. Boysen, N., Emde, S., Hoeck, M., Kauderer, M.: Part logistics in the automotive industry: Decision problems literature review and research agenda. In: European Journal of Operational Research, pp. 107−120 (2015)
4. Carrum, E.G., Pérez, P., Robles, D.M.: Caso de estudio: Simulación para determinar la cantidad exacta de carros materialistas en una celda de manufactura de asientos automotrices. Compendio Investigativo de Academia Journals (2017)
5. Emde, S., Gendreau, M.: Scheduling in-house transport vehicles to feed parts to automotive assembly lines. In: European Journal of Operational Research, 260, pp. 255−267 (2017)
6. Fahlstedt, M., Halldin, P., Kleiven, S.: Importance of the bicycle helmet design and material for the outcome in bicycle accidents (2014)
7. Hebdige, D.: Travelling light: one route in to material culture. Rain, 59, pp. 11−13 (1983)
8. Manenti, P.: Productos individualizados. La plataforma ardiente para la competitividad del futuro. Reino Unido: SCM World (2016)
9. OECD/ITF: Improving safety for motorcycle, scooter and moped riders. OECD Publishing (2015)
10. Restrepo, R.J.: La logística y las soluciones en la gestión de la red de abastecimiento. Quid, (21), pp. 53−60 (2013)
11. Sali, M., Sahin, E.: Line feeding optimization for just in time assembly lines: An application to the automotive industry. In: International Journal of Production Economics, (174), pp. 54−67 (2016)

ISSN 1870-4069

Creation and Implementation of a Serious Game to Detect Depression in Young People and Children

José Jimenez Peralta[1], Jaime del Angel[1], Alberto Ochoa[2], Antonio García Domínguez[3], Carlos E. Galván Tejada[3], Jorge I. Galván Tejada[3]

[1] TecNM/Instituto Tecnológico Superior de Naranjos, Mexico

[2] Universidad de Ciudad Juárez, Mexico

[3] Universidad Autónoma de Zacatecas, Mexico

josejimenezperalta0@gmail.com, jaime.delangel@itsna.edu.mx, {antonio.garcia, ericgalvan, gatejo}@uaz.edu.mx, alberto.ochoa@uacj.mx

Abstract. In medicine, according to the International Classification of Diseases (ICD-10), within the area of psychological diseases, there are 23 mental disorders of which neurodevelopment, psychotic, bipolar, obsessive-compulsive, stress disorders, anxiety stand out. and depressants, among others. At present, the creation of technological tools that facilitate the detection or diagnosis of diseases have revolutionized the way in which they are treated. In recent years, the design and creation of video games focused on educational purposes (Serious Games) has increased. The Serious Games are based on real scenarios, and their objective is to enhance the learning of higher order cognitive processes and skills in a specific context, which helps to improve behaviors and gather information. Within this area, simulations and video games designed to help the recovery of patients with chronic or terminal illnesses are included, as well as those designed to help with psychotherapy and overcome trauma, such as depression. The present work is based on the creation of a serious game based on the psychology of color of Max Luscher, the test of the human figure of Karen Machover, HTP by John Buck, with the aim of detecting depression in young people and children through of Criteria that can be analyzed according to their behavior and selective preferences during the game using an information gathering methodology in the analysis and design phase of the serious game, which allows to obtain a quality game, for its detection, fulfilling the specific purposes established.

Keywords: Serious games, color psychology, unity 3d, depression in young people and children, avatars 3d, information gathering methodology.

1 Introduction

Mental disorders are considered a public health problem worldwide. According to the ministry of health [1], it is estimated that around 15 million people suffer from some mental disorder. The results of the latest National Survey of Psychiatric Epidemiology (ENEP) [2] indicate that 28.6 percent of the population presented some of the 23 disorders of the International Classification of Diseases (ICD-10), conducted by the World Health Organization [3]. Some of these disorders are: neurological, psychotic, bipolar, obsessive-compulsive development, stress disorders, anxiety, depressives, among others [4].

Depression is an emotional disorder that is basically characterized by mood disorders, loss of interest, sadness, inhibition, fatigue, insomnia, negative thoughts, and that produces a decrease in pleasure in habitual activities, a negative view of oneself, the future and the world [5]. The most common treatments are cognitive behavioral therapy and medications [6].

The appearance of depression in children and adolescents has increased in the last fifty years [7]. It is estimated that by 2020, depression will occupy second place as a disabling condition and first in developed countries It is estimated that by 2020, depression will take second place as Disability status and first place in developed countries [8].

There are currently several tools for the detection of depression, several of them based on test, such as that of the human figure of Karen Machover [9]. This test is based on the theoretical basis of the body scheme that is projected through the drawing and that serves as an instrument to reveal the internal dimensions of the personality that generally cannot be evaluated [10]. Another of these test-based depression detection tools is the John Buck H.T.P test (home, tree, person), which allows you to evaluate psychic dynamics in culturally different individuals and allows you to obtain clinical information without awakening threatening experiences [11].

In recent years, with the recent technological development, numerous solutions have emerged to the problems in different areas, including the medical area, in which the procedures that were previously performed manually were automated and optimized. Under this perspective, Information and Communication Technologies (ICTs) have revolutionized these areas and have provided solutions that facilitate everyday life [12].

Many and diverse have been the solutions that have been proposed to facilitate the interaction of the human being with the environment in which it develops [13, 14], among the software products that have been created are the Serious Games, which are digital games used as a tool for learning social behaviors, attitudes and practices [15].

Serious games can be applied to a wide spectrum of areas such as military, government, educational and health care, such as that presented by Martins et al. [16], where a game is presented to investigate the evolution of patients with mental disabilities. This game promotes the development of patient memory, time to make decisions, the ability to observe, learn and the application of known skills.

Serious games are interesting for mental health for three reasons: They offer attractive potential as the popularity of computer games suggests.

Serious Games approaches can increase the scope of mental health interventions, this is important given the large number of people who experience mental disorders and who, however, do not receive treatment. Second, users can experience the game's approaches as something fun, wanting to "win" the game or see how the story unfolds. These dynamics can contribute to reducing high dropout rates in Internet-based interventions naturally.

Third, the game has a potential for effectiveness because it provides opportunities for both conventional and non-traditional processes for behavior change and learning. It can offer immersion experiences where a state of "flow" can be achieved, provide sensory environments to support social learning, allow users to test new skills in a safe and reactive environment, and facilitate repeated behavioral tests [17].

This article proposes a serious game that focuses on the detection of depression through analyzable criteria obtained from the player's behavior. The proposed serious game, has 3 levels in which it allows the player to personalize his avatar taking into account the psychology of color, both in clothes and in hair, interpreting his behavior through the test of the human figure of Karen Machover. In addition, it is also be possible to customize different avatars with which it interacts, taking as a reference the way in which the player sees the people around him and choosing an environment, among several options, to see if the player is sociable or prefers closed and solitary spaces, among other aspects to evaluate.

2 Design

The design of a Serious Game should focus on the user, the playability and the immersion [18], as shown in Figure 1. The playability makes the game easy and fun to use, emphasizing the style and quality of the game-user interaction, usability, narrative and history, interactive intensity, degree of realism, among other aspects [19]. Immersion is the ability to believe what is played and integrate into the virtual world that is shown in the game [20]. From a design point of view, serious play depends on the balance between the proposed challenges and the player's necessary skills to overcome them. If you also consider the characteristics of immersion, such as awareness, concentration, realism, skill and socio-cultural closeness, the need to take the user into account in the game design becomes evident [18].

The first phase when designing Serious Games is the analysis of the context, that is, the identification and study of the requirements of the game [21]. The target audience must be well defined and the design plan clearly delimited. In this phase several criteria are established, such as: objectives of the game, fun complements, that is, sounds, video, 2D and 3D images, effects, etc. In addition, certain stimuli are also defined for the player, such as rewards (during the game and / or at the end of the game) and desirable content focused on children and youth with depression.

In the second phase is the design, the main elements that are included in the serious game are determined, such as the environment, the mechanics of the game, the scenarios, the objects of the game, the learning system and the technical specifications [18]. When we talk about the environment, we talk about the game environment, which

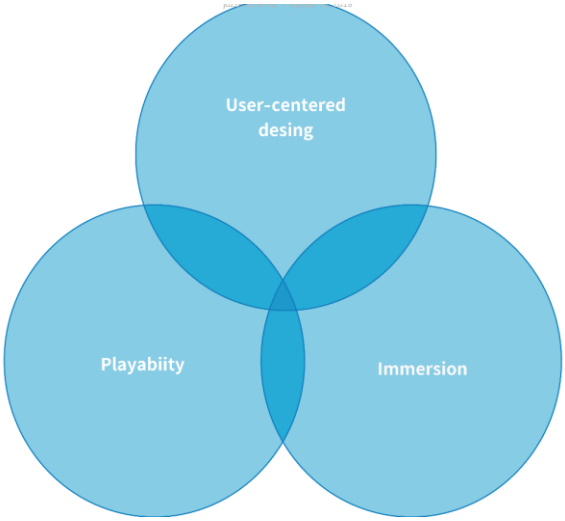


Fig. 1. Design features of a serious user-centered game.

can be physical or virtual, it also promotes an emotional appeal that attracts the attention of the players and an analysis of the general vision is carried out (target audience, purpose, gender, design of levels and market analysis).

The mechanics of the game is the most important element, since here we describe all the actions that allow us to build the rules of the game, the methods designed for the interaction between the player and the serious game [22]. It allows to establish the communication, the score, the rewards or the punishments and the flow of the game, and the elements of the gameplay.

Game objects are virtual elements included in the environment, which allow you to have a combination of skills such as decision making, movement and activities within the game.

They have a set of characteristics (appearance, functions, functions) and are capable of creating actions that describe their aesthetic representation, at this point the attributes are taken into account: avatars, actions (sounds, animations, movements, graphic styles) and appearances [23].

Another important aspect to consider in this design stage is the technical specifications, ranging from coding, emerging technologies applied, within serious gaming and hardware / software resources [18].

Level Design. As mentioned earlier, the serious game consists of 3 particular levels, which allow analyzing the player's behavior through established criteria to obtain information. In this way, it is possible to determine satisfactorily whether the child or young person suffers from depression.

Character Customization. The first level is designed for the player to determine the color of the avatar's clothes and hair, this with the objective of obtaining relevant

information that allows to know the mood of the player, following the criteria established within the psychology of color [24]. An example of this is children who are generally in favor of the colorful and bright, that is, they like light, but there are times when they are attracted to dark colors and shadows, because they correspond symbolically to their mood state at that moment [25]. Dark colors are also used by the child or young person who wants to indicate their sadness. As an example: blue is the deepest of colors, it is a cold color that produces calm and tranquility. The good and affectionate child often uses the color blue, while the nervous and aggressive child prefers red. In the same way, the color brown is the color of the negative, of the difficulties, and of the conflicts of adaptation to a familiar and social environment, for that reason if the player leans towards opaque, dark and sad colors, it would be a key that determine the presence of depression [26]. In other words, level one aims to use the player's perspective on himself through the avatar and the psychology of color as a reference.

Social Environment. In level 2 it is intended that the player personalize a group of avatars with which he will surround himself, taking into account again the psychology of color and the criteria established for the interpretation of the combinations. As an example, the combination of brown with black, according to Luscher [27], has an interpretation of contempt for the same person, or gray with black that is associated with separative isolation or absolute lack of participation. It is intended that the player when choosing this type of combinations for the group of avatars, show the way in which the player perceives the people around him. These avatars have different body characteristics that help the analysis of player behavior following the criteria established by Machover in his famous human figure test. Test [9].

Environment selection At level 3, the player must choose an environment, taking into account the different structures of colors and shapes. You should also choose environments such as cities with avatars, fields, forests, deserts and even swamps, taking as a reference mainly the criteria of the psychology of colors, shapes and all the components that are present in these environments, to know if the player is sociable or inclined towards closed places, that is, that prefers loneliness, associating all this with the appropriate criteria for a successful diagnosis of depression.

3 Development

Unity 3D is one of the most popular video game development environments today [28], which is used for 2D and 3D projects. Among the features that stand out are the ease of use and, in turn, the power to create video games and applications for various platforms using the programming language C# [29].

The serious game proposed in this work was programmed on this platform, using several external components such as Vroid studio [30] to create avatars, Sweet Home 3D [31] to model house, Blender [32] to model some additional components and graphic editors for create and modify icons and logos used, among other external components compatible with unity 3D.

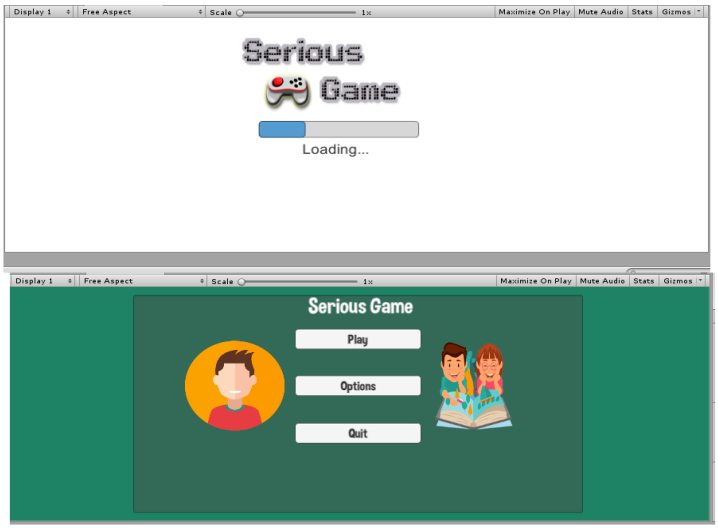


Fig. 2. Home screen and menu.

In the first phase of development, a home screen with white background was created, with the aim of giving greater seriousness and perception of space and breadth. In the center the logo of the serious game was placed, in addition to a loading bar to move to the next scene. Subsequently, a menu with three buttons is presented: "Play" to start the game, "Options" to configure the parameters within it and "Exit" to exit the game. The screens and elements mentioned are shown in Figure 2.

The next stage of development is to create the scene where the player can choose his avatar, according to sex, as shown in Figure 3. For the first level of the Serious Game there are options to choose 4 colors, 2 of them correspond to the specific attributes of the avatar: color of the clothes and hair, the other 2 correspond to the platform and the environment. For the first level of the Serious Game there are options to choose 4 colors, 2 of them correspond to the specific attributes of the avatar: color of the clothes and hair, the other 2 correspond to the platform and the environment. Taking into account the criteria established by the psychology of color, which states that the presence of dark and opaque colors are clear evidence of the presence of depression in young people and children, this scenario will provide information that will help detect the presence of said disease. Figures 4 and 5 show two hypothetical examples of avatars created by people who show signs of depression, according to the psychology of color.

Based on the scenes and objects created for the serious game, the objective is to make an analysis of the choices made by the players, in terms of clothing color, hair and environment, which allows to determine if there are signs of depression.

Figures 6 and 7 show two hypothetical examples of avatars created by players who show high self-esteem, according to the theory of color psychology.

At level 2, the criteria established in the psychology of color are retaken, which allows the player to modify the color of the clothing and hair to different avatars with

Fig. 3. Avatars selection.

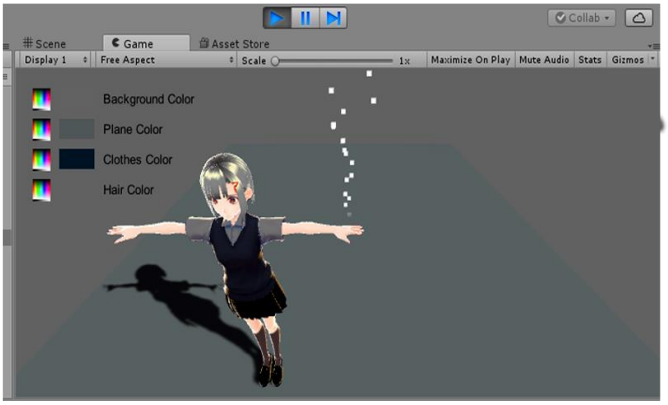


Fig. 4. Female avatar designed by a person showing signs of depression.

which he interacts, taking as a reference the player's perspective towards the people around him.

The above is shown in Figure 8, in which it is possible to perceive a shaded environment with opaque colors. The selection of these colors is directly related to the emotional state of the player, in this way, by observing the combination of gray and black colors in the dress of the avatars, it is possible to determine that the player is an isolated person. The selection of the yellow color of the platform and the black environment determines that the player tends to suffer sudden crises.

In the third and final level of the serious game, the player's behavior is evaluated, choosing environments, interpreting the essential characteristics of these and combining the criteria established by the psychology of color. At this level, shapes, colors and all visible components are interpreted in the environments chosen by the

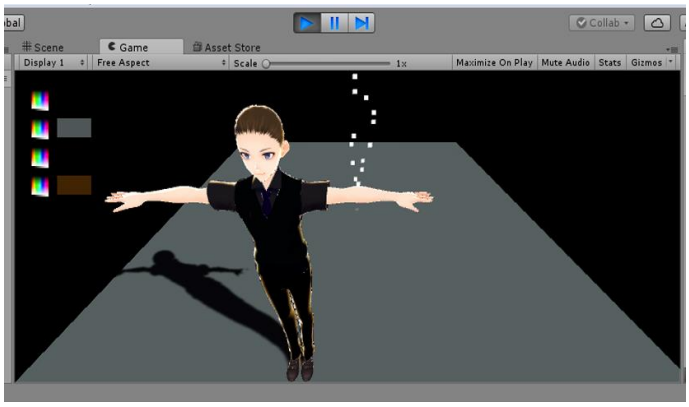


Fig. 5. Male avatar designed by a person showing signs of depression.

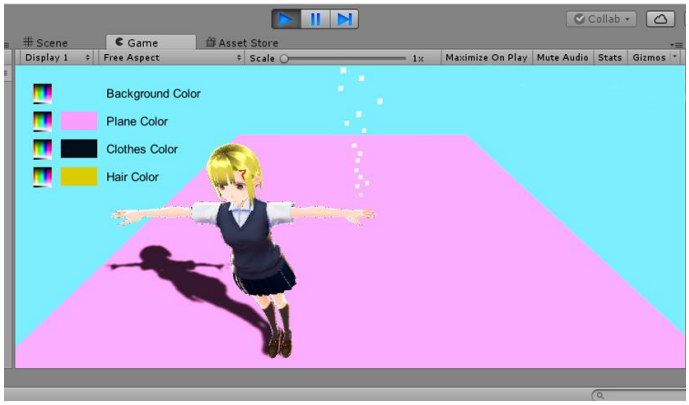


Fig. 6. Female avatar designed by a person who has high self-esteem.

user, it is determined if the user is sociable or lonely and, most importantly, detects if he suffers from depression.

Two examples of this are shown in Figures 9 and 10. Figure 10 shows a shady and lonely forest in contrast to a dark gray background and dry trees, which are interpreted through HTP and color psychology as an eligible environment for people with depression and low self-esteem.

4 Conclusions and Discussion

The Serious Game proposed in this document aims to detect depression in young people and children through the Max Luscher color psychology test [27]. This approach is presented in the Game through the presence of different elements, divided by levels, in which a specific analysis of the choice made by the player is performed based on the colors considered.

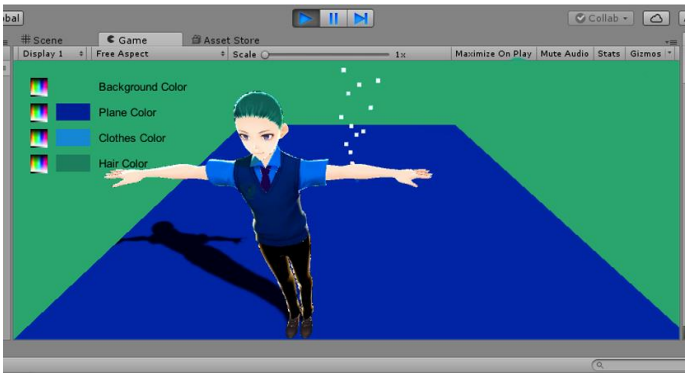


Fig. 7. Male avatar designed by a person who has high self-esteem.

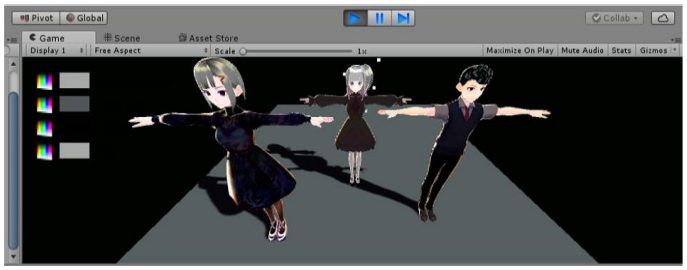


Fig. 8. Design of a group of avatars with colors associated with mood.

Fig. 9. City with avatars.

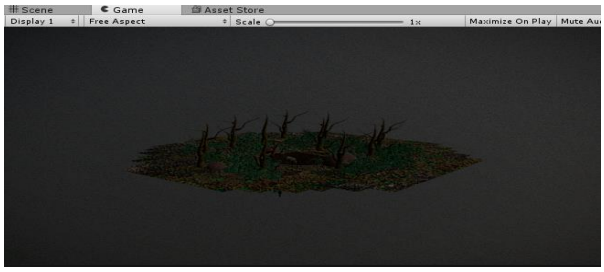


Fig. 10. Gloomy forest.

The color blue (dark) has an interpretation of depth of feeling, concentric, passive, associative, heteronomous, sensitive, perceptive and unifying, which in turn is associated with player moods such as tranquility, satisfaction, tenderness, love and affection, allowing making a correct diagnosis according to the preferences that the patient has. The color green (bluish) is representative of the constancy of the will, having as emotional interpretation, persistence, self-affirmation and self-esteem. The color red (orange) is representative of the willpower and represents the eccentric, active, offensive, aggressive, autonomous, locomotor, competitive, efficient and is related to appetite, excitability, authority and sexuality. The yellow (light) color represents spontaneity and is characteristic of someone eccentric, active, planner, heteronomous, expansive, ambitious, inquisitive and its affective aspects are variability, expectation, originality and joy.

In addition to the isolated analysis of colors, an analysis of color combinations, such as gray with blue, was carried out, which has a structural significance of an interval of tranquility. The gray color is representative of a protective shield, while blue precedes the need for peace. The color red combined with black is interpreted as an exaggerated desire or dramatization. The black and yellow combination is interpreted as sudden crisis or stubborn decisions. The black with the violet represents the need for identification or compulsive union.

One of the most obvious combinations that show depression is black with brown, since it is interpreted as contempt of itself, with the help of these three levels together it is possible to determine depression.

5 Future Work

The future work that can be applied to this development is to take into account other test based depression detection models, such as the HTP test, thus creating a new level that allows the player, through basic objects, to make drawings of people, houses and trees taking into account the criteria established in said test. This would allow to analyze in depth the characteristics of the drawings made by the player and interpret every detail to obtain better diagnoses.

Another aspect to consider is to take into account the criteria for the classification of depression levels and, therefore, not only detect depression, but also classify and determine whether the level of depression is moderate or extreme using Itakura distance formula.

References

1. Gob.mx: Site of the ministry of health. https://gob.mx/salud (2019)
2. Inpr.gob.mx: National Survey of Psychiatric Epidemiology http://inprf.gob.mx/ psicosociales/archivos/ encuestaepidemiologia.pdf (2019)
3. Who: World Health Organization: https:// who.int/es (2019)

4. Brämer, G.R.: International statistical classification of diseases and related health problems: Encyclopedia of Clinical Neuropsychology. World Health Stat Q, 41(1), pp. 1347–1347 (1988)
5. Belló, M., Puentes-Rosas, E., Medina-Mora, M.E., Lozano, R.: Prevalencia y diagnóstico de depresión en población adulta en México. Salud Pública de México, 47(1), pp. S4–S11 (2005)
6. López-Ibor, M.I.: Ansiedad y depresión, reacciones emocionales frente a la enfermedad. Anales de Medicina Interna, 24, pp. 209–211 (2007)
7. Bella, M.E., Fernández, R.A., Willington, J.M.: Intento de suicidio en niños y adolescentes: Depresión y trastorno de conducta disocial como patologías más frecuentes. Archivos argentinos de pediatría, 108(2), pp. 124–129 (2010)
8. Acosta-Hernández, M.E., Mancilla-Percino, T., Correa-Basurto, J., Saavedra-Vélez, M., Ramos-Morales, F.R., Cruz-Sánchez, J.S., Duran-Niconoff, S.: Depresión en la infancia y adolescencia: Enfermedad de nuestro tiempo. Archivos de neurociencias, 16(1), pp. 20–25 (2011)
9. Machover, K.: Proyección de la personalidad en el dibujo de la figura humana: Un método de investigación de la personalidad. Ediciones Cultural (1987)
10. Machover, K.: Dibujo de la figura humana: Un método de investigar la personalidad. Técnicas proyectivas del diagnóstico psicológico. Anderson y Anderson (1963)
11. Buck, J.N.: The h-t-p test. Journal of Clinical psychology, 4(2), pp. 151–159 (1948)
12. Altés, J.: Papel de las tecnologías de la información y la comunicación en la medicina actual. Seminarios de la Fundación Española de Reumatología, 14(2), pp. 31–35 (2013)
13. Recuero, A.: La domótica como medio para la vida independiente de discapacitados y personas de la tercera edad. Informes de la Construcción, 50(459), pp. 55–59 (1999)
14. Cortés-Sánchez, I.J.: Diseño, desarrollo y puesta en marcha de un sistema de información de acceso web, que facilite la detección de enfermedades a partir de la historia clínica del paciente para una población, muestra de gambitasantander. Tesis Universidad Piloto de Colombia (2016)
15. Marcano, B.: Juegos serios y entrenamiento en la sociedad digital. Teoría de la Educación. Educación y Cultura en la Sociedad de la Información, 9(3), pp. 93–107 (2008)
16. Martins, T., Carvalho, V., Soares, F., Moreira. M.F.: Serious game as a tool to intellectual disabilities therapy: Total challenge. In: IEEE 1st International Conference on Serious Games and Applications for Health (SeGAH), pp. 1–7 (2011)
17. Fleming, T.M., Bavin, L., Stasiak, K., Hermansson-Webb, E., Merry, S.N., Cheek, C., Lucassen, M., Ming-Lau, H., Pollmuller, B., Hetrick, S.: Serious games and gamification for mental health: Current status and promising directions. Frontiers in Psychiatry, 7, pp. 215 (2017)
18. Evans, F., Spinelli, A., Zapirain, E., Massa, S., Soriano, F.: Proceso de desarrollo de serious games. Diseño centrado en el usuario, jugabilidad e inmersión. In: 3er Congreso Argentino de Ingeniería y 9no Congreso Argentino de Enseñanza de la Ingeniería (CAEDI) (2016)
19. Aarseth, E.: Investigación sobre juegos: Aproximaciones metodológicas al análisis de juegos. Artnodes: Revista de Arte, Ciencia y Tecnología, 7, pp. 4–15 (2007)
20. Gros, B.: Juegos digitales para comprender los sistemas complejos. Comunicación y Pedagogía, 216, pp. 47–50 (2006)
21. Sánchez-Gómez, M.: Buenas prácticas en la creación de serious games (objetos de aprendizaje reutilizables). In: SPDECE (2007)
22. Vilches-Antao, D.G.: Juegos serios, evaluación de tecnologías y ámbitos de aplicación. Tesis Universidad Nacional de la Plata (2014)
23. Elkonin, D.B., Uribes, V.: Psicología del juego. Pablo del Río Madrid (1980)

24. Martínez-Cañellas, A.: Psicología del color. Maina, pp. 35–37 (1979)
25. Heller, E.: Psicología del color: Cómo actúan los colores sobre los sentimientos y la razón. Gustavo Gili (2004)
26. Dorothea-Vernon, M.: Psicología de la percepción/the psychology of perception. Technical report, Hormé (1967)
27. Lüscher, M.: The Luscher color test. Simon and Schuster (1990)
28. Henson Creighton, R.: Unity 3D game development by example: A seat-of-yourpants manual for building fun, groovy little games quickly. Packt Publishing Ltd (2010)
29. Norton, T.: Learning C# by developing games with unity 3D. Packt Publishing Ltd (2013)
30. Home Sweethome-Sweet: 3d Sweet Home 3D (2015)
31. Hess, R.: The essential Blender: guide to 3D creation with the open source suite Blender (2007)

ISSN 1870-4069

Implementation of an Intelligent Model Based on Big Data and Decision Making Using Fuzzy Logic Type-2 for the Car Assembly Industry in an Industrial Estate in Northern Mexico

José Luis Peinado Portillo, Carlos Alberto Ochoa,
Sara Paivab, Darwin Young

Universidad Autónoma de Ciudad Juárez,
Institute of Engineering and Technology,
México

josepeinado@outlook.com, alberto.ochoa@uacj.mx,
sara.paiva@estg.ipvc.pt,
darwin.young@cilssconsulting.com.mx

Abstract. In our days, we are living the epitome of Industry 4.0, where each component is intelligent and suitable for Smart Manufacturing users, which is why the specific use of Big Data is proposed to determine the continuous improvement of the competitiveness of a car assembling industry. The Boston Consulting Group [1] has identified nine pillars of I4.0, which are: (i) Big Data and Analytics, (ii) Autonomous Robots, (iii) Simulation, (iv) Vertical and Horizontal Integration of Systems, (v) Industrial Internet of Things (IoT for its acronym in English), (vi) Cybersecurity, (vii) Cloud or Cloud, (viii) Additive Manufacturing including 3D printing, and (ix) Augmented Reality. These pillars can all be implemented in factories or take some depending on the case you want to improve. In Industry 4.0, the Industrial IoT is a fundamental component and its penetration in the market is growing. Car manufacturers such as General Motors or Ford expect that by 2020 there will be 50 billion (trillion in English) of connected devices and Ericsson Inc. estimates 18 billion. These estimated quantities of connected devices will be due to the increase in technological development, development in telecommunications and adoption of digital devices, and this will invariably lead to the increase in the generation of data and digital transactions, which leads to the mandatory increase in regulations, for security, privacy and informed consent in the integration of these diverse entities that will be connected and interacting among themselves and with the users. Finally, the use of Fuzzy Logic type 2 is proposed to adapt the correct decision making and achieve the reduction of uncertainty in the car assembly industry in the Northeast of Mexico.

Keywords: Smart manufacturing, industrial IOT, big data applied to the automotive industry, fuzzy logic type 2 for decision makings.

1 Introduction

Today technology is an important part of everyday life, from the way we communicate, to the different types of technologies that allow us to carry out many types of processes in different industries. On the other hand the Mexican industry, particularly the automotive industry is not exempt from these technological advances, which are part of industry 4.0 (I4.0) has an endless number of technologies that make it compete in the market, but in turn these technologies are not being effective enough to meet the demands of today's world, therefore this chapter will show a literature review of the concepts that will be the basis for the proposal of a new intelligent model that is able to combine cutting-edge technologies, in order to optimize processes and resources within the automotive industry in northern Mexico.

2 Literature Review

This section shows the main concepts to this article and how they have been generating and evolving along the history, this section gives us an idea of what exists with respect to the technologies mentioned as Industry 4.0, Big Data, Fuzzy Logic Type-2.

2.1 Industry 4.0

Industry 4.0 (I4.0) is the latest standard for data and computation oriented advanced manufacturing [2], The term "Industry 4.0" originated from a project initiated by High-tech strategy of the German government to promote the computerization of manufacturing. Industry 4.0 is considered as the next phase in the digitization of the manufacturing sector, and it is driven by four disruptions: the astonishing rise in data, computational power, and connectivity, especially new low-power wide-area networks [3].

The I4.0 was named because in along the history it was the fourth industrial revolution, the first one (I1.0) refers to the first revolution which occurred in the 1800s, where the most important change was mechanical manufacturing, then in the 1900s take place the second revolution which have as main chance the assembly line and it means an increase in mass production, before the I4.0 occurs the third revolution, this happened around the 1970 when the industry introduce the use of robots get better in the production, all this information was taken from the next table 1.

As it mentions before the I4.0 is based on nine pillars this was written by [1] and they are:

I Big Data and Analytics.
II. Autonomous Robots.
III. Simulation.
IV. Horizontal and Vertical System Integration.
V. The Industrial Internet of Things.
VI. Cybersecurity.
VII. The Cloud.

Table 1. Technology evolution from Industry 1.0 to Industry 4.0. [2].

Time Technology	Evolution Transition	Defining
1800s	Industry 1.0	Mechanical Manufacturing
1900s	Industry 2.0	Assembly Line (mass production)
1970s Manufacturing	Industry 3.0	Robotic Manufacturing (Flexible Manufacturing)
2010	Industry 3.5	Cyber Physical Systems
2012 Foward	Industry 4.0	Virtual Manufacturing

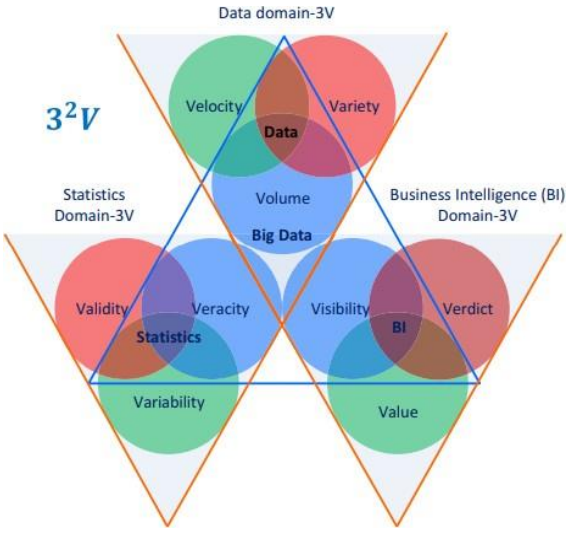


Fig. 1. 3v's Model for Big Data.

VIII. Additive Manufacturing.

IX. Augmented Reality.

2.2 Big Data

One of the most important part of I4.0 is the Big Data and Analytics, normally is associated with the result of the use of internet, sensors, management systems, but big data isn't about a big group of data, is a model named "Model of 3v's", Volume, Velocity, Variety [4]. Then this model was increase with a new "Vs", variability [5] for the "Model 4v's",the next suggest for the "Model 5v's" was value, and along the time this model has been increasing to the las model named "3v2 Model" and is mentioned by Wu et al. [6], and he show us the Venn Diagram.

Some of the autors like Zhang, Zhan, Yu [7] talk about the use of Big Data in the industry of car, He proposes that the use of big data helps determine the characteristics that a user searches for in a car, in addition to predicting how sales will be in the coming months. Otherwise, Kambatla, Kollias, Kumar Grama [8] talks about the future to big data, he gives us an idea of what the use of big data implies, from the type of hardware that is needed to apply this technology, be it the use of memory, the hierarchy of memory that this implies, to the types of network and systems distributed that allow the application of big data for companies.

On the other hand, Philip-Chen and Zhang [9] mention that in order to be competent the use of big data is a big part for innovation, competition and production for any company, and that the use of big data should include the use of cloud computing. , quantum computation and biological computation, besides that the development of tools is an important part of the use of these technologies. Making decisions in a company is one of the big problems for them, the use of data science techniques base on big data allows making decision at massive scale depends from the big data technologies, storage and engineering that the company has.

2.3 Fuzzy Logic

Fuzzy logic has obtained attention of researchers for last couple of decades. It has opened new horizons both in the academia and the industry site, although, conventional fuzzy systems (FSs) or so called type-1 FSs is capable of handling input uncertainties, it is not adequate to handle all types of uncertainties associated with knowledge-based systems [10], the type-2 provide additional design degrees of freedom fuzzy logic systems, which can be very useful when such systems are used in situations where lots of uncertainties are present, The resulting type-2 fuzzy logic systems (T2 FLS) have the potential to provide better performance than a type-1 (T1) FLS [11]. A type-2 fuzzy set is characterized by a fuzzy membership function, i.e., the membership value (or membership grade) for each element of this set is a fuzzy set in [0,1], unlike a type-1 fuzzy set where the membership grade is a crisp number in [0,1] [12]. Membership functions of type-1 fuzzy sets are two-dimensional, whereas membership functions of type-2 fuzzy sets are three-dimensional. It is the new third-dimension of type-2 fuzzy sets that provides additional degrees of freedom that make it possible to directly model uncertainties [11] (Fig. 2).

3 Discussion

The automobile assembly industry today has multiple options for the assembly, from different models of cars, different types between these models, even the color of these is an important factor for decisions within companies. On the other hand, currently companies use different mathematical models as a solution for decision making, which, although useful and functional, only present between 60% and 65% of success in them, showing a little less than half of failure within the decisions for the company. Case, a car is assembling in 7 stages and this passes through 4 work stations, only the assembly

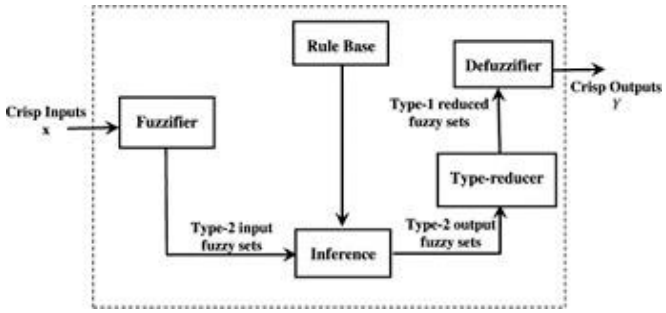


Fig. 2. Show us the diagram of a fuzzy logic controller.

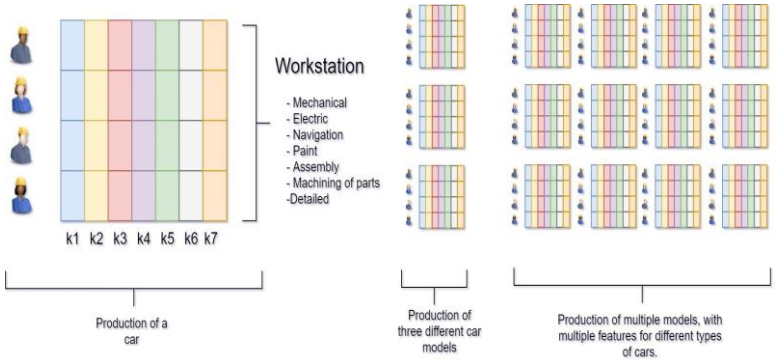


Fig. 3. A multiple production of cars with multiple variables produce multiple critical points within the company.

of this car has as result 28 critical points, now if 3 different models are made at the same time, and what happens if 4 cars are made of each model, the number of variables and critical points of the process grow significantly (Figure 3), so the mathematical and stochastic models are not being practical enough for this type of companies, representing 40% of losses or inefficiencies in the production of final products.

4 Proposal

The proposal to help the way to optimize resources in the supply chain of a company is the realization of an intelligent model based on Big Data, which will be the technology responsible for generating the best options to optimize the use of materials in the warehouse of a car assembly industry in north-eastern Mexico (Figure 4), as well as a great help in making decisions for the company. Once the analysis through Big Data and the best options generated are available, Fuzzy Logic Type 2 technology will be integrated to determine the best way to use the company's resources or the best decision for the company.

The combination of these cutting-edge technologies would represent an improvement for many of the warehouses within the assembly industry within Mexico,

Fig. 4. Use of big data for sorting and generation of options.

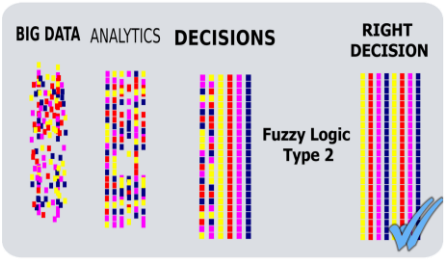


Fig. 5. Integration of Fuzzy Logic Type-2 for the choice of the best option.

even this model can be adaptable to other industries and government agencies or any business that has a warehouse and involves decision making in it, since the goal of this intelligent model is to increase by up to 85% the optimization of resources and the effectiveness of decisions made by the company.

5 Conclusion

There are many scientific articles that allow to continue with the research and development of the intelligent model, it is worth mentioning that, although there are articles related to Big Data, other Fuzzy Logic Type-2, but there is not much about the combination of both technologies, so it is thought that the development of hybrid intelligent model can be a great revolution in the management of decisions and warehouses within the industry.

References

1. Rüßmann, M., Lorenz, M., Gerbert, P., Waldner, M., Justus, J., Engel, P., Harnisch, M.: Industry 4.0: Future of productivity and growth in manufacturing. Boston Consulting Group, 4, pp. 20 (2015)
2. Govindarajan, U.H., Trappey, A.J.C., Trappey, C.V.: Immersive technology for human-centric cyberphysical systems in complex manufacturing processes: A comprehensive overview of the global patent profile using collective intelligence. Complexity (2018)

3. Sung, T.K.: Industry 4.0: A Korea perspective. Technological Forecasting and Social Change, 132(10), pp. 40–45 (2018)
4. Khan, M., Jan, B., Farman, H.: Deep learning: Convergence to big data analytics. Springer Singapore (2019)
5. Kaur, N., Sood, S.K.: Efficient resource management system based on 4vs of big data streams. Big Data Research, 9(2), pp. 98–106 (2017)
6. Wu, C., Buyya, R., Ramamohanarao, K.: Big data analytics-machine learning + cloud computing (2016)
7. Zhang, Q., Zhan, H., Yu, J.: Car sales analysis based on the application of big data. Procedia Computer Science, 107(2017), pp. 436–441 (2017)
8. Kambatla, K., Kollias, G., Kumar, V., Grama, A.: Trends in big data analytics. Journal of Parallel and Distributed Computing, 74(7), pp. 2561–2573 (2014)
9. Philip-Chen, C.L., Zhang, C.Y.: Data-intensive applications, challenges, techniques and technologies: A survey on Big Data. Information Science, 275, pp. 314–347 (2014)
10. Zamani, M., Nejati, H., Jahromi, A.T., Partovi, A., Nobari, S.H., Shirazi, G.N.: Toolbox for Interval Type-2 Fuzzy Logic Systems. In: 11th Joint International Conference on Information Sciences (2008)
11. Mendel, J.M., John, R.I., Liu, F.: Interval type-2 fuzzy logic systems made simple. IEEE Transactions Fuzzy Systems, 14(6), pp. 808–821 (2006)
12. Hagras, H.A.: A hierarchical type-2 fuzzy logic control architecture for autonomous mobile robots. IEEE Transactions Fuzzy Systems, 12(4), pp. 524–539 (2004)

ISSN 1870-4069

Implementation of Big Data in Intelligent Analysis of Data from a Cluster of ROVs Associated with System of Prevention and Reparation of Hydrocarbon Leaks to Optimize their Distribution in Gulf of Mexico

Raúl Mendez[1], Alberto Ochoa[2], Benjamín Zayas[3], Miguel Perez[4], Olivia Quintero[5]

[1] Instituto Tecnológico de Parral,
Mexico

[2] Universidad Autónoma de Ciudad Juárez,
Doctorado en Tecnología,
Mexico

[3] Instituto Nacional de Electricidad y Energías Limpias,
Gerencia de Control de Procesos,
Mexico

[4] Instituto Nacional de Electricidad y Energías Limpias,
Gerencia de Tecnologías de la Información,
Mexico

[5] Instituto Tecnológico de Parral,
Departamento de Sistemas y Computación,
Mexico

alberto.ochoa@uacj.mx

Abstract. The objective of this work is to present the multiplayer version of SimROV: a simulator of a ROV (Remote Operation Vehicle). Besides allowing sharing the same scenario between an instructor and different students through a network, the system include artificial intelligence algorithms. At the moment, these algorithms perceive the actions of students within the virtual environment and provide help for students to be guided to successfully achieve the goal assigned by the instructor. Among other things the trajectory of the movements of each ROV is verified, in this way when working on a specific maneuver such as closing a valve to stop a fuel leak, the trajectory of students is compared with the trajectory that is expected. It's worth adding that even without thinking about taking actions to respond to a contingency maneuver, SimROV can also be used for a trainee to learn how to use and control an ROV. This includes not only guiding or directing the ROV to a specific point, but knowing how to control it even in the presence of currents, which make it difficult to maneuver. The control of the arms also requires some expertise that can be obtained with the help of

SimROV, the difficulty that is presented here, is that you have to learn to use the controls to perform an action, which implicitly demands the realization of activities in parallel: move the different controls of each arm, in addition to guiding the ROV within the virtual environment.

Keywords: Virtual reality, artificial intelligence, rov multiplayer, simrov, harmony search algorithm.

1 Introduction

There are several applications for the operation of a cluster of ROVs including maritime leak monitoring in the distribution of oil in underwater scenarios, which is why each ROV for underwater work is equipped with two arms and 2 video cameras. It is worth adding that even without taking actions to respond to a contingency maneuver, SimROV (ROV Simulator) can also be used for a student to learn how to use and control a ROV. This includes not only guiding or directing the ROV to a specific point but also knowing how to control it even in the presence of marine currents, which increase difficult to maneuver it. In addition, a group of ROVs will allow generating a large set of data through the use of sensors. Control of the arms also requires some expertise that can be obtained with the help of SimROV, The difficulty presented here is learning how to use the controls to perform each of the actions to be performed, which implicitly demands carrying out activities in parallel: controlling each arm movements, in addition to ROV navigation within the virtual environment. In this research a Metaheuristic is used to find the most adequate way of dealing with an underwater leakage by a cluster of seven ROVs working collaboratively.

All this process is depicted in Fig. 1. Detecting each ROV position and the movements of their arms will be helpful to identify possible areas for improvement in the student's learning process. This also can feed the student model so that SimROV always knows the progress of the students and their current status, a key aspect in the

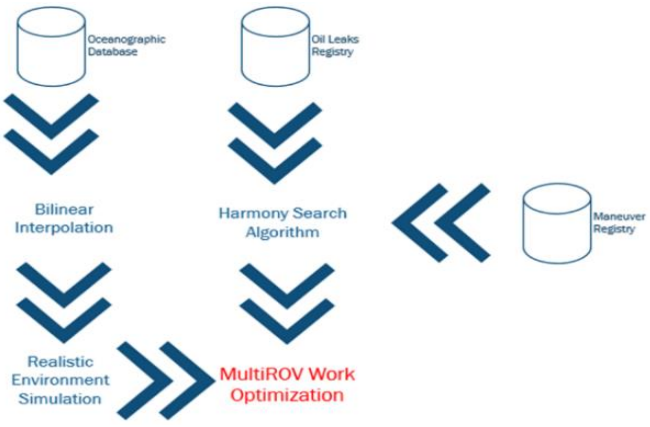


Fig. 1. Optimization of MultiROV.

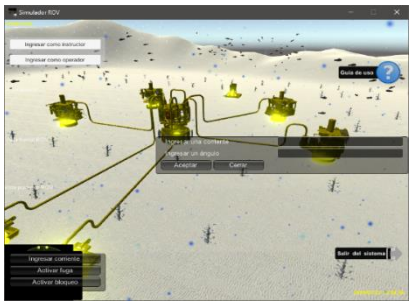


Fig. 2. Instructor entering current.

Fig. 3. Instructor inserting leakage.

training models by the national petroleum agency in Mexico.The rest of the paper is organized as follows.

Section 2 includes some concepts of simulators using a ROV to model a set of solutions. Section 3 presents the SimROV architecture including the proposal for a ROV Cluster. Section 4 discusses the main achievements of the development of this multiplayer ROV version for SimROV. Section 5 details a multicriteria analysis of their behavior, Section 6 includes some conclusions and the future work, followed by a list of references.

2 Simulation of Underwater Scenarios Associated with an ROV

A simulator for training is an intelligent system, which allows to acquiring some specific type of skills [1].

A literature review on the subject of simulators distinguishes and specifies between two types of simulators:

a) The simulators oriented to the design of facilities (SODF)

b) Training simulators, whose main purpose is training (TS).

In turn, within the TS there are two types, depending on the type of action they generate:

i) Total-range simulators (TRS), which completely reproduce the operating environment. These simulators are associated with a replica of the control room (CR), both in appearance and functions, and seek through the use of multimedia processes and sensors to specify a behavior associated with their learning.

ii) The simulators that reproduce the behavior of the process (SRBP), but do not reproduce the CR, but that allow to act on the simulation in time of execution, and manage to evaluate the experience of its use, with specifications of its implementation.

This research work is intended analyze data generated by both SimROV and a database (DB) from nullschool.net. SimROV could be considered as a SRBP, since is a simulator of Remotely Operated Vehicles (ROVs) [2].

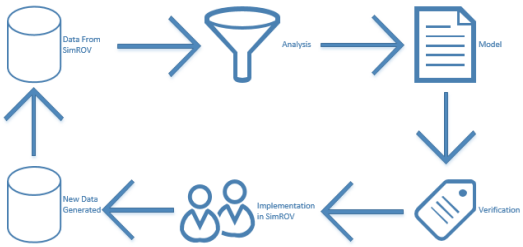


Fig. 4. Data Processing.

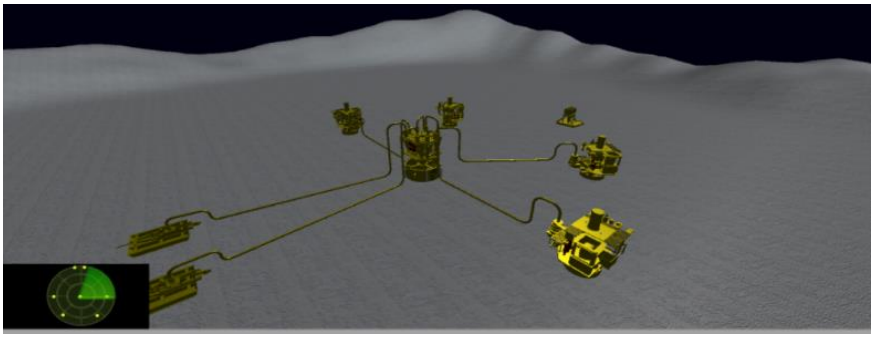


Fig. 5. SimROV environment.

Thus SimROV, is used to train the future ROV's operators. Including different parameters SimROV provides a simulation as realistic as possible.

In SimROV, (as mentioned) the trainees are learning how to operate a ROV, whose purpose is repair oil leakages at submarine pipelines. For this, the trainees and instructors log into the simulator as operator and instructor mode, respectively. Instructors have privileges to introduce leakages and marine currents whereas operators can close valves. [3] These functionalities are shown both in Fig 2. as Fig 3.

The only missing thing for SimROV to be considered as a full range simulator (TRS) is the control cabin.

However, in this multiplayer version of SimROV is possible to perform multiple actions by means of a cluster of ROVs using a framework associated with an innovative Metaheuristic under a Harmony Search Algorithm model. The controls of an actual ROV are based on joysticks and other similar motion controls, while a previous version of SimROV used only keyboard and mouse. The way in the data is processed with this metaheuristic is explained in Fig 4.

Regarding the metaheuristic, is an important part of this research, a software-assistant was developed in R. This language was selected after a comparative evaluation with Matlab [4], where R ended up being the most appropriated for the purpose established because is more portable and GPL-licensed [5], this translates into a considerable development cost reduction. This will be discussed in detail in section V. Considering that the development of the control capacity of the device associated with training operations of the ROVs cluster is being improved, SimROV contains the

student model in order to personalize the instruction, besides being equipped with artificial intelligence algorithms to monitor and guide the student in his actions during his response to contingency situations, which are introduced by the instructor to monitor his performance as time progresses and the operator's learning curve increases.

3 Simrov and Why Use A ROV's Cluster instead of Single One

Working in underwater environments require better skills than maneuver in land or even in the air. In submarines oil ducts, besides dealing with leaks, the operator has restricted vision (because the darkness of the deeps where the oil ducts are located), and might need to fight against forces coming from many sides of the ROV caused by the submarine currents, and so on. This is why is considered a priority that the operators working together during their training. Thus while some are repairing a leak, others would be working with the valves and the rest would be checking for new leaks in the surrounding oil ducts, that might be originated by oil pressure because of the leak repairing work activities.

3.1 Work Together? That is the Question

Working together is a big improvement for the simulation and therefore in the real world. Many people working together could be a mess for the instructor, if each one has a different opinion, a different strategy or simply different expertise. SimROV stores so much data about the work did in the different sessions that not take advantage of it would be a waste a time and resources. Once put this data on the table, is time to show the proposal for SimROV. It is proposed here to develop a software (SW) which calculates the optimal movements to be realized by the trainees. This SW, makes an analysis of the actual conditions of the system (valve's leaking, ROV's positions, arms movements, etc.) contrasting them with the data stored in previous sessions where students were trained. Based on this analysis, it proposes the best maneuver, which theoretically would take less time to the team. With this implementation, is expected that the team not only acquire the maneuver skills, but also learn to implement the best version of them.

3.2 Preparing SimROV for a More Accurate Environment

In order of have a more realistic simulator, it was used a Database (DB) with recordings of real Gulf of Mexico's currents (speed and angle in certain coordinates). This data was obtained from nullschool.net, project created by Cameron Beccario, which in turn refers to OSCAR (Ocean Surface Current Analyses Real-time, a NASA funded research project and global surface current database). From this DB the DB the specific point the instructor wants can be calculated. For this, the instructor can provide the coordinates where the simulation should be recreated. All this because the procedure should change according the environment state.

For the creation of this DB, it was used a sample of 150 points in the Mexican oil exploitation zone, in 99 dates separated by 5 days one from each other (whose distribution are represented in Fig. 6, where are shown only the means of all the records

Fig. 6. Sampling of the marine currents Source.

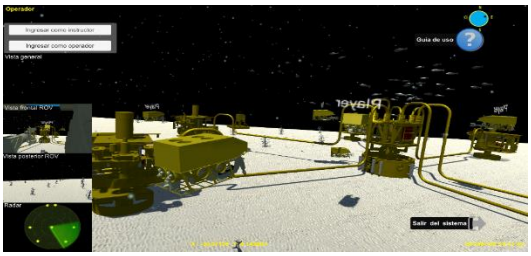


Fig. 7. Example of multiple ROV working together.

in the point). With this information the team expect make SimROV more realistic, adapting the conditions the instructor provides to the actual conditions presents in the real Gulf of Mexico. The first step, is make a bilinear interpolation for the speed with the surrounding points in the DB. This mathematical method was selected due its simplicity compared to other methods like bicubic interpolation or Bézier Surface and its accuracy in comparison with the most popular K Nearest Neighbors (KNN)). The second step, is calculate from the speed the exerted force by water currents in Newtons, while the pressure of a fluid in a pipe is measured in megapascals. To get this value is used the drag force formula, represented in equation 1:

$$F = \frac{1}{2}\rho v^2 C_D A \,, \tag{1}$$

where:

1. P is the density of the fluid. In this case is water, ergo 1000 kg/m^3.
2. v is the flow speed.
3. C_D is the drag coefficient for the object. Since the ROV is basically a cube. In order to simplify the calculations, this is going to be used as 0.8.
4. A is the surface area normal to the fluid flow.

The final step is to calculate the direction, for which is going to be used a bilinear interpolation too.

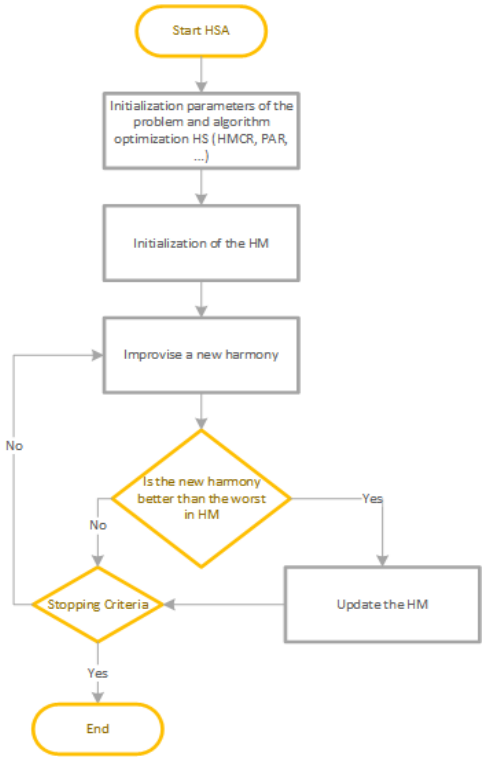


Fig. 8. Harmony Search Algorithm flowchart.

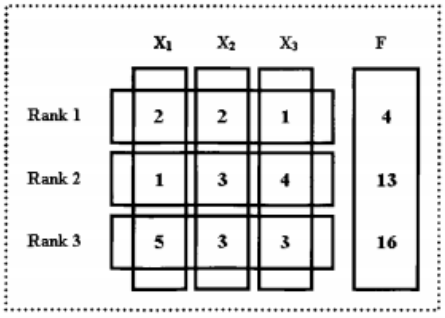


Fig. 9. Initial Harmony Memory Structure Source: [3].

4 Achievements of MultiROV

As mentioned, is really hard to work in submarines environments, besides that the ROV has limited resources (such only two arms) with this improvement in SimROV, is expected to see a significant reduction both in time and cost.

5 Multi-Criteria Analysis

For the creation de decision maker would be considered the work realized for the teams that used previously SimROV, analyzing their maneuvers (which include the movements of the ROV and the actions did with the arms) and the environment conditions.

5.1 Harmony Search Algorithm

The harmony search algorithm (HSA), inspired by musical performance process, consists of three operators: random search (RS), harmony memory considering (HMC) rule and pitch adjusting (PA). Standard HSA applies the HMC rule for both exploration and exploitation phases, RS for the exploration phase and PA rule for the exploitation phase. Indeed, the HMC rule acts as an exploration operator during the initial iteration because of large variations in the harmony memory (HM). However, as the iteration continues, this operator behaves as an exploitation agent for the HAS. [6] Since it first appearance in 2001, it has been applied to solve many optimization problems including function optimization, engineering optimization, water distribution networks, groundwater modelling, energy-saving dispatch, truss design, vehicle routing, and other [7].

In order to use the memory more effectively, it is typically assigned as a parameter $r_{accept} \in [0,1]$, called harmony memory accepting or considering rate (HMCR). If this rate is too low, only few best harmonies are selected and it may converge too slowly. If this rate is extremely high (near 1), almost all the harmonies are used in the harmony memory, then other harmonies are not explored well, leading to potentially wrong solutions. Therefore, typically, we use $r_{accept=0.7\ 0.95}$ $r_{accept} = 0.7\ 0.95$. [7]. The algorithm originally proposed in [8] (and graphically represented in Fig. 8) was this:

Step 1. Initialize a Harmony Memory (HM) with randomly generated solutions.

Step 2. Improvise a new harmony from HM.

Step 3. If the new harmony is better than minimum harmony in HM, include the new harmony in HM, and exclude the minimum harmony from HM.

Step 4. If stopping criteria are not satisfied, go to Step 2.

An example of the structure of Harmony Memory (HM) is shown in Fig. 9.

For the implementation of the current solution of the SimROV's problem was used the package metaheuristicOpt, which is free under the GPL-2 and GPL-3 license. This library includes many optimization algorithms, among which is Harmony Search (HS), this version of the algorithm originally proposed by Geem recommend certain values for the original values of HSA, for each of them are an explanation in [9]. Even so, it was decided make some empirical test to get the more optimal parameters given the characteristics of the problem. Once analyzed the algorithm, is moment to dive into the problem and the solution. Looking in the literature for similar problems and the way they were solved, is justly in the original article of HSA where are three examples of the applications for the algorithm.

In this case which cares is the first one, where like the SimROV's problem, is presented a problem with a discrete solution. In that case, HSA is applied to Traveling Salesman Problem (TSP) connecting points in a plane that represents the route for the salesman. Extrapolating the solution, the maneuvers of the ROVs are interpreted as linear movements, where it has a start and end point in the 3-dimensional space. Also, these maneuvers have registered the time it took and the valve that was repaired. As mentioned above, the library used is based in [9], and since the results were acceptable.

It was chosen use the default parameters included in the package. Even so, could be a theme for future research that born from this the optimization of the algorithm's parameters.

5.2 Cost Function or Time Function

The cost function, which is evaluated multiple times by HSA, consists in a function, which receives 3n variables, where n is the number of valves to repair. The variables follow the following structure:

a) $x_i$is the number of valve to repair,
b) x_{i+1} is the rov assigned to repair the valve x_i,
c) x_{i+2} is the priority of the valve to being repaired. Is important to remark that this number is not specifically sequential, instead of it, it only represents which one goes before which.

All this considering:

a) $i \in \{3N\}$,
b) $1 \leq x_i \leq 6$,
c) $1 \leq x_{i+1} \leq 7$,
d) $1 \leq x_{i+2} \leq 6$.

Once defined the variables, the function starts the evaluation, looking in the database for the optimal maneuver. The algorithm for determinate the optimal maneuver is the following:

1) Select all the previous maneuvers that repairs the specified valve.
2) Determinate the speed of the maneuver, for which it calculates the Euclidean distance traveled divided by the duration of it. This operation gets the unitary speed:
$$\mathrm{v} = \frac{d_E(m_0, m_f)}{t}.$$
3) Calculate the "adjustment time", that is to say, the estimated time that would takes to the ROV goes from its start position to the maneuver's start position $\Delta \mathrm{t} = \frac{d_E(P_r, P_m)}{v}$.
4) Sum the adjustment time plus the maneuver's duration and get the maneuver that has the minor estimated total time $t_e = \Delta t + t$.
5) Repeat the process for each valve. If a ROV repairs multiple leakings, the times are sum.

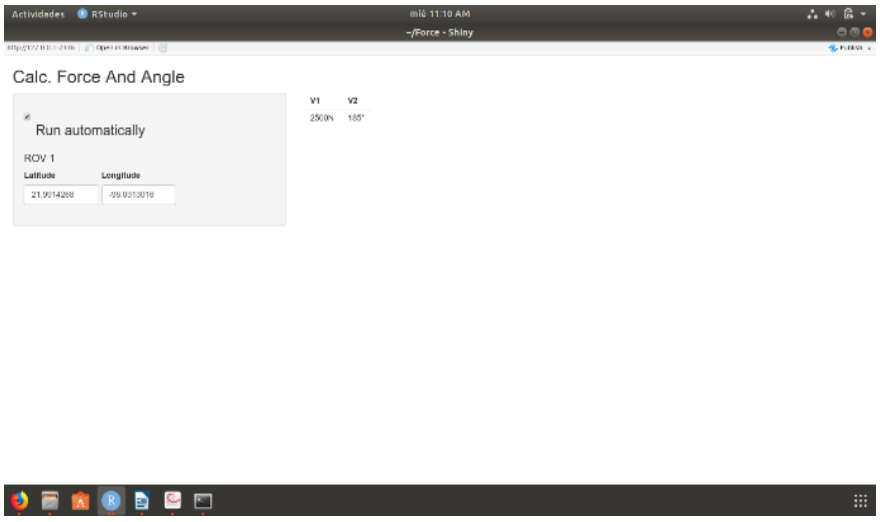


Fig. 10. Calc. of currents.

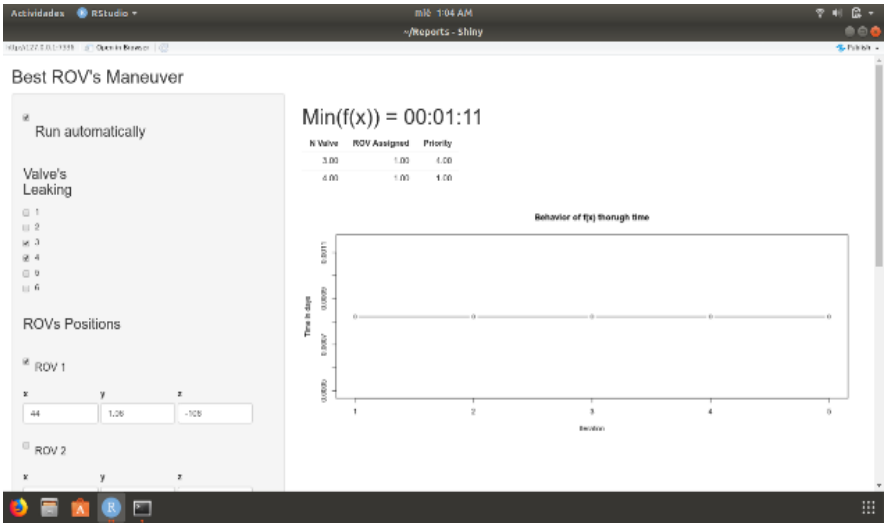


Fig. 11. SW for best maneuver.

6) Once all the valves' repairing time are calculating gets the higher which is interpreted as the global and is returned to the HAS.

Is important to remark that some parts of the algorithm are made in R, while others are implicit in the SQL queries or in the views made to simplify them. The tools developed for solve the optimization problem consists in two GUIs. The first one is in charge of calculate the velocity, therefore, the drag force of the submarine current in the given point (Fig 10). This receive the coordinates and the date of the year from which apply the methods and formulas mentioned previously.

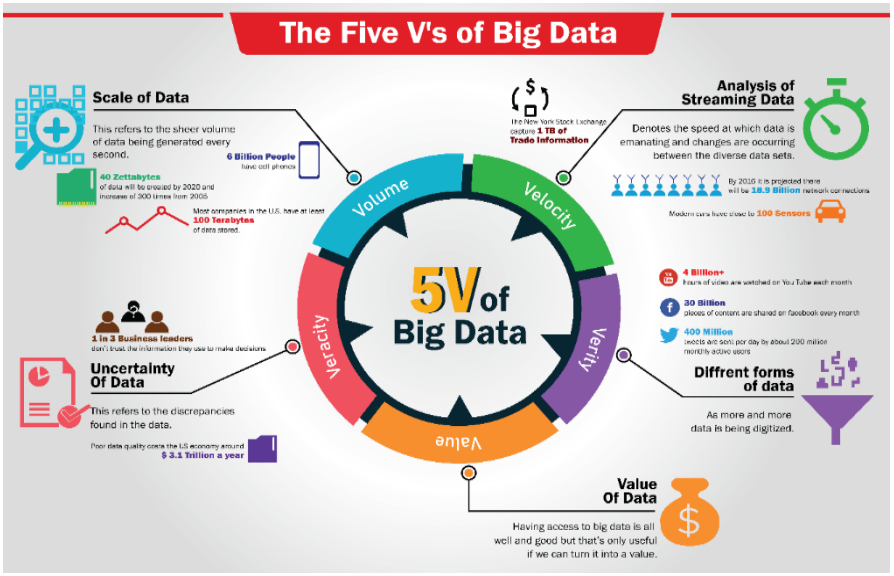


Fig. 12. Considerations for Big Data.

The other GUI is made for the user input the number of the leaking valves and the coordinates of the actives ROV. After the processing, is shown the minimum time, the maneuvers that the operators should make and the behavior of the f(x) value during the iterations of the algorithm (Fig 11).

5.3 Big Data

Big Data can be considered as a trend in the advancement of technology that has opened the door to a new approach to understanding and decision making, which is used to describe the huge amounts of data (structured, unstructured and semi-structured) that it would be too long and expensive to load a relational database for analysis. Thus, the concept of Big Data applies to all information that cannot be processed or analyzed using traditional tools or processes. In general terms, Big Data and the processes that this technique represents has a wide spectrum of potential applications. The biggest challenge for investment in Big Data occurs in relation to projects related to decision-making on a large amount of data in decision-making, definition of strategies and obtaining better experiences on consumer consumption actions. The challenge of Big Data is to capture, store, search, share and add value to the little used or inaccessible data to date. The volume of data or its nature is not relevant. What matters is its potential value, which only new technologies specialized in Big Data can exploit. Ultimately, the goal of this technology is to provide and discover hidden knowledge from large volumes of data.

In our investigation in particular, it will be used for the correct decision making in the discovery of major affectations derived from a fuel leak in an underwater scenario [10].

6 Results

An example of the work made by both SW is shown below. Where we enter a coordinate pair and the SW realize the interpolation for calculate the corresponding drag force. The instructor will enter this into SimROV and voila, the simulation is a bit more near to reality. In the side of the optimization of the maneuvers, we have a similar GUI, where enter the data (in this case, the leaking valves, the active ROVs and their corresponding coordinates in the space). After run the optimization, we get the minimum time, the order on which the valves should be repaired to get that time approximately and ends with the behavior of f(x), this more focused on watch how the algorithm work, ergo for technical purposes.

7 Conclusions and Future Research

Due to this work was possible implement an innovative algorithm, which met expectations in its work getting the optimal values. In some cases, even better than the expected due to human mistakes. Also, is important emphasize that we hope the SW would be important part in the improvement of the ROV operator's training procedure. Besides all the proposals for future research we would like to make a really big one: all this data could be used not only to train humans; this could be part of the supervised learning for Autonomous Underwater Vehicles (AUVs). Touching a related point, the research has a big trouble about time. Due that, was not possible use a big amount of data in the analysis of maneuvers. Since generate it would take a huge amount of time.

Also, as was mentioned in some points of the article, is from this site where can born many research branches some that we proposed are:

1. Optimization of the HSA's parameters for this specific problem.
2. Development of a version of HSA specially designed to discrete problems, which was not found during the time this research was made.
3. Implantation inside the SimROV.
4. Improvement of the SimROV to handle better the work with the valves (even that, the actual functioning of the solution proposed here are prepared to work with this).

8 Future Research

Could be a great future research to join the SW made as product of this research with SimROV in one unique, which putting together the best part of both, would result in a powerful learning tool. Moreover, even more can be found from this one. An important aspect to highlight will be to improve the design of experiments using the ad hoc validity of an orthogonal design.

References

1. Gopinath, C., Sawyer, J.E.: Exploring the learning from an enterprise simulation. Journal of Management Development, 18(5), pp. 477−489 (1999)
2. Beltran-Labra, R., Pérez-Ramírez, M., Ochoa-Zezzatti, C.A., Ontiveros-Hernández, N.J.: Simulador ROV multiplayer para escenarios petroleros submarinos. Research in Computing Science, 140, (1), pp. 66−77 (2017)
3. Olguín-Tolentino, N.D., Ingram-Ramírez, J.M.P.R., Nava-Ayala, M.Y.E.R.: Prototype of a ROV simulator using dynamic animation and Virtual. CIINDET (2016)
4. Ozgur, C., Colliau, T., Rogers, G., Hughes, Z., Myer-Tyson, E.: MatLab vs. Python vs. R. Journal of Data Science, 15, pp. 355−372 (2017)
5. R-Project: https://www.r-project.org/Licenses (2019)
6. Kim, J.H.: Harmony search algorithm: A unique music-inspired algorithm. In: 12th International Conference on Hydroinformatics (2016)
7. Yang, X.S.: Harmony search as a metaheuristic algorithm. In: Music-Inspired Harmony Search Algorithm: Theory and Applications, Berlin, Springer, pp. 1−14 (2009)
8. Geem, Z.W., Kim, J.H.: A new heuristic optimization algorithm: Harmony search. Simulation, 76(2), pp. 60−68 (2001)
9. Mahdavi, M., Fesanghary, M., Damangir, E.: An improved harmony search algorithm for solving optimization problems. In: Applied Mathematics and Computation, Iral, Elsevier, pp. 1567−1579 (2007)
10. Fragoso, R.B.: IBM. https://ibm.com/developerworks/ssa/local/im/que-es-big-data/index.html (2019)

ISSN 1870-4069

Preliminary Results of a Methodology for Measuring Pain Threshold Associated with Low Competitiveness in Industry

Velia Chávez Sáenz, Vianey Torres Argüelles, Salvador Noriega, Alberto Ochoa

Universidad Autónoma de Ciudad Juárez,
Instituto de Ingeniería y Tecnología,
Doctorado en Tecnología,
Mexico

velia.chavez.saenz@hotmail.com

Abstract. This research shows the preliminary results of tests based on a proposed methodology consisting in the acquisition of electroencephalographic signals (EEG), by means of electrotherapy techniques as stimuli of changes in the brain activity of test subjects in steady state. The purpose of the tests is to identify the changes that occur in the brain activity through the application of electrical (painful) stimuli and verify that the brain activity presents a change under the stimuli. The paper presents the methodological proposal for the application of the tests as well as the results obtained from their application. Then, results are applied in the evaluation of the perception of physical pain influenced by work-related fatigue, driving the brain activity through a brain computer interface. This proposal is intended to subsequently generate a tool for the measurement of the pain threshold in order to study the work-related fatigue in the industry.

Keywords: Brain activity, pain threshold, BCI, work-related fatigue, smart manufacturing.

1 Introduction

Mental fatigue is a psychobiological state caused by prolonged periods of demanding cognitive activity [1]. Although fatigue represents a major risk factor for the workers, few organizations or governments currently manage work-related fatigue in a systematic or quantitative way [2].

Work-related fatigue occurs basically in people who have an excess of physical or intellectual work, where a great mental effort or physical activities are required that involve repetitively: handle or move objects, understanding, reasoning, resolution of problems, among others.

When fatigue appears at work, there is a significant decrease in the attention levels, slowing thinking processes that, in turn, decreases the level of response to problems, generating a significant decrease in motivation towards work. As a result of work fatigue, there is a decrease in professional performance, the activity level is reduced, increasing the execution errors of the tasks, which in turn, increase and change the perception of physical pain [3].

This is a problem highly associated with smart manufacturing, becoming visible through physical pain, it cannot be associated with a specific disease or cause and it is difficult to measure or generate any indicator. Pain is an unpleasant sensory and emotional experience associated with actual or potential tissue damage or described in terms of such damage. This experience is considered a chronic problem when it persists or occurs repeatedly over a period of three to six months [4] and it is a severe and disabling condition (often associated with physical and psychological comorbidities) that negatively impacts the quality of life in about one fifth of the adult population in the western world [5]. It has been found that chronic pain is significantly related to the functioning and structural reorganization of the nervous system [6] as well as resulting from the activation of multiple areas of the brain, which is described as a pain matrix [7].

This situation creates a recurring problem in the industry due to absenteeism, bad performance, impaired quality of services and products, and the dropout of personnel [8]. Also is difficult the objective determination of who should go to the medical service after experiencing pain as well as the classification if that pain is light or deep. Studies have shown that mental fatigue due to a high level of stimulation causes an increase in pain ratings, while the mental fatigue due to low stimulation level causes a decrease in pain ratings [3].

Considering the relationship between brain activity and pain, various pain study techniques have been developed using electroencephalography. Most of the cases that handle these techniques have used specialized laboratory equipment [9]–[11] studies are expensive, inaccessible and with specialized knowledge requirements for the use of the equipment. Talking about cost, EEG hardware has a high monetary cost, between US $1,000 and US $25,000 [12]. Regarding studies related to fatigue, researchers have made efforts by using electroencephalogram (EEG) and event-related potential (ERP) measures, to examine the physiological changes related to fatigue and attention [13].

With the development of new technologies in the field of brain computer interfaces (ICC or BCI), a field has opened to exploration in the area of brain activity measurement. The technological advances in recent years have allowed the implementation of new mechanisms for the design of adaptive user-interfaces, which seek to cover a greater degree of satisfaction of users when interacting with them [14]. A brain computer interface provides a communication channel that interconnects with the brain through an external device. In particular for BCI's based on electroencephalograms (EEG), the electrical potentials recorded from electrodes placed on the scalp provide a direct measure of the brain activity [15].

Considering the techniques used for pain analysis based on brain activity and the technology available in BCI's of scientific context, a methodological proposal was developed for the acquisition of EEG signals in test subjects while they are in a steady state, while simultaneously receive a series of stimuli based on electro stimulation [16] for generating muscle pain in the subject.

The purpose of these tests is to evaluate whether electro stimulation can be used as a painful stimulus for the study of the perception of pain due to work-related fatigue and to analyze the results that can be obtained using the equipment for the acquisition of EEG signals. Once this is analyzed, it is proposed to subsequently develop a protocol to visualize the changes presented in the brain activity and to identify the behavior of the signals to be applied in the development of pain indicators, as a measurement of work-related fatigue.

2 Materials and Methods

2.1 Computer Brain Interface (BCI)

It is proposed to acquire the EEG signals using the Emotiv EPOC+ device. This is a neuroelectric detection system that captures and amplifies brain waves generated by different mental "actions." This device can obtain 14-channel signals: AF3, F7, F3, FC5, T7, P7, O1, O2, P8, T8, FC6, F4, F8, AF4, based on the international 10-20 system, which It is an approved method to describe the location of the electrodes on the scalp, for the registration of EGG. This device also handles a filter for frequencies from 0.2 to 45 Hz, which can take up to 128 samples per second on each channel [17].

2.2 Software

Among the tools that Emotiv provides with the BCI EPOC +, is the Emotiv Xavier software development kit (SDK). This is composed of the Emotiv Xavier control panel, version 3.3.2 and the Bench Emotiv Xavier Test, version 3.1.20. The control panel allows the user to visualize the communication status between the BCI and the computer, as well as the connection status of each of the 14 signal acquisition channels. The Bench Test is the platform on which the acquired signals can be displayed in real time and where the person in charge of obtaining the signals can establish the acquisition parameters (Figure 3). The software provided by Emotiv will be used to know the connection status of the device and to perform a visual analysis of the behavior of the signals.

2.3 Electro Stimulator

Electrotherapy is a discipline within physiotherapy that consists of different ways of applying electromagnetic energy to the body, in order to produce biological and physiological reactions. An electro stimulator is a current generator, which produces electrical impulses with enough energy to generate an action potential (PA) in excitable cells: muscular or nervous (sensitive with analgesic and efferent results with motor results), and thus modify their most frequent state, which is rest [18].

The device to be used in the application of these tests is the Twin Stim Plus 3rd Edition equipment. This system is capable of generating 4 types of electro stimulation but for the purpose of this test and considering the recommendation of an expert, the study only considers the ones that are described in Table 1.

Table 1. Types of electro stimulation applied.

Acronym	Meaning	Description
TENS	Transcutaneous Electrical Nerve Stimulation	Tiny electrical impulses sent through the skin to nerves to modify your pain perception [16].
EMS	Electrical Muscle Stimulation	Impulses through the skin that stimulate the nerves in a treatment area. When the muscle receives this signal it contracts as if the brain has sent the signal itself [16].
Russian	Russian	Medium frequencies to provide electrical stimulation to muscles groups and is used to reduce muscle spasms as well as for muscle strengthening [16].

3 Methodology

The proposed methodology for the implementation of preliminary tests consists of the following steps:

1. Survey application to verify that the test subject complies with the requirements where the following conditions are basically excluded:
   a. People with pacemakers.
   b. People with tumors and metastases.
   c. People with thrombosis, thrombophlebitis and varicose veins.
   d. Diabetic and epileptic people.
   e. People with sensitivity disorders.
   f. People with bleeding processes.
   g. People in febrile and / or infectious states.
   h. Pregnant women.
   i. Hypersensitive or very nervous people.
   j. Children under 10 years.
2. Explanation of the process to the test subject and request with signed consent:
   a. It will be explained verbally, and the format will be provided with instructions and consent to be signed.
3. Electrode placement for forearm electrotherapy.
4. BCI set-up:
   a. Moisten electrodes.
   b. Installation of electrodes.
   c. Place BCI in test subject.

d. Verification of connection status on all channels.
e. Time taken in which the 14 channels show a good signal.

5. Placing plugs for noise in order to prevent noise from interfering with the results.
6. Relaxation process:

   a. Relaxation request through visual instructions.
   b. Time taken when the signals of the 14 channels are stable.

7. Encouragement application:

   a. The stimulus will initially be applied at level 1 managed by the Twin Stim Plus system.
   b. The stimulus level will be elevated in intervals of 5 in 5 based on level.
   c. The stimulus will be applied to the level in the test subject exterminates discomfort.

8. Measuring scales:

   a. The verbal rating scale will be used for the subject to express the level of pain after feeling.
   b. A record of the activity of the test subject will be made during:
      - Rest
      - Stimulus application.

9. Close the test:

   a. The BCI of the test subject will be removed.
   b. Electrodes will be detached from the forearm of the test subject.

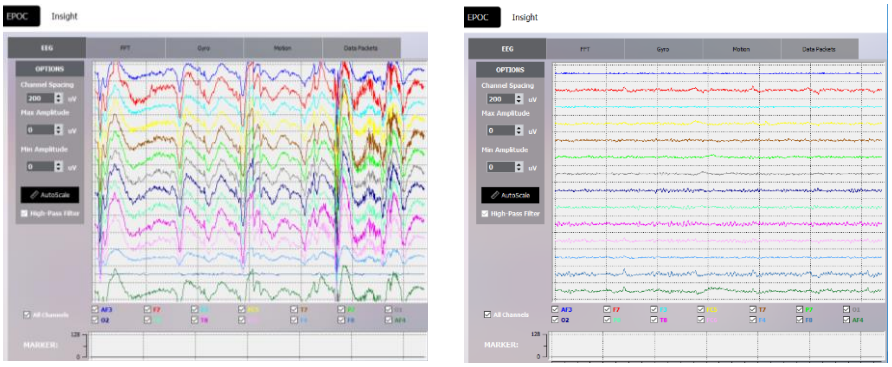
The test was applied to a sample of the population of 5 healthy subjects (3 women and 2 men) to whom the procedure was explained in detail and their consent was requested to carry out the tests. All subjects agreed to participate and signed the consent letter. To evaluate this proposal, preliminary tests were carried out considering the instruments and equipment mentioned above and strictly following the proposed protocol.

4 Results

Table 1 presents the information obtained. It shows the connection time, the time the system Emotiv EPOC+ takes to establish a good quality connection. The Relax time represents the time that the subject takes to relax, and this can see through the behavior of signals (Figure 3). Type of electro stimulation applied, EMS, TENS and Russian.

Table 2. Preliminary study results.

Subject of study	Connection time (min)	Relax time (min)	Type of electro stimulation applied (painful stimulus)	Electro stimulation that generates pain	Max Pain level
1	11:47	**8:33**	TENS/EMS/ Russian	EMS	1
2	3:24	3:00	TENS/EMS Russian	EMS	1/2/2
3	**22:19**	3:00	TENS/EMS Russian	EMS	2/2/2
4	10:39	4:15	TENS	NA	NA
5	4:10	3:15	TENS/EMS Russian	EMS	1/2/1



a) b)

Fig. 1. EEG signals obtained through Emotiv EPOC+. (a) Subject in normal state. (b) Subject after relax process.

Electro stimulation that generates pain, in this case, it is asked to the subject which of the three kind of stimuli applied they felt painful. Max Pain Level is the level that the subject said based on the verbal rating where 0 is for no pain, 1 for mild pain, 2 for moderate pain and 3 for intense pain.

The EEG response is different in every moment of the study. The Figure 1a shows the signal when the subject is not relaxed and the Figure 1b, shows the EEG signals when the subject is relaxed.

After the application of stimuli, the signals have different behaviors, but one relevant change was in one study subject in the channel AF4 (Figure 2). Is important to

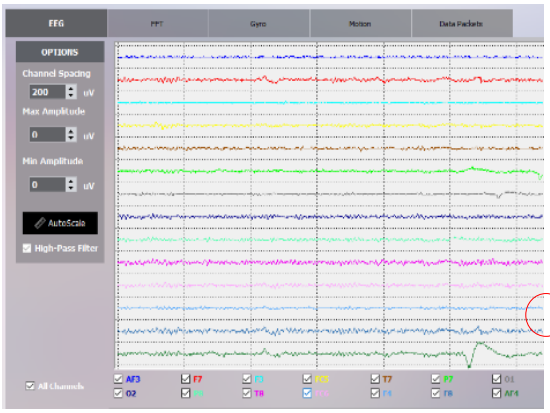


Fig. 2. EEG signals obtained through Emotiv EPOC+ with change in the channel AF4 after the application of EMS stimuli.

take into consideration, this change can be attributed to electromyography because is presented in the frontal area, so that can be the representation of the eyes blinking, but the subject was blinking along the study and this change is clear (graphically) when the level of the electrotherapy goes up. To identify these changes, a detailed analysis is made using technics of signal processing.

5 Discussion

The results of this methodological proposal are the questionnaires used for the application of tests, as well as the methodology established in order to standardize the tests in the study subjects. Although the preliminary test was applied to healthy volunteers, the generality of the proposal can be tested under diverse volunteers. The maximum level of pain obtained was 2 (moderate pain), and all the subject said that the only electro stimulation that is felted as a painful stimulus was the EMS.

About test times, the longest connection time was 22:19 minutes and the least 3:24 minutes, in this case it is important to note that the shortest time occurred in a man with little hair and the longest in a major with abundant hair.

The study subject that got the longest time to relax took 8:33 minutes and two study subjects relaxed in at least 3:00 minutes. It is proposed to repeat the study in a group of subjects with mental fatigue to visualize the possible changes in the results and integrate a test to determine the fatigue level in order to establish a correlation between fatigue level, pain level and EEG behavior.

It is also important to establish that this study proposes the use of a scientific context, BCI which offers advantages such as portability, easy placement and low cost, but sacrifices information in the bandwidth due to the fact that it manages a bandwidth of 0.5 at 50 Hz and it has been reported in pain studies that the frequencies associated with physical pain range between 30 and 100 Hz [19], so that incomplete information could be obtained when using this equipment.

6 Conclusions and Future Research

This preliminary test showed that the application of electro stimulation is considered a painful stimulus but in a range of low pain level, for this reason it could be consider another type of stimulus. For this, we proposed to continue with this work with additional conditions as, considering a population sample with work-related fatigue condition, application of a questionnaire to evaluate the level of fatigue, acquisition of EEG signals under conditions of stress. This work could contribute to determinate the relation between fatigue and pain perception and establish a pain threshold to determinate effective actions in the industrial environment.

References

1. Marcora, S.M., Staiano, W., Manning, V.: Mental fatigue impairs physical performance in humans. Journal of Applied Physiology, 106(3), pp. 857–864 (2009)
2. Dawson, D., Fletcher, A.: A quantitative model of work-related fatigue: Background and definition. Ergonomics, 44(2014), pp. 37–41 (2001)
3. Marek, T., Noworol, C., Karwowski, W.: Mental fatigue at work and pain perception. Work Stress, 2(2014), pp. 133–137 (1988)
4. Davis, K.D., et al.: CONSENSUS medical, legal and ethical issues. PubMed, 13(10), pp. 624–638 (2017)
5. Ploner, M., Sorg, C., Gross, J.: Brain Rhythms of Pain. Trends in Cognitive Sciences, 21(2), pp. 100–110 (2017)
6. Tatu, K. et al.: How do morphological alterations caused by chronic pain distribute across the brain? A meta-analytic co-alteration study. NeuroImage: Clinical, 18(2017), pp. 15–30 (2018)
7. Morton, D.L., Jones, A.K.P.: Brain imaging of pain: State of the art. Journal of Pain Research, 9, pp. 613–624 (2016)
8. Coombs, J.: Fatigue at work. Occupational Health in Auckland, 67(3), pp. 15–17 (2015)
9. Furman, A.J. et al.: Cerebral peak alpha frequency predicts individual differences in pain sensitivity. Neuroimage, 167(2017), pp. 203–210 (2018)
10. An, J.X., Wang, Y., Cope, D.K., Williams, J.P.: Quantitative evaluation of pain with pain index extracted from electroencephalogram. Chinese Medical Journal, 130(16), pp. 1926–1931 (2017)
11. Kumar, S., Kumar, A., Trikha, A., Anand, S.: Electroencephalogram based quantitative estimation of pain for balanced anaesthesia. In: International Measurement Confederation, 59, pp. 296–301 (2015)
12. Vivar-Vera, J., René, S., Figueroa, A., Rodríguez-Vásquez, M.A., Juárez-Martínez, U., Peláez-Camarena, G., Mercado-Gutiérrez, J.A.: Desarrollo de una BCI utilizando el potencial P300 y la diadema Mindwave®. 140(2017) (2008)
13. Boksem, M.A.S., Meijman, T.F., Lorist, M.M.: Effects of mental fatigue on attention : An ERP study. 25, pp. 107–116 (2005)
14. Avalos-Viveros, H., Molero-Castillo, G.: Towards a method for biosignals analysis as support for the design of adaptive. Research in Computing Science,147(11), pp. 9–19 (2018)
15. Minguillon, J., Lopez-Gordo, M.A., Pelayo, F.: Trends in EEG-BCI for daily-life: Requirements for artifact removal. In: Biomedical Signal Processing and Control, 31, pp. 407–418 (2017)
16. Emotiv: Emotiv epoc and testbench specifications. In: Brain Computer Interface Science Context EEG, pp. 1–7 (2014)

17. Cenetec, S.: Estimulador Nervioso Eléctrico Transcutáneo (TENS). Guía Tecnológica, 22 (2005)
18. Bright, P., Nottage, S.: Is there a correlation between objective and subjective pain measurements and gamma oscillation frequencies?. Journal of Pain Management, 2(1), pp. 1–7 (2018)

ISSN 1870-4069

Demand Forecasting Applied to Radio Frequency Identification Technology

Verónica Reyes de Loza[1], Edgar Gonzalo Cossio Franco[2], Ana María Pescador Oñate[1]

[1] Centro de Tecnología Avanzada Guadalajara, Mexico

[2] Instituto de Información Estadística y Geográfica de Jalisco (IIEG), Mexico

vereloz@hotmail.com, {anapesc, kofrran}@gmail.com

Abstract. Nowadays, companies have concern about having accurate inventories, inventory control is vital for employee organization, cost control and business profitability, therefore if the company do not have a proper administration there may be **s**tock shortages, accumulation of unwanted inventory, due to lack of automation, consequently generating wrong forecasts. Using RFID technology for inventory control, in addition to reduce efficiency problems in a logistics warehouse it's possible to analyze effectively the demand, and through different mathematical models, be able to generate a more accurate demand forecast, reducing uncertainty and making decisions regarding the forecasts obtained. The investigation allowed to conclude that, due to the particularities in the rotation of the PL's of the Ryder warehouse, it is appropriate to use the seasonal index method obtains a mean absolute percentage error (MAPE) of 13% in the forecast, adapting to the real demand.

Keywords: RFID, forecast, radio frequency identification, trend, seasonality, forecast error, product line, demand, MAPE.

1 Introduction

The purpose of this document is to expose different mathematical models to generate forecasts, leveraging the benefits of an inventory control system using RFID technology, where the control of input, output and updates the products in the inventory, will be controlled in a more efficient and faster way, avoiding delays in the operation, as well reducing of human errors.

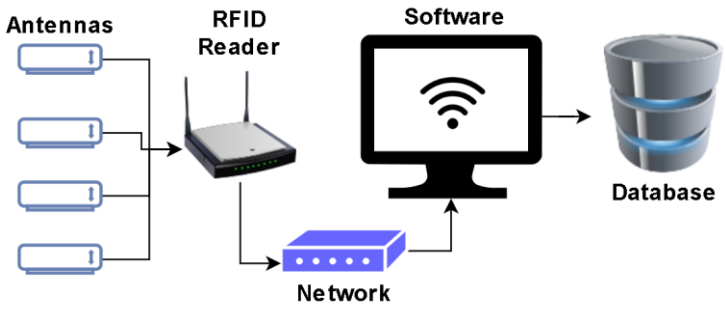


Fig. 1. RFID Structure.

2 Theoretical Framework

2.1 Structure of an RFID System

Radio frequency identification is a wireless and remote identification technology in which the RFID reader device linked to a computer, communicates through an antenna with a tag, over electromagnetic radio waves, generating a remote data storage and recovery system.

The basic components of an RFID system are:

Tags: also known transponders. Tags are composed of an antenna that is responsible for transmitting information, a radio transducer that converts the information, transmitted by the antenna and a microchip capable of storing the identification number and other data:

- **Passive tags:** They don't need an internal power supply, they are resonating circuits. They can reach distances between a few millimeters and 7 meters. Their size is smaller than usual. They are usually inserted in stickers' tags and have a lower cost.
- **Active tags:** They have an internal battery, so their coverage (hundreds of meters) and storage capacity is bigger. It can be used in areas with water, or with metal presence, and they are still suitable. They are more reliable and safer, therefore, more expensive and have a larger size.
- **Semi-passive tags:** A combination of the previous two tags.

RFID reader: The reader receives the information transmitted by the tags and transfers the data to the processing system. Composed by an antenna, a transceiver and a decoder.

Data processing subsystem: Software that is the intermediary between the reader and the application. It filters the data it receives, so only the useful information reaches the application.

To read the information of a tag, RFID readers emit a radio signal, once the tag is within reach of a reader, allowing the tag to be identified.

It is important to mention that the labels can be read remotely as shown in figure 1, without direct physical contact or aligned to the reader [1].

The antenna is responsible for transmitting and receiving through radio waves to perform communication between the components, making the energy transfer. Antennas are the most sensitive component of an RFID system.

RFID readers can generate interference with each other when installed incorrectly. These types of problems must be considered when making the definition and implementation plan to ensure an optimal installation. Therefore, the system has a mechanism that allows filtering to detect and remove duplicated RFID tags, likewise the anti-collision algorithm that is integrated in the RFID reader must be activated, because if more than one tag is read the data would be mixed and could not be read.

It's necessary to place the antenna in a position where the energy transmission is directed towards the tags, in this way, the data transmission is emitted optimally.

There are 3 characteristics of the antennas that contribute to the optimal reading of an RFID tag [2]:

Radiation pattern: It's the 3D energy field that an antenna creates. Also known as the reading area.

Aattenuation: the signal can be reduced or attenuated to limit the reading range of the tag or direct it to the tags that need to be read.

Polarization: is the orientation of the electromagnetic field transmission.

Passive tags are cheaper; therefore, it would be more suitable for implementation in a warehouse [3], due to the quantity of materials registered. Passive tags don't need any type of power supply. Through the signal emitted by the readers / antennas they create a small electric current, which is enough to operate the circuit of the tag in such a way that it can generate and transmit information [1].

Using RFID technology in an inventory generates different benefits [4]:

a) Identification of a product in the supply chain, automatically and accurately.
b) Reading is fast and accurate, without a direct line of sight [1].
c) Reduction of stock shortage.
d) Ability to inform the people in charge when it's time to replace the products on the shelves or when the items have been placed in a wrong place. [5]
e) Optimize the monitoring of products on pallets or boxes.
f) Tags can be reused.
g) Product recall control.

This leads to an increase in sales of products that are always available, optimizing the distribution process, reducing the excess inventory in the warehouse. RFID technology is frequently used to control products, being used in warehouse to control merchandise sold [6].

Some experts estimate that 30% of the inventory in the supply chain corresponds to existing safety stocks because the information of demand and supply is not accurate, nor is not updated in real time [7].

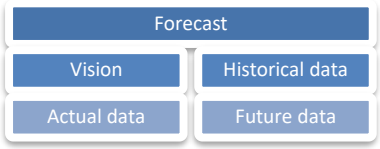


Fig. 2. Forecast elements [10].

RFID technology can provide automation for the process of identification of products, human intervention can be reduced, but not be eliminated, and however, there would be an increase in productivity, efficiency and quality of processes and an increase speed of product collection and product control.

Using the information obtained from the RFID system, additionally from the information obtained by the warehouse register, an optimal demand forecast can be generated, it's necessary to have a reliable database to generate an successful forecast [8], in this manner the information will be analyzed to select the most appropriate prediction method for the product line, depending on the category in which the product line is found.

If we can generate a more accurate forecast, the risks of product obsolescence can be reduced, the coordination of product arrival can be improved, advance reacting to high demand, improving customer services.

2.2 Forecast Demand Planning

Demand planning is the process of analyzing the evolution of sales and market in order to estimate their values in the future, this means, anticipate customer needs and determine strategies for production, purchasing and inventory that they can offer high availability with high profitability [9].

The future demand for a product line in a company can be modified by many factors and sometimes it is difficult to select an appropriate method to generate forecasts. The four elements of a forecast (see Figure 2) are: vision, historical, present and future data.

Statistical methods use historical data to find relationships within the time series [11], in this manner, the actual demand of a product line is examined, in which different factors that influence the series are analyzed, consequently generating an optimized forecast, closer to the demand that will be generated in the future. An optimal forecast allows a logistics warehouse to be prepared to manage the warehouse.

There are different demand behaviors for different product lines, which in some cases can be classified to use appropriate methods for the demand it generates, among these factors are [12]:

Seasonality: Demand changes because cyclical events, where a pattern of increases or decreases is repeated every certain months or season.

Trend: Average incline of increase or decrease over time.

Randomness: Unpredictable changes in demand.

Cyclic: Patterns of increments or decrements, which are presented in the course of longer periods.

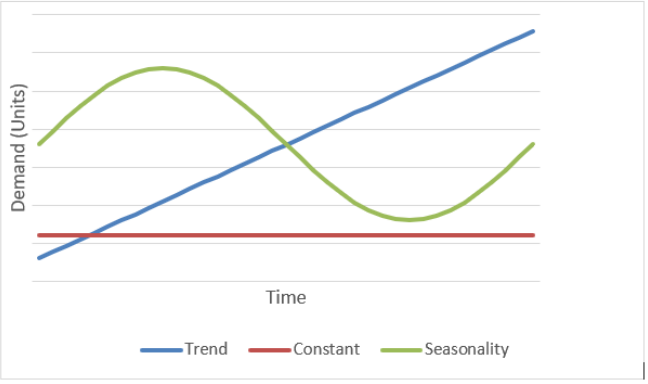


Fig. 3. Factors that affect demand [12].

The importance of a forecast for demand management is therefore essential to optimize all these processes, as well to be competitive, profitable and productive. [3]

Adjusting the appropriate algorithms for handling the data obtained from the RFID system, a demand forecast can be generated optimally for the product line, since there will be more control of input and output of the product in the warehouse.

It is important to mention that the product lines that are new, are not suitable for testing in this investigation, since it does not guarantee product rotation and there is a risk that they will not be formulated in future periods and remain in the inventory [13], therefore we will use stable PL's in the market, discarding new products for this investigation.

The different tools and prediction methodologies that were used in this research are described below.

2.2.1 Seasonal Indexes

The method of seasonal indexes is recommended in cases where the demand of a product has a well pronounced seasonal pattern.

Changing this pattern in series of times in a year. The seasonal index of the time series shows variability due to the influence of the seasons for example year by year.

This variation corresponds to the events that occur in the same months, where it can be modified by weather, holidays, school events, sports, etc.

The equations that are used are [14]:

$$\hat{X}_t = \frac{\sum X_{t+} Y_t}{2},$$

$$Z = \frac{\sum \hat{X}_t + \cdots + \hat{X}_{t+n}}{n},$$

$$S_t = \frac{\hat{X}_t}{Z},$$

$$P_t = d * S_t.$$

X_t	Demand for the seasonal period of the current year
Y_t	Demand for the seasonal period of the last year
$\widehat{X'}_t$	Average of the seasonal period of the current and previous year
S_t	Seasonal index
d	Calculated demand
Z	Average of the entire seasonal series
P_t	Forecast of the seasonal period

2.2.2 Simple Exponential Smoothing

The simple exponential smoothing method calculates the average of a time series with a self-correcting mechanism that searches for adjust the forecasts in the opposite direction to the deviations of the past, through a correction that is affected by a smoothing coefficient.

The simple exponential smoothing forecast is optimal for time series where demand has random patterns, to reduce the impact of irregularities.

The simple exponential smoothing method works through a smoothing constant alpha (α) that has a value between 0 and 1, where the value usually varies between 0.05 and 0.30 [15]:

$$\hat{X}_t = \hat{X}_{t-1} + \left(\alpha * \left(X_{t-1} - \hat{X}_{t-1}\right)\right).$$

$\hat{X}_t$	Forecast for the current period
$\hat{X}_{t-1}$	Forecast for the previous period
X_{t-1}	Demand of the previous period
α	Smoothing constant (values between 0.0 y 1.0)

2.2.3 Triple Exponential Smoothing (Holt-Winters)

The Holt-Winters method is an improved extension of the simple exponential smoothing method, while the smoothing technique provides a general impression, long-term movements in the data allows the elaboration of short-term forecasts [16].

It´s recommended to consider at least 21 previous periods of sales, which allow adjusting the values of the different components of the model [17].

The Holt-Winters method forecast is generated using the following equations [18]:

$$I_t = \left(\alpha * \frac{Y_t}{S_{t-L}}\right) + [(1-\alpha) * (I_{t-1} + T_{t-1})],$$

$$S_t = \ (\gamma * \frac{Y_t}{I_t}) + [(1-\gamma) * (S_{t-L})],$$

$$T_t = \ \beta * (I_t - \ I_{t-1}) + [(1-\beta) * (T_{t-1})],$$

$$F_{t+m} = \ (I_t + mT_t) * (S_{t+m-L}).$$

I_t	Exponential smoothing for the current period
S_t	Seasonality estimation for the current period
T_t	Trend estimation for the period
F_t	Forecast for the current period
Y_t	Demand for the current period
L	Number of months it takes for seasonality to be repeated
α	Smoothing coefficient (values between 0.0 and 1.0)
β	Smoothing coefficient for trend (values between 0.0 and 1.0)
γ	Smoothing coefficient for seasonality (values between 0.0 and 1.0)

2.2.4 Absolut Error on Forecast

This value calculates the absolute difference between the demand of the period and the forecast generated, adjusting the values in the equation to minimize the error in any forecast method [15]:

$$e_t = |X_t - \hat{X}_t|.$$

$\hat{X}_t$	Forecast of the current period
X_t	Demand of the current period

3 Methodology

3.1 Base Information for the Research

To implement the development of this methodology, historical data from 2017-2019 outputs from the Ryder warehouse were used, using the HP Inc. section, located in Guadalajara Jalisco.

Using the demand for the GP product line as a sample, where no new product lines have been considered, since the lack of historical data affects directly on the reliability of the results of this study.

Table 1. Seasonal index applied.

Period	2018-2019	2017-2018	Monthly average	Season index	Forecast
1	72593	95498	84045.5	1.22	85196.4
2	82510	78180	80345	1.16	81445.2
3	71561	84162	77861.5	1.13	78927.7
4	77277	80561	78919	1.14	79999.7
5	67099	71150	69124.5	1.00	70071.1
6	95321	98306	96813.5	1.40	98139.3
7	28710	62726	45718	0.66	46344.1
8	50449	36585	43517	0.63	44112.9
9	83875	81640	82757.5	1.20	83890.8
10	28276	74527	51401.5	0.74	52105.4
11	37463	58717	48090	0.70	48748.5
12	67526	72593	70059.5	1.01	71018.9
Total			**758593**		
Average			**69054.38**		

3.2 Definition of Forecast Models

The demand for the product line was taken to define the most appropriate forecasting method. Performing development simulation, through the Excel tool, the future requirements were determined using the methods of Seasonal indexes, Simple Exponential Smoothing and Holt-Winters, making comparisons between the methods to define the most appropriate, using as criteria the minor absolute error.

4 Results

4.1 Seasonal Indexes

Seasonal indexes method is used in demand series where there is a pronounced seasonality, this means that, there is a repetition of the increments and decrements every certain months.

The following example expose that the product line has a very pronounced seasonality, that is repeated year after year, so it's possible to get the seasonal index, for a forecast closer to his historical demand, see Fig. 5 and Fig. 6.

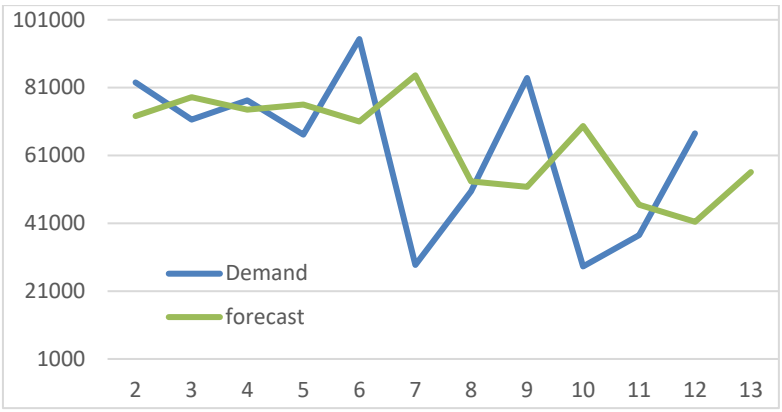


Fig. 5. Simple exponential smoothing.

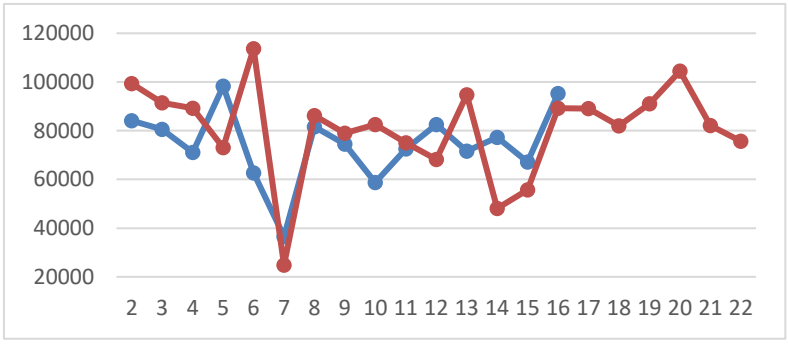


Fig. 6. Triple exponential smoothing.

This method adapts to the irregular behaviour of the demand, taking the seasonal index per month, because the series generated in this warehouse has annual cycles, so it is appropriate to use as historical data from the same period in previous years, without taking into consideration the trend of previous months on the same year, this method generated a mean absolute percentage error (MAPE) of 13%.

4.2 Simple Exponential Smoothing

Using the data obtained from the "GP" product line, assigning α = '0.56'. This method, as it was mentioned before, search's for reduce the peaks that are generated in an irregular demand, by random patterns.

This method is looking to counter the peaks generated on the demand, as we can observe on the figure, however this method is suitable for series that have very pronounced cycles where the cycle is notorious, and this method is not appropriate for the demand for the product line GP because of the irregularities on the series, that are not on a cycle every certain months of the year, generating a MAPE of 33%.

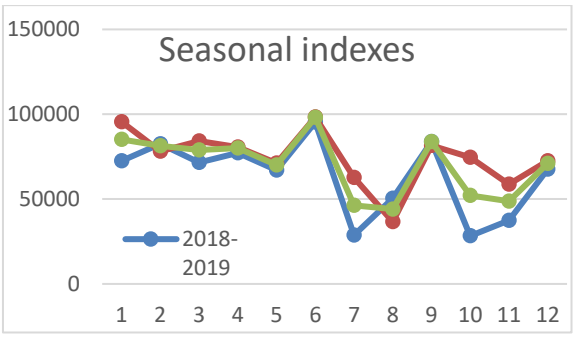


Fig. 4. Seasonal index applied.

Table 2. Simple exponential smoothing.

Period	Demand	Forecast
1	72593	
2	82510	72593
3	71561	78146.52
4	77277	74458.63
5	67099	76036.92
6	95321	71031.68
7	28710	84633.7
8	50449	53316.43
9	83875	51710.67
10	28276	69722.69
11	37463	46512.54
12	67526	41444.8
13		56050.27

4.3 Triple Exponential Smoothing

This method considers seasonality also the trend. Using the data obtained from the "GP" product line, the equation generated in the Holt-Winters method will be using α = '0.32', β = '0', γ = is assigned '0.64'.

In this case, the trend is repeated every few months, therefore I used a semi-annual trend, so 6 periods are added to calculate the seasonality, exposing them as the negative periods (-6, -5, -4, -3, -2, -1, 0) in the table.

This also allows to generate a forecast of 6 months in the future, the first 6 values of seasonality St in the 6 periods, are obtained by the seasonal index's method, mentioned previously.

Table 3. Triple exponential smoothing.

Period	Demand	At	Tt	St	ft+1
-6				1.22	
-5				1.16	
-4				1.13	
-3				1.14	
-2				1.00	
-1				1.40	
0				0.36	
1	95498	95498.000	0.000	1.1	
2	78180	85398	0	1.0	116230
3	84162	81177	0	1.1	99361
4	80561	78034	0	1.1	91531
5	71150	72937	0	1.0	89182
6	98306	81101	0	1.3	73011
7	62726	69354	0	0.7	113702
8	36585	79907	0	0.7	24871
9	81640	78534	0	1.0	86225
10	74527	77100	0	1.0	78991
11	58717	69923	0	0.9	82484
12	72593	69197	0	1.0	75000
13	82510	73910	0	1.2	68145
14	71561	68075	0	0.9	94701
15	77277	81464	0	0.9	48035
16	67099	86832	0	0.9	55733
17	95321	88757	0	1.0	89200
18					89132
19					82062
20					91034
21					104417
22					82129
23					75645

This method has adapted to the irregular behavior of the demand, since 6-month cycles are taken, however, it is impossible to prevent product falls for reasons beyond the control of the company, so there is (MAPE) of 24%.

4 Conclusion and Future Work

Forecasts are a very useful and important on the management of the inventory control because the information generated affects in different ways to the operation, allowing knowing how much product will receive, as well, the staff that will be required, improving the management of the operation.

The information obtained during this research reveals that, there is no method that fits all demands, because each PL has different characteristics, trend and seasonality.

In this scenario, it's important to make a classification of PL's to find the appropriate method for distinct time series, identifying which product lines have trend, as well seasonality, determine which product lines handle only seasonality, trend, or cycles. Because, generalizing a method for all PL's can generate forecasts distanced from real demand, meanwhile, analyzing the data series, it's possible to properly categorize, selecting the best method specified by the small differences between the classifications, creating a more accurate and appropriate estimation.

For the PL taken in the sample, it has been observed that the seasonal index method obtains a mean absolute percentage error (MAPE) of 13%, so it has been taken as the appropriate method for this system, since it shows a more accurate forecast.

Part of the future work consists in implementing different statistical methods to find which method generates the minor error in the forecast and define which method to use.

References

1. Williams, J.R., Miles, S.B., Sarma, S.E.: RFID technology and applications. Cambridge University Press (2008)
2. Banks, J., Pachano, M., Thompson, L., Hanny, D.: RFID applied. John Wiley and Sons, Inc. (2007)
3. Kyocera Document Solutions: https://smarterworkspaces.kyocera.es/blog/ importancia - forecast-gestion-demanda/ (2016)
4. Kimaldi-Lusa, L.: Kimaldi Electronics. https://www.kimaldi.com/blog/rfid/ ventajas_de_la_tecnologia_rfid/ (2019)
5. Sepúlveda, E.: Implementación de RFID en un almacén logístico (2018)
6. Anaya-Cantellan, A., Lopez-Martinez, I.: Research in Computing Science (2014)
7. García, L.F., Cano, M.C.: Pontificia Universidad Javeriana. https://repository.javeriana.edu.co/handle/10554/10291 (2013)
8. Pineda, S.E.P., Arroyo-Figueroa, G.: Research in Computing Science (2019)
9. Nambo, V.M.: Logistica MX. http://logisticamx.enfasis.com/articulos/ 67699-planeacion-la-demanda-la-logistica-contemporanea (2019)
10. Vitta, A.d.: Leshoteliers. https://leshoteliers.com/que-es-un-forecast/ (2019)
11. Rangel, H.R., Garcia-Carrillo, N.A.: Research in Computing Science (2019)
12. Osaín, C.L.: Monografías. https://monografias.com/trabajos97/planificacion -y-control-operaciones/planificacion-y-control-operaciones2. shtml (2019)
13. Perez, R., Mosquera A., Bravo, J.: Scielo - aplicación de modelos de pronósticos en productos de consumo masivo. http://scielo.org.co/scielo.php?Script= sci_arttext&pid=S1692-35612012000200014 (2019)

14. Gestión de Operaciones: https://gestiondeoperaciones.net/proyeccion-de-demanda/ejemplo-pronostico-de-demanda-utilizando-variacion-estacional/ (2019)
15. Vidal, C.: Fundamentos de gestión de inventarios. Cali (2003)
16. Berenson, M.L.: Estadística básica en administración: conceptos y aplicaciones. Prentice Hall (1996)
17. Billah, B., King, M.L., Snyder, R.D., Koehler, A.B.: Exponential smoothing model selection for forecasting. In: International Journal of Forecasting, Elsevier, pp. 239–247 (2006)

ISSN 1870-4069

Portable Device as Vein and Artery Viewer in vivo and in situ

Angélica Hernández Rayas[1], Eduardo Pérez Careta[2], Rafael Guzmán Cabrera[2], José Francisco Gómez Aguilar[3], Teodoro Córdova Fraga[1]

[1] Universidad de Guanajuato Campus León,
División de Ciencias e Ingenierías,
Mexico

[2] Universidad de Guanajuato Campus Irapuato-Salamanca,
División de Ingenierías,
Mexico

[3]CONACyT-Tecnológico Nacional de México,
Mexico

guzmanc@ugto.mx

Abstract. The location of blood vessels is a difficult technic, especially, when drawing blood and administer drugs in or other fluids. The use of the catheter for this use is not a new activity, it is a clinical assignment that must be improved daily, nevertheless the wounds cause can weaken vein, trauma, and difficult to use for the short term. The implementation of a lighting system with IR LEDs type geometrical matrix. The LEDs' characteristics are wavenumber 850 nm and 3 W power, those are adequate and efficient for detecting and irradiate blood vessels in patients undergoing venipuncture procedures. The lighting system has an infrared filter with conjunction with a CCD camera that is connected electronic tablet. The proposed device has an application software that allows us to visualize and acquire in real-time the area in the skin, recognizing the veins and arteries for the puncture will be performed on the patient's forearms. The application in the area of breastfeeding is proposed to help avoid reduce errors or punctures of the venipuncture procedure to patients. The device has been tested with patients and health personnel, allowing to improve patient care and obtaining certainty that the procedure is performed properly.

Keywords: Vein and artery viewer, blood vessels.

1 Introduction

The arteries have a tubular, thick-walled shape formed by different layers located throughout the body [1]. Arteries such as the aorta and the pulmonary are connected to the heart.

Its main function is to carry oxygenated blood to the whole organism from the heart. The veins are also tubular, but their walls are thinner than those of the arteries and they are found throughout the entire body (the main sites are the cava and the pulmonary vein) [2].

The function of the veins is to transport blood rich in carbon dioxide (C02). In the case of capillaries, the walls are much thinner than veins and arteries, and as such allows them to reach our entire body in large quantities. The capillaries allow a union between veins and arteries. Its function is vital since through them the exchange of nutrients with the cells takes place, the latter being oxygen, carbon dioxide, and waste [3].

Venous and arterial vascular accesses are very common in almost all hospital services. For example, in Hemodialysis [4, 5], Intensive Care, and the Operating Room [6]. To achieve a successful venous puncture it is necessary to carry out the venipuncture procedure includes several steps, among them the following: a) Inform the patient of the procedure to be subjected, reassure the patient by eliminating the tension and stress that can cause phlebotomy, b) Posture should be sitting because a passage of body water occurs from inside blood vessels to interstitial spaces, leading to an increase in test values for lipids, enzymes and proteins, c) preparation of the material which includes the collection tubes of objects used to clean the skin, syringes, etc. and d) Application of the tourniquet that consisting of an elastic band placed on the arm or wrist that increases the venous pressure, that should not exceed 1 minute [1].

Even today, the most widespread method of finding veins is the tourniquet and finding an improvement for viewing and venous palpation to reduce the chances of "clicking" in an area of error [7]. However, many patients struggle with venous access, along with the fact that many report discomforts and a lot of tension, and what they want is for the intervention to end as soon as possible [8]. The difficulty of achieving intravenous access is in many cases a challenge for health personnel fear of many patient experiences in the presence of a needle has become a problem for the administration. Medications, fluids, blood, or their derived products, parental feeding, and hemodynamic controls in severe patients are more common than previously thought. Also, the problem is accentuated in new-born's and patients in hemodynamic areas [9].

We are aware of different studies and publications about the prevalence of difficulties with vascular pathways inserted in admitted patients: for all cases around 45 % are peripheral; 5.5 % with a central venous catheter; 4.0 % with central peripheral insertion catheter; and 2.5 % with total parental nutrition catheter [4, 5].

This allows us to extrapolate their clinical, nursing, clinical care, and humanization management interest, as well as the special interest of the criteria related to technical applications of insertion, maintenance, permanent care, and the prevention of adverse phenomena among which infections are cited. Local and systemic with them related. Infectious problems associated with vascular accesses, concerning their location, are of two types: local (infection at the exit of the catheter, thrombophlebitis), and general (catheter-associated bacteremia and possible distant complications such as arthritis, endocarditis, etc.) [8-10].

In spare situations, it would be very useful to have a tool that allows the vein to be detected in the shortest possible time regardless of the pathology and condition of the patient and the operator [6].

For example, in the case of a patient in severe shock, there may be collapsed veins, which make it harder to find a vein for venipuncture and this puts the patient's life in danger if not assisted immediately.

The existence of a technique that succeeds in easy vascular detection could reduce the stress caused. Besides, this will significantly reduce the number of failed attempts at each puncture. At present there are several non-invasive methods for vein detection, among which are: (a) use of ultrasound images, this uses the eco-Doppler technique as a working principle for the location of the vascular network [7].

The visualization of the images is done through a screen and not on the patient's arm like in other techniques. (b) Surface patches of thermal liquid crystal created by lighting with the application of a thermochromic liquid crystal sheet sensitive to temperatures within the range of 32 to 38 degrees Celsius [8]. Once the sheet is placed, the patient must squeeze a grip placed on his hand to produce greater blood flow. The areas of the superficial vasculature will be observed on the sheet because they have a higher temperature than the surrounding tissue.

The operator can then insert the needle through the sheet in the differentiated place indicated by the vasculature. (c) Illumination with visible light: in this procedure venous intervention is carried out by placing an array of high power visible light-emitting LEDs on the surface of the patient's skin, so that the high-intensity light generates a contrast between the veins and the surrounding tissue, thus facilitating detection of their location [9]. (d) Use of near-infrared, which allows us to see a contrast between the blood vessels and the rest of the skin, in addition to eliminating some unwanted features of the skin surface and the environment. This method uses the area of the electromagnetic spectrum that extends from 760 nm to 1500 nm, called near-infrared spectrum [10, 11, 14, 15].

Biologically there is a spectral band from 700 nm to approximately 900 nm in which the incident light, with wavelength within that range, can penetrate deeply into the tissues. An attribute of the use of infrared is that the level of spectral absorption of deoxygenated hemoglobin has a maximum point in the region of the near-infrared spectrum; that is, we perceive objects with a certain color because they reflect a certain wavelength, corresponding to their color. Within the electromagnetic spectrum, only a very small portion is visible to the human eye. This portion is called the visible spectrum and includes those radiations with wavelengths between 380 and 780 nm. The infrared accounts for the part of the spectrum between 780 nm and 1 mm approximately [11-12, 15, 16].

The aim of this paper is the development presentation of a device that allows us to find blood vessels in people with difficult venous access. This procedure works with infrared light and it is for patients who are under treatment and frequently require venous interventions. It is a technical-scientific procedure that is easy to operate. This technology is available to virtually everyone and can be used by anyone seeking a positive impact on the success of medical procedures.

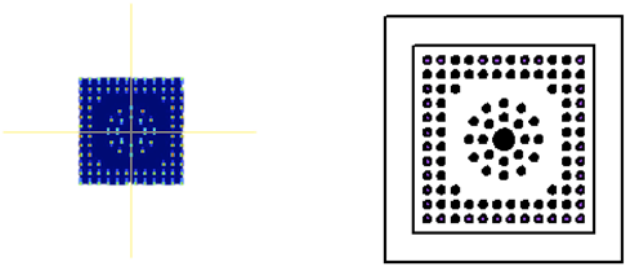


Fig. 1. Arrangement of 104 IR-LEDs**.**

2 Device Design

This device includes a commercial CCD: Logitech C270-720P [13, 14, 17], which one contains a filter that allows the infrared light visualization in addition to other filters integrated with the arrangement to exclude other wavelengths from the surroundings of the camera, namely those emitted by the IR-LEDs [15] and in this way help avoid alteration of uniformity in lighting. Its transmission percentage is significant from 700 nm to block visible light.

Commercial infrared LEDs were used, whose emission range falls within 750 nm to 810 nm. Different prototypes of infrared LED lamps were made by placing the camera in the center and thus to obtain a better image. The process is based on the design of commercial infrared cameras, especially those that are circular. Different designs of the lamp were tested to improve lighting [15-17]. Due to the greater effectiveness of the transmission principle, two lighting sources were built.

The first consists of a matrix of 40 emitting LEDs located under the forearm or fold of the elbow (ulnar fascia) and the second were used to achieve a surface uniformly illuminated and consisting of two arrays of five diodes located around and at the same height as the lens of the camera. To achieve the best configuration of the irradiation distribution of LEDs with Rhinos software simulation processes were carried out to allow us to see in advance how the behavior of the proposed configuration might be before its implementation was made in place[16].

For example, Figure 1 shows the map of the distribution that was finally built, because it was the one-sample case that showed better performance. In this figure, we can see an arrangement of 104 LEDs, distributed in three square arrangements (two of them with 44 and 36 LEDs separated of 10 mm each and the third arrangement of 4 LEDs with a separation of 60 mm between them) and two circular arrangements (one 12 LEDs separated by 25 mm and the other with 8 LEDs separated by 15 mm) with 90 grades aperture according to the company specification sheet.

Simulation of the array of IR LEDs was also performed to find the distribution of lighting generated by these LEDs at 11 cm distance from the CCD in the center of the lamp with an infrared filter to measure their irradiance and distribution homogeneous in the area to be analyzed. The results obtained from the simulation are shown in Figure 2.

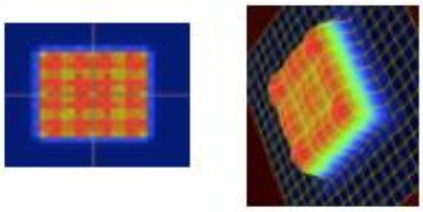


Fig. 2. The lighting distribution spectrum for the LEDs array implemented in this work.

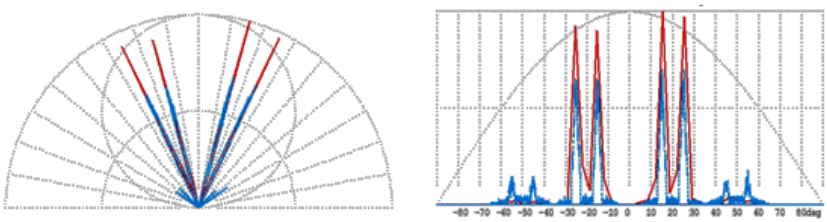


Fig. 3. Radiation is emitted by the array of 104 IR-LEDs.

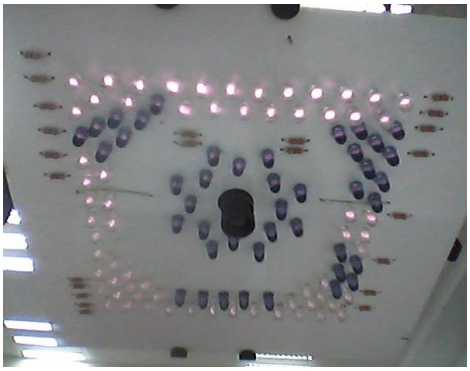


Fig. 4. IR LED Panel.

The polar graph shows the distribution of the radiation emitted by the arrangement of 104 LEDs, see Figure 3.

In Figure 4, the real image of the implemented LED array is shown, which allows us to maintain a uniformly illuminated surface, since it radiates frontally with the implemented LED array.

This method of lighting, in backlight, allows to obtain a digital image of the veins through the chamber, and the product of infrared radiation that penetrates the surface of the skin, part of the radiation is reflected and another is absorbed, by what the contrast represents the absorption part of the vascular network.

Image acquisition is done with the connection to a Nexus 7 Tablet using OTG adapter cable, an application (App) was made to connect the external USB camera

Fig. 5. Health staff using the prototype.

and capture images or video. Image processing is carried out by employing algorithms implemented in Matlab.

The study of the different effects of illumination uniformity and irradiance of arrays of LED sources have been studied from different areas for their versatility of applications. In particular, the implementation of LED radiation in the area of medical bioengineering has been experienced in areas of phototherapy, plant growth, and visualization of blood vessels [17, 18].

Generally, the wavelengths used in the biomedicine area are in the range of the visible light spectrum. Low-emission green laser sources have been used to improve the visualization of arteries and veins in patients [19-21]. This denotes the importance of having a method that facilitates this procedure, reduces complications in affected patients, and easy the work of the operator.

3 Results

Healthy men and women were evaluated in a range between 20-40 years, which have different skin color and complexion. Personnel from the health sector were needed to perform the first steps of the venipuncture process. The measurements were made on the right forearm by placing the lamp at an approximate height of 11 cm from the patient. The health sector staff easily visualized and identified the vein on the screen, which can be saved and sent by email to the doctor or for your medical history if requested. Figure 5 shows a team, which is using the prototype developed in a male patient.

In Figure 6, it is shown images of veins taken on patients when the IR lamp is projected on the area of interest.

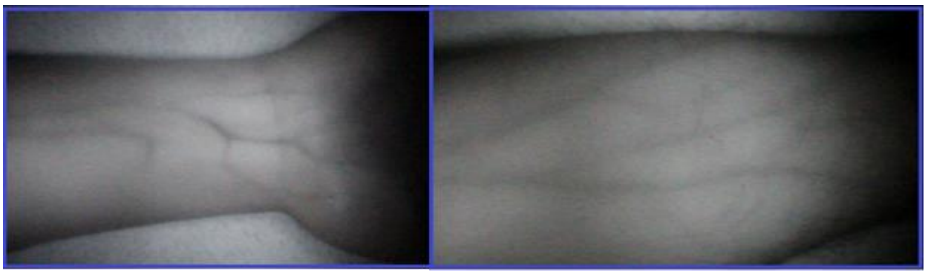


Fig. 6. Answer to the IR lamp on blood vessels recorded with the use of the implemented device.

4 Discussion

The importance of introducing a non-invasive technique that optimizes the blood collection method and reduces the number of failed venipunctures enormously benefits the neonatal and pediatric population. These patients are not the only ones with problems in the detection of veins. In particular, the patients with overweight, dark skin, diabetics, and difficult venous access can be considered due to several factors that make visualization of their veins difficult. Elderly patients may have hardened or fragile veins, they also tend to become tortuous because of poorly active circulation.

In patients with a dehydration condition, problems are also detected for the detection of veins because vasoconstriction occurs as a result of reduced blood volume. In diabetic or hypertensive patients there are lesions at the level of the smooth muscle. Vasoconstriction and hypercoagulation occur causing greater rigidity in the vessels and making canalization difficult. The lighting intensity of the LED panel is increased or decreased according to the type of skin and gender. This was done by varying its supply voltage.

The implemented device is now being validated in the medical area. More assessments are needed in newborns (0-4 months). The identification of veins on the fingers and use these results as biometric identifiers is another application of this device. The use of this blood vessel viewer on not clean hands is an advantage that this system offers.

Acknowledgments. Authors wishing to acknowledge at the University of Guanajuato for the partial support in this project under grant DAIP2019/59023. José Francisco Gémez Aguilar acknowledges the support provided by CONACyT: Cátedras CONACyT para jóvenes investigadores 2014.

References

1. Anesthesiology; Practice Guidelines for Central Venous Access. Anesthesiology, 116(3), pp. 539–573 (2012)

2. Bishop, L., Dougherty, L., Bodenham, A., Mansi, J., Crowe, P., Kibbler, C., Shannon, M., Treleaven, J.: Guidelines on the insertion and management of central venous access devices in adults. Int. J. Lab. Hematol., 29(4), pp. 261–278 (2007)
3. In, C., Plants, V., Invertebrates, C.I.: Circulatory System Circulation in vascular plants Circulation in invertebrates. pp. 1–5 (2019)
4. Docplayer: Estudio de Factibilidad de un Método No Invasivo para Detección de Venas en Neonatos y Pacientes Pediátricos (2019)
5. Chawla, Y.K., Bodh, V.: Portal vein thrombosis. J. Clin. Exp. Hepatol., 5(1), pp. 22–40 (2015)
6. Ramos, J.A.: Lesión del nervio cutáneo antebraquial lateral relacionada con la venopunción: ¿qué debemos saber?. Brazilian J. Anesthesiol, 64(2), pp. 131–133 (2014)
7. Paolinelli, G.P.: Ultrasonido Doppler de extremidades inferiores para el estudio de la insuficiencia venosa. Rev. Chil. Radiol., 15(4), pp. 181–189 (2009)
8. Cuper, N.J.: Near-infrared vascular imaging in peripheral venous and arterial access (2012)
9. Yu, G., Durduran, T., Zhou, C., Cheng, R., Yodh, A.: Near-infrared diffuse correlation spectroscopy for assessment of tissue blood flow. In Handbook of Biomedical Optics, CRC Press, pp. 195–216 (2011)
10. Limbad, N., Parmar, P.: Vein pattern detection system using cost-effective modified ir sensitive webcam. Int. J. Technol. Res. Eng., 1(9), pp. 975–979 (2014)
11. Strehle, E.M.: Making the invisible visible: Near-infrared spectroscopy and phlebotomy in children. Telemed. e-Health, 16(8), pp. 889–893 (2010)
12. Marín, F.J.S.: Aplicación del infrarrojo en la detección de problemas de circulación sanguínea en pacientes diabéticos. pp. 1–8 (2013)
13. Zeman, H.D.: Imaging system using diffuse infrared light (2003)
14. Sozo Yokogawa, Itaru Oshiyama, Harumi Ikeda, Yoshiki Ebiko, Tomoyuki Hirano, Suguru Saito, Takashi Oinoue, Yoshiya Hagimoto, Hayato Iwamoto: IR sensitivity enhancement of CMOS Image Sensor with diffractive light trapping pixels. Sci. Rep., 7(1), pp. 3832 (2017)
15. Raharijaona, T., Mawonou, R., Nguyen, T.V., Colonnier, F.: Local positioning system using flickering infrared LEDs. Sensors, 17(11) (2017)
16. Ochoa, C.E., Aries, M.B.C., Hensen, J.L.M.: State of the art in lighting simulation for building science: a literature review. J. Build. Perform. Simul., 5(4) (2012)
17. Veinlite: Clinically proven vein finders for iv access (2019)
18. Bosse, J.B., Tanneti, N.S., Hogue, I.B., Enquist, L.W.: Open LED illuminator: a simple and inexpensive LED illuminator for fast multicolor particle tracking in neurons. PLoS One, 10(11), p. e0143547 (2015)
19. Conway, K.M., Zhou, Y.: LED lamp with reflector and multicolor adjuster (1999)
20. Lee, E.C., Jung, H., Kim, D.: New finger biometric method using near-infrared imaging. Sensors (Basel)., 11(3), pp. 2319–33 (2011)
21. Choi, S.Y., Kwak, B.K., Seo, T.: Mathematical modeling of radiofrequency ablation for varicose veins. Comput. Math. Methods Med., 2014, pp. 485353 (2014)

ISSN 1870-4069

Digital Diversions for Educational Recess: An Evaluation of Mood Reinforcements with Interactive Multimedia

Tirtha Prasad Mukhopadhyay[1], Baidya Nath Saha[2], José Ruiz Pinales[1], Rafael Guzman Cabrera[1]

[1] Universidad de Guanajuato Campus Irapuato-Salamanca, División de Ingenierías, Mexico

[2] Concordia University, Edmonton, Canada

guzmanc@ugto.mx

Abstract. A set of short-duration interactive multimedia was designed to assess how their introduction in the middle of long stressful class-hours could trigger positive mood changes in adolescent students, and therefore induce better learning curves. The digital Adobe Shockwave software was used to combine multimedia including video, photography, humorous references, and music to evoke empathetic engagement and create relief from learning overload. Whether such digital interventions could affect mood in a positive manner both during consumption and later phases of learning performances were studied for a group of undergraduate students at the San Diego State University, California and The University of Guanajuato, Mexico (n = 88). Statistical analyses of mood changes indicate a trajectory of positive reinforcement. Younger positively motivated participants prior to the start of the game (age $\leqslant$ 19 years) engage more positively in digital diversions than reluctant and slightly older participants (Pearson *r* 0.311 vs. -0.189). The study indicates the possibility of using digitally created interactive diversions for better cognitive output in unilateral classroom scenarios. The findings underline the basic assumption that digital diversions are integral to contemporary socio-educative environments, are capable of being accommodated in the general educational structure in contemporary times.

Keywords: Brain breaks, interactive multimedia, recess, mood change, reinforcement.

1 Introduction

The rationale for this experiment is based on a three-fold purpose: the first being a need to understand the role of recess or transitory diversions for adolescents in the contemporary educational environment (Toppino 1991; Pellegrini and Smith 1993; Pellegrini 2005). Children, especially teenagers, poised to complete their undergraduate

studies are already having to confront an extraordinarily heavy curriculum and its correlated stressful task requirements.

We examined if a positively motivating recess or break, offered during long and intensive study sessions for a day, could be of benefit for students subjected to unilateral classroom scenarios.

The effects of recess, especially play activity, have been studied although results of such findings have been strongly debated (Jarrett 2002); the issues pertaining to usefulness of recess activities have not been fully resolved either in theory or in practice, especially in countries with advanced curricular programs.

Hence in the second part of our project we developed a unique short-duration interactive multimedia which students could access on their PCs, tabs or other similar platforms. The purpose was to design a humour-integrated deictic multimedia that could affect teenagers' mood states and alleviate pressure deriving from pedagogical strain. With hints taken from studies on digital engagement (Dickey 2005; Dickey 2007) the multimedia also incorporated a click and answer mechanism for recording students' responses, and assessing the trajectory of their mood.

Finally, in the third related and concluding part of the project we ran a statistical data analysis of the responses on a MATLAB program created to evaluate the effects of the multimedia on students. A post engagement semantic factor analysis determines if the hypothesis regarding digitally manipulated recess could reinforce learning behaviour and encourage better post-session performance for the selected teenagers.

2 Literature Review

The primary concern here has been to design an interactive media for recess or intervals during, or in-between, sessions of classroom based learning. In order to do that, we assumed that recess or break is necessary for cognitive reset, and further that such recess periods could be manipulated to induce positive mood states in young and adolescent learners. By definition recess is a time of physical diversion intended to trigger playful creativity, release and mood enhancement (Smith and Boulton 1990; Stevenson and Lee 1990; Pellegrini and Smith 1993). Recess breaks monotony, and provenly reduces stress and cognitive interference (Pellegrini and Bjorklund 1997).

We sought to engage students with play behaviour of an indoor (rather than outdoor) nature, and tried to arouse positive moods with the hope of achieving better task appraisals. In fact, we synchronized recess with mood arousal strategies in a combinatorial experiment uniquely adapted for our investigations. Recess is generally known to have beneficial effects on growth and learning capacities in children (Smith and Boulton 1990; Stevenson and Lee 1990). But studies on recess are mostly concerned with physical exercise and activity; the proven necessity of physical exercises has been integrated in terms of dedicated class hours of physical training or exercise (Bryan and Bryan 1991; Yasutake and Bryan 1995; Dillman et al 2008), sometimes in contra-distinction to recess as a conceptually undefined period of free and uninhibited enjoyment.

The question of recess time physical activity is old as Vygotsky's first analytical description of the role of games in the developmental process (Vygotsky 1967).

Piaget also emphasized on the rough and tumble interactions of recess as necessary aspect of a child's maturity and adjustment, as well as self-esteem (Piaget 1987). Recent studies have focused more on precise mechanics of physical exercise as a means of creative diversion. For example, experiments coding variables of physical activity have demonstrated that children preferred rough and tumble games as an inalienable part of their self-assessment and growth (Alderman, Beighle and Pangazi 2006).

Symbolic play was already being considered by Vygotsky to be an important factor in the growth of the child. Recess appears to provide the space for engagement, physical contact and mimetic conflicts which promote social accommodation and ambitions.

More recently, Pellegrini (2005) and Pellegrini and Bjorklund (1997) drew attention to the more incumbent stress factors that operate in learning scenarios. It is suggested that recurrent signal induction creates an overload for the cognitive system, and that this problem is particularly acute for learning situations in which breaks or diversions are eliminated. Cognitive interference may be considerably reduced by offering recess or time-out sessions; the digital opportunities for diversions has not been explored to the best of our awareness, although it is true that Dickey and his colleagues have roundly studied how things like big data, and socially interactive media might actually enhance various kind of non-curricular skills, especially of empathy (Dickey 2007).

When compared to non-laptop classrooms, students in laptop classrooms reported higher participation rates, more interest in learning, and a greater motivation to perform well (Trimmel and Bachmann 2004). Surveys of current students and alumni frequently show varying but generally positive levels of satisfaction with laptop programs (Finn and Inman, 2004; Mitra and Steffensmeier 2000). Demb, Erickson, and Hawkins-Wilding (2004), in a survey of current students, found that students felt laptops had a positive effect on their study habits and were important to their academic success. Granberg and Witte (2005), in one of the few studies that looked at non-structured classroom use of laptops, even promoted instant messaging as a benefit.

They claimed that this technology allowed students to make comments to or ask questions of fellow students "silently" without disturbing others, though they provided no evidence that this was beneficial to student learning. Two issues stand out in the research on the benefits of laptops. First, much of the research focuses on studying recess is also probably not related to questions of distraction. Even though literature suggests that emotional distractors impair goal-oriented task appraisal (Dolcos and Maccarthy 2006), the same criteria may not be applied to recess. Indeed, research on the presence of detractor type interferences like use of laptops inside classrooms, initiated during the same time demonstrates both positive and adverse results.

But adverse cases where laptop usage is shown to have distracting effects on working memory not all variable included in the class room scenarios have been considered (Fried 2008). Cases where multitasking seems to have been facilitated by laptop use is more supportive of greater accommodative potential – especially in our research. We have chosen a cross–section exposed to overburdened learning, to study how recess or breaks reduce cognitive interference by dissipating focus and feedback related to their tasks. The correlation between feedback and performance may not be a good indicator in all cases but it may be important to test how mood affects or interacts with feedback. (Kluger and DeNisi 1996; Kort et al 2001).

To minimize cognitive overload and to introduce short-term diversions in the form of digital games or interactive media could be thus useful, rather than proving to be a distraction in the learning process.

3 Mood Changer Paradigm

Coupled with the basic ideas on recess or diversion – although the latter term is more clearly confined to non-educational therapeutic or palliative efforts, - is the question of mood. Indeed 'recess' does not stand a chance in education, unless its orientation recognized. Mood states are emotional states and are usually considered more in terms of their valence, that is positive or negative condition but they have to be distinguished from protracted emotions or feelings, and are generally conceived as having more immediate consequential influences on future emotional states (Schinnerer 2004; Christensen and Lyager 2015). In this mood states are distinctive and consequential, "Mood is considered as a group of persisting feelings associated with evaluative and cognitive states which influence all the future evaluations, feelings and actions." (Amado Boccara et al 1992), In fact research shows that mood states are analysable in terms of the behaviors they promote. It is probably more helpful to connect mood states, rather than feelings, with learning abilities.

The precise causal relationship between positive moods and increased learning have been studied for a long time. It is known that positive mood facilitates memory and tasks of discrimination in children. Such experiments have been traditionally conducted by inducing mood states with affective narrative content –and then measuring performances of memory task designed specifically for the purpose (Potts et al., 1986). Related and more relevant measurements have demonstrated better acquistion of mastery in tasks involving discrimination **(**Masters et al. 1979). Aside of educational concerns mood has been seen to promote altruism when induced for experimental cases (Isen & Levine, 1972; Carlson 1988; Bryan 1999; Berto 2005). Brainwave entrainment also shows a correlation between mood and intrinsic motivation (Schlegel et al 2017). Mood states facilitate motivation. Whereas studies on behavioral enhancements induced by positive moods call for introduction of devices or strategies of mood enhancement: these are recorded in the literature.

The fact that mood states have consequential actions lead to productive studies on the effects of a positive mood on learning was studied productively by Bryan and Bryan 1991. Bryan and Bryan (1991), but also Yasutake and Bryan (2005) studied the effects of moods – more precisely, we may say- focussed study of the behavioral differences produced under experimentally simulated conditions, including interventions created with the help of videos, music, verbal illusions and other kinds of strategic settings (Bryan and Bryan 1991; Bryan et al 1996; Yasutake and Bryan changes are correlated to learning behaviors are scace but not unimportant. Infact, the behavioral fcets of positive mood and arousal could be studied for more accurate predictions of learning outcomes. Although in studies of Bryan et al, pellegrini and colleagues have generally concluded how inducing positive moods, even such as involving recess activities can enhance learning task achievements, both in case of impaired children with learning disabilities, as much as in normal students.

What mood induction strategies lack however – in experiments so far – are more explorative possibilities, especially in the context of the more obsessive engagements with media. A brief survey at the tools of experiments on mood and learning indicate that conventional methods of inducement have been used. Consider for example, moods were aroused using self-reports of well-being, odorification, or gifts of money Isen & Levine, 1972; Isen, Horn, & Rosenhan, 1973). We believed that there is ample opportunity to explore digital bases of emotions. In a sense, these are also socioeconomically conditioned possibilities of mood evocation, especially for societies that are more affluent and have access to technology. Our methodology involving mood states were appropriate for the target audiences selected in students cross-sections from both California, and Mexico

4 Digital Affordances

For our project, we have narrowed down and simplified the propositional structure of our experiment by combing both procedural theories into a single account of practical intervention in educational environments. A prescriptive bias underscores the process as we correlate and dissolve the issues of recess and mood arousal for predictable and positive outcomes. The conceptual synthesis may be represented in terms of Gibsonian affordances - as a quest to identify or implement a form of environment (Haynie 2008). Even here though we consider that restorative environments have a directly proportional impetus for heightened attentional capacity (Camargo 2006; Berto et al. 2010).

The question of creating recreational niches is intrinsic to education –but it is somewhat one-sided because of the recurrent emphasis on the need for physical exercise or engagement. The insights into leisure activities (and their relationship with educational tools) naturally leads us to consider the digital environment, and the emerging immersive affordances created by virtual or alternative worlds. The social networking sites are ample proof of how we are increasingly exposed to a digital workplace, or digitally interconnected environment are turning to the resources of the digital world itself, and not outside of it, to include things like social networking sites, or big data entertainment modules in the form of YouTube and other internet blogging activity, for simultaneous bouts of leisure and reinforcement.

We may note that on the one hand there is a distrust of digital platforms and media. Students in the young adolescent category may be prone to a growing and an almost obsessive engagement with social media -involving multimedia, video and video-games, and various kinds of interactive formats (Song et al.2004; Stafford et al. 2004; Yarush 2016).

But keeping that in mind another group of researchers find more evident positive effects of digital media on children, especially in contemporary settings in which they use not just computer, i.e. desktop, or TV and similar stationery portals, but also increasingly, devices like mobile phones, or internet enabled devices like tablets. Indeed, such media are implicating more time as also depth of involvement among all segments of users (Song et al 2004; Gross 2004). Our question is to examine if non-serious viewing and interaction may not be detrimental in all cases (Roaten 2011; Courage et al 2015; Mallon 2015). Advantages of diversions and game induced

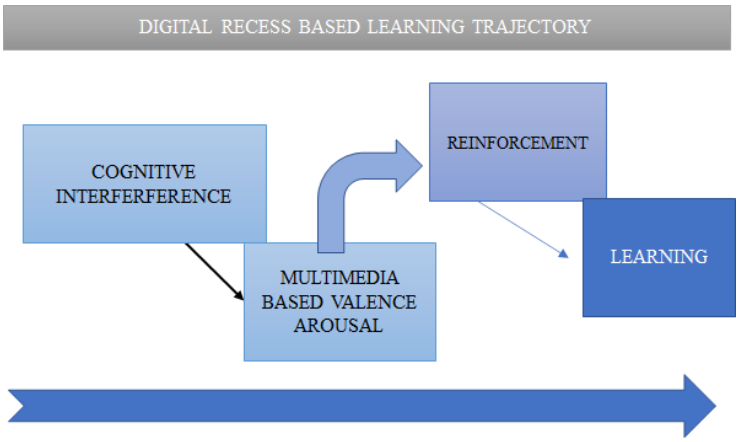


Fig. 1. A map demonstrating possible trajectory of digital interactive media for mood orientation and reinforced learning ability.

attention have also been already acknowledged (Abate and Benghiat 1993; Ophir et al 2009; Bekele 2010).

Such studies, specifically on advantages of interactive media, may have some promise for enhanced perception and learning (Bekele 2010; Courage 2015; Rosen 2011). Indeed, a good of research has already introduced us to the question of how differently abled persons may be empowered to cope with stress and imposing factors of the environment. Not only this, the effects of digital media on veterans and seniors have been closely studied. Digital platforms may provide independence as well as shared opportunities of entertainment and positive attitude building for broader social acceptance. It is a new area and has much potential for application, especially where digital media and various multi-method strategies could be used to alleviate depression and isolation of seniors, veterans, retired and challenged personnel (Wiemeyer and Kliem 2011; Anguera 2013).

For this purpose, we developed an interactive multimedia of very short duration to check if digitally open recess and diversions – if they are wisely incorporated within learning schedules, may actually help the learner to refresh and re-invigorate the passion for further learning.

The primary objective is hence to investigate if such diversions could be used for reinforcement of learning behaviors in adolescents who study within normal unilateral educational contexts of school and college.

4.1 Building the Media

Though there is a general agreement on the definition of narrative in interactive games, this project tends to follow a more open-ended interactive format which involves less decision making. Games have been traditionally considered as decision making modules of engagement. The authors here proposed an affect indecision for the interactive program. This keeps the possibilities open (Whitney-Vernon 2004). More significantly, the games are meant to register a score of liking, rather than competence

measures so common to other platforms (Deen 2015; Salen and Zimmerman 2005). Sladkey takes a very decisive experiment on engendering positive effects to its next level.

In his remarkable prescriptive quasi-games in his brain energizing manual Sladkey involves all different techniques of recess, physical ardour and sensuous interactions with arts and color objects to reinforce learning attitudes in young children "a quick physical and mental challenge that's like hitting the refresh button on your computer, but for your students" (Sladkey 2009; Stone 2015). The rationale for such brain breaks is most appropriate for development of a digital interactive media of the kind achieved for this project (Stone 2015). In brief, digital media offers more attractive, and more engaging features for the contemporary generation and every advantage of this fact has been taken. Not only this, it was thought meaningful to include a human and empathetic component in the design of the human which is much unlike what standard Mario prototypes could offer. The situations depicted are not stereotypes of programming language but human, video inputs and narratives that evoke emotive, mood changing responses. Hence the interaction between age, gender, and above all prior mood states are important for assessing how such games generate a trajectory of responsiveness for young learners.

5 Experiment

For this experiment, an online link was forwarded to select students (n= 86) at the San Diego State University and of students in the undergraduate program of Digital Arts at the Universidad de Guanajuato, Mexico. To all intent and purposes the basic objective was to allow these students to access the interactive media in the given link and to play the game for a certain period of time. One of the preconditions defined was to acknowledge if the participants had been subjected to a long duration of class or workshop for the day and were then allotted a free period to engage in the multimedia. The students may have felt necessary to take a break from the extent of learning hours administered for the day.

5.1 Methodology

Participants who engaged with the interactive media had to first answer a PANAS-POMS type questionnaire for mood assessment (Watson et al 1988). This test was not offered in a formal pen and pencil format but integrated into the media kit as a set of three questions. Responses had to be provided by clicking on emoticons to which specific numerical values were attached. The emoticons were included in a defined metrics, similar to the Likert scale prototype of -1 to +1, and translated into a 100 points incremental scale. Students had to respond to an emoticon corresponding to a three-dimensional structure of the emotion-valence scale (Barrett 1998). Hence by clicking on the emoticon participants were not merely indication if at that moment they were either happy or sad, but also what amount of arousal or excitement they experienced (Lane 1990; Jang 2015). In fact, the same mechanism of emoticons was deployed for the click-type interactive media, namely the five games. Not all participants were asked to play all games. They had a degree of choice and freedom not only to break the spell

of learning for the period but also to choose a game that suited their temperament and to play with its specific narrative.

5.2 Project Concepts and Techniques (Games 1 – 5)

The authoring intent in all five multimedia projects described in this article was to create short entertaining game-like experiences that could be experienced in a gallery installation or viewed in a browser on the internet. Adobe Director was the primary authoring tool because it provides tools for importing images, video, and audio. It has a user-friendly programming language called "LINGO" for assembling and authoring the content.

After the projects were completed, they were published from Adobe Director as DCR Shockwave files which could then be imported into HTML web pages. The programing facilitates visual and audio events such as random or sequential changes of images, video and audio; conditional events that occur if and when other occurrences are true; timing changes; mouse clicks; keyboard clicks; etc. Images were processed using Adobe Photoshop. In most cases, images were cropped masked and the color and tones ware manipulated and enhanced. In some cases, variations were produced to create animations. Videos were edited and composited in Adobe After Effects and Adobe Premiere. Audio was edited, mixed and manipulated using Audacity. Of the total of five different interactive medias developed all are comic recreational game-like reactions to life changing and life influencing occurrences.

5.3 Recess Interface Game 1

Walking in the Woods

Walking in the Woods presents a humorous metaphoric walk through life using self-portraits. The user clicks on my face and the perceived walking changes direction. Versions of a face change as clean-shaven or bearded. Changing directions symbolizes struggles with decision making in life choices and changing versions of the face itself as clean-shaven or bearded relates to the protagonists struggles with a self-image. The audio helps create a playful and comic atmosphere.

The sudden and abrupt change in direction of walk and the appearance of the face is brought by the click of the mouse. The click creates an unexpected reversal, with a resulting incongruously nervous release, thus eliciting laughter. Participants especially adolescents were visibly moved to laugh and toy out with the traveler's destiny in the game.

5.4 Recess Interface Game 2

Hit Me invited a reaction to how the traveler felt at the way the world was treating him. While the multimedia piece is idle, the user finds the image of the protagonist repeating random phrases such as "I just want to be happy in life". When the user clicks the "Z" and "X" keys, boxing gloves appear on either side of a face and strike the side of the character's head. The user is enabled to keep striking him with rapid motion. It is quite entertaining to watch him get beaten up, especially by kids-gloves.

Fig. 2. [a] *Walking in the Woods*. Game involving ability to change direction and spin the character's lifestyle [b] *Hit Me*. Game with fun evocation for pseudo-sadistic strikes [c]*Anti-War* is a game on gently mocking celebrities you dislike [d] *Dancing in the Kitchen* simulates efforts to break one's heart with love [e] *Selfies* elicits fun from a rapidly changing facial expressions against unpredictable and humorous backdrops.

5.5 Recess Interface Game 3

Anti-War was a reaction to the war. It contains a multiplicity of cartoon characters and childrens' music. The animated playful carnival was made up of a similar click-type shooting gallery in which adolescents could 'shoot' a figure of their liking or choice in order to transform the face into a funny cartoon character. The music is a song by the children and adds to the fun atmosphere. Occasionally, at random time intervals, a hummer drives by that can be shot at with a resulting explosion sound.

5.6 Recess Interface Game 4

Dancing in My Kitchen simulates a love and heartbreak game in which a person presumably tries to clinch love by throwing a dart at the character's heart. The piece also celebrates the freedom of the protagonist by showing him as, dancing in my kitchen. The playful interactivity occurs when the user moves a cross-hair around the screen attempting to line it up with the funny man's heart and then shoot the dart by pressing the "Z" or "X" keys) to hit the heart (break my heart). The protagonist then ducks while dancing and then return to the dance. As hard as the user tries, the user always misses.

5.7 Recess Interface Game 5

The photographs for *Selfies* were taken over one year period of everyday activities. There are over 800 self-portrait photographs in this project. The photographs of the character are set in the exact same location in each frame so that all photographs would align themselves with each other when animated. In this fun animated animation, the self-portraits change so fast that it is difficult to identify the background imagery. On the mouse-click, the image stops so that the composition of the self-portrait against a background can be seen. This way ever click sets up a colorful or scenic backdrop and a correspondingly emoting face.

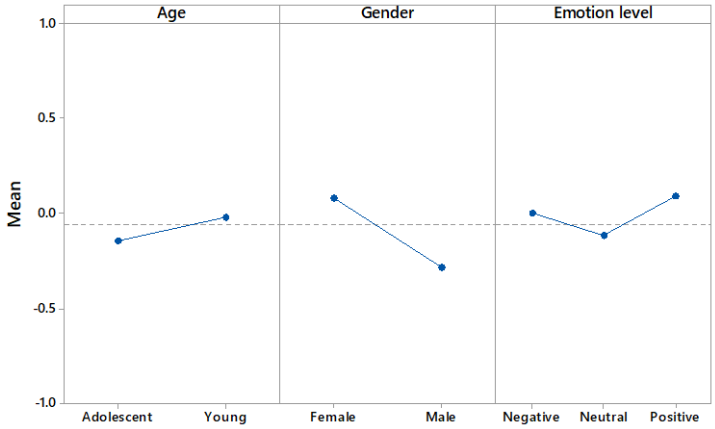


Fig. 3. Plot of main (age, gender and prior emotion level) effects on mood changer (the emotional level after all game).

5.8 The Survey Form and integration of multimedia projects

As previously stated, the multimedia projects were published from Adobe Director as DCR Shockwave files. The Shockwave files were then integrated into HTML pages by importing them into Adobe Dreamweaver. Along with the multimedia project, a caption and button to close the window (and return to the survey) was inserted into the page. The Survey Form was created using the "Forms" Feature in Google Docs. The Pre-Game questionnaire was assembled using the questions and emoticons. Each of the questions in the Interactive Media Questionnaire start with a link to the HTML page that has the respective multimedia project/game. After playing the game, the user closes the page with the game and returns to the Questionnaire.

6 Results

The three major observations for the interactive process have to be based on (a) age (b) gender (c) the emotive-valence score of participants prior to engagement with multimedia. Fig. 3 and Fig. 4 shows the main and pairwise interaction effects on the mood of the media on these participants. Of all three, perhaps the first, i.e. 'age' constitutes a specific target audience for the enquiry on what kind of difference in mood states are evoked. Consequently, the post-game trajectory of the experiment describes the difference that conditions and either motivates or demotivates participants during the recess. The 'submit' comment score comprises a semantic factor response. We translate this on the emotive-valence engagement score for assessing motivation levels after interaction and before the return to study-related tasks.

As Fig. 3 illustrates age has been divided into two levels of observation, (i) adolescent (age ≤19) and (ii) young (age >19) since the age of the participants vary between 13 and 25 years. Gender has been normatively considered on two levels,

Table 1. Chi-square test of independence for different factors (age, gender and emotion level prior to the game) on the emotion level after the game.

Factors	*dF*	Pearson χ^2 Square	*p*-values	Likelihood ratio χ^2 Square	*p*-values
Age	2	2.005	0.367	1.979	0.372
Gender	2	5.748	0.056	5.757	0.056
Emotion level prior to the game	2	4.104	0.392	4.452	0.348

Table 2. Chi-square test of independence for different factors (age, gender and emotion level prior to the game) on mood change (change of emotion level after the game).

Factors or Treatment		**Pearson r**	**Spearman ρ**	**Pearson Chi-Square**	**p-values**	**Likelihood ratio Chi-Square**	**p-values**
Age	Adolescent	-0.037	-0.079	10.07		12.134	
	Young	0.04	0.040	4.993	0.288	6.432	0.169
Gender	Male	0.159	0.129	4.645		3.860	
	Female	-0.079	-0.082	7.654	0.105	9.994	.041

'male' and 'female'. Finally, emotional level prior to game has been divided into three levels, (i) negative, (ii) neutral and (iii) positive as demonstrated in Fig. 1.

Sum of the scores are calculated from clicks on "I like", reverse of "I don't like" and "emoticon that describes me best" (since the last ranged from positive to negative on the visual scale). Score extractions corresponding to $\leq 5, 7, \geq 8$ have been considered as 'negative', 'neutral' and 'positive' respectively on the emotive- valence scale.

Fig. 3. shows that there is no significant difference in mean values of the mood change (emotion level after the game) for different level of age and emotion level, however substantial difference in mood change is noticed for two different levels of gender. We conduct the chi-square (χ^2) test of independence to test for a statistically significant relationship between factors (age, gender and emotion level prior to the game) and the response (emotion level after the game) and. We adopt the null hypothesis:

- H_0: There is no relationship between the factors and the response, i.e., they are independent.

Our alternate hypothesis is:

- H_a: There is a relationship between the response and factors and the responses, i.e. they are dependent.
- If $p \leq \alpha$ we reject the null hypothesis. If $p > \alpha$ we fail to reject the null hypothesis. We choose the value of Cronbach's α as 0.05.

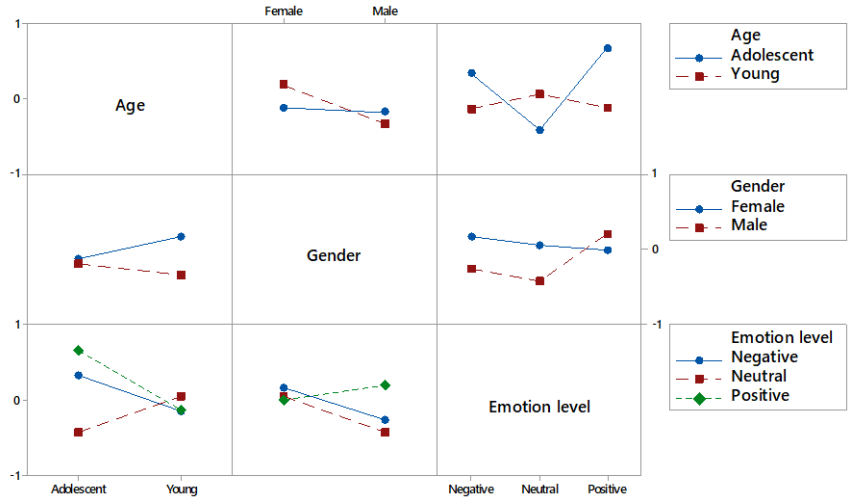


Fig. 5. Interaction plot of the effects of age, gender and prior emotion level on the emotional level after all game.

The *p*-values associated with these factors are shown in Table 1. Table 1 illustrates that the factor variable of gender is more significant than age and emotion levels prior to the game or interaction, because both of their *p*-values are much larger than that of age. However, the *p*-value for gender (0.056) is equal to the Cronbach's α level of 0.05, which indicates that it might be statistically significant and act as a mood changer.

To further identify the factors responsible for mood change through the entire application (difference between the emotion levels before and after the game), we conduct the chi-square (χ^2) test of independence for age and gender independently on two different levels, results for which are illustrated in Table 2. Results show that age and gender independently cannot account for any significant change of mood (since combined factorial *p-values* are greater than 0.05). This could imply that there is no sufficient evidence to believe that age or gender are natural determinants for the outcomes of the interactive recess. We would have to investigate if other psychological elements are also proactive in either predicting or understanding how they might affect the learners chosen for the experiment.

Fig. 5 demonstrates the interaction plot of the factors. An interaction plot is a plot of means for each level of a factor with the level of a second factor held constant. Interaction plots are useful for judging the presence of interaction. We conduct chi-square test of independence for interaction effect of age with gender, prior emotion level and combined effects of gender and prior emotion level with age on mood change registered after the game: the interaction effects are demonstrated in Table 3.

Similarly, Table 4 illustrates chi-square test of independence for interaction effect of gender with age, prior emotion level, and combined effects of age and prior emotion level with gender on mood change (change of emotion level after the game). Table 5 demonstrates chi-square test of independence for interaction effect of prior emotion

level with age, gender, and combined effects of age and gender with prior emotion level on mood change (change of emotion level after the game) due to digital diversion.

7 Conclusions

What is most import in designing such educational diversions is the necessity of incorporating an empathetic factor for the media. This is possible for designers who value long term acculturation and understanding of adolescent psychology and expectations of children at the very crucial and formative phase of their maturation. The game designs have a kind of reflexive and comedic value which appeals directly to the adolescent observer. Simple observation demonstrated that for most of the participants both in two different locations and countries, with similar social environments and values, would laugh and appreciate the comic gesticulations of the videos.

Thus, empathy and fun are ruled in for the games in a way an audio-visual prototype dependent on a programming sequence might never be able to achieve. Further This also goes ahead to show that games are not decision-making tools for cognition just as most gaming designers tendto show. It depends in fact on the nature of the game which may or may not involve cognitive decision making – although on some level decision tasks would have to be involved. But unlike what Sid Meir or Salen and Zimmerman showed in games they designed, mood enhancer games may have more of an emotive content. Games, as mood changers need to deal with affect and emotional arousal in a much more concerted manner rather than leaving the outcome solely on decisions. This suggests that game strategies are not exhausted in practice, nor is there much reference to this aspect in contemporary game design.

References

1. Abate, R.J., Benghiat, K.: Multimedia in a preservice reading course. Journal of Computing in Teacher Education, 9(3), pp. 13−16 (1993)
2. Alderman, B.L., Beighle, A., Pangrazi, R.P.: Enhancing motivation in physical education. Journal of Physical Education, Recreation & Dance, 77(2), pp. 41−51 (2006)
3. Amado-Boccara, I., Donnet, D., Olié, J.P.: The concept of mood in psychology. L'Encephale, 19(2), pp. 117−122 (1992)
4. Anguera, J.A., Boccanfuso, J., Rintoul, J.L., Al-Hashimi, O., Faraji, F., Janowich, J., Gazzaley, A.: Video game training enhances cognitive control in older adults. Nature, 501(7465), pp. 97−101 (2013)
5. Barnes, K., Marateo, R.C., Ferris, S.P.: Teaching and learning with the net generation. Innovate: Journal of Online Education, 3(4), 1 (2007)
6. Barrett, L.F.: Discrete emotions or dimensions? The role of valence focus and arousal focus. Cognition & Emotion, 12(4), pp. 579−599 (1998)
7. Bekele, T.A.: Motivation and satisfaction in internet-supported learning environments: A review. Journal of Educational Technology & Society, 13(2), 116 (2010)
8. Bauze, P., Quirke, J.: Developing policies and procedures within diversional therapy: a how to guide. Health and Leisure Communications (2004)
9. Bittorf, B., Wuethrich, C.: EmotiCon Interactive emotion control for virtual characters (2012)

10. Bryan, T., Bryan, J.: Positive mood and math performance. Journal of Learning Disabilities, 24(8), pp. 490−494 (1991)
11. Bryan, T., Mathur, S., Sullivan, K.: The impact of positive mood on learning. Learning Disability Quarterly, 19(3), pp. 153−162 (1996)
12. Camargo, C.: Interesting complexity: Sid Meier and the secrets of game design. Crossroads, 13(2), pp. 4 (2006)
13. Cattell, H.E.P., Schuerger, J.M.: Essentials of 16PF assessment. Hoboken, NJ: John Wiley & Sons, Inc. (2003)
14. Christensen, T., Lyager-Rasmussen, T.: Talk to me nicely (2015)
15. Courage, M.L., Bakhtiar, A., Fitzpatrick, C., Kenny, S., Brandeau, K.: Growing up multitasking: The costs and benefits for cognitive development. Developmental Review, pp. 355−341 (2015)
16. Cunningham, M.J., Wuthrich, V.M., Rapee, R.M., Lyneham, H.J., Schniering, C.A., Hudson, J.L.: The cool teens cd-rom for anxiety disorders in adolescents. European child & adolescent psychiatry. 18(2), pp. 125−129 (2009)
17. Deen, M.: GAME games autonomy motivation & education: How autonomy-supportive game design may improve motivation to learn. Doctoral dissertation, Ph. D Dissertation, Technische Universiteit Eindhoven, Eindhoven, NL (2015)
18. Demb, A., Erickson, D., Hawkins-Wilding, S.: The laptop alternative: Student reactions and strategic implications. Computers & Education, 43(4), pp. 383−401 (2004)
19. Dickey, M.D.: Engaging by design: How engagement strategies in popular computer and video games can inform instructional design. Educational Technology Research and Development, 53(2), pp. 67−83 (2005)
20. Dickey, M.D.: Game design and learning: A conjectural analysis of how massively multiple online role-playing games (MMORPGs) foster intrinsic motivation. Educational Technology Research and Development, 55(3), pp. 253−273 (2007)
21. Dillman-Carpentier, F.R., Brown, J.D., Bertocci, M., Silk, J.S., Forbes, E. E., Dahl, R.E.: Sad kids, sad media? Applying mood management theory to depressed adolescents' use of media. Media Psychology, 11(1), pp. 143−166 (2008)
22. Dolcos, F., McCarthy, G.: Brain systems mediating cognitive interference by emotional distraction. Journal of Neuroscience, 26(7), pp. 2072−2079 (2006)
23. Finn, S., Inman, J.G.: Digital unity and digital divide: Surveying alumni to study effects of a campus laptop initiative. Journal of Research on Technology in Education, 36(3), pp. 297−317 (2004)
24. Fried, C.B.: In-class laptop use and its effects on student learning. Computers & Education, 50(3), pp. 906−914 (2008)
25. Geckle, J.: Use of multimedia or mobile devices by adolescents for health promotion and disease prevention: a literature review. Pediatric Nursing, 42(4), pp. 163−167 (2016)
26. Granberg, E., Witte, J.: Teaching with laptops for the first time: lessons from a social science classroom. New Directions for Teaching and Learning, 2005(101), pp. 51−59 (2005)
27. Gross, E.F.: Adolescent Internet use: What we expect, what teens report. Journal of applied developmental psychology, 25(6), pp. 633−649 (2004)
28. Haynie, L.T.: Examining recreational activity and setting characteristics and their influence on mental restoration. Doctoral dissertation, Clemson University (2008)
29. Isen, A.M., Levin, P.F.: Effect of feeling good on helping: cookies and kindness. Journal of personality and social psychology, 21(3), 384 (1972)
30. Jarrett, O.S.: Recess in elementary school: what does the research say? ERIC Digest (2002)
31. Jang, Jin Yea, Kyungsik Han, Patrick C. Shih, Dongwon Lee: Generation like: comparative characteristics in Instagram. Proc. of CHI, ACM, pp. 4039–4042 (2015)

32. Lane, R.D., Quinlan, D.M., Schwartz, G.E., Walker, P.A., Zeitlin, S.B.: The Levels of emotional awareness scale: a cognitive-developmental measure of emotion. Journal of Personality Assessment, 55(1-2), pp. 124−134 (1990)
33. Lee, C.O.: Part I: Expanded psychosocial interventions in cancer care: an introduction to diversional therapy. Clinical Journal of Oncology Nursing, 7(6), 682 (2003)
34. Masters, J.C., Barden, R.C., Ford, M.E.: Affective states, expressive behavior, and learning in children. Journal of Personality and Social Psychology, 37(3), 380 (1979)
35. Mallon, B., Webb, B.: Structure, causality, visibility and interaction: propositions for evaluating engagement in narrative multimedia. International Journal of Human-Computer Studies, 53(2), pp. 269−287 (2000)
36. Meier, S.: Civilization IV. Hunt Valley, Maryland: Firaxis Games, 2K Games, Aspyr (2005)
37. Mitra, A., Steffensmeier, T.: Changes in student attitudes and student computer use in a computer-enriched environment. Journal of Research on Computing in Education, 32(3), pp. 417−433 (2000)
38. Ophir, E., Nass, C., Wagner, A.D.: Cognitive control in media multitaskers. Proceedings of the National Academy of Sciences, 106(37), pp. 15583−15587 (2009)
39. Piaget, J.: Possibility and Necessity. University of Minnesota Press, 1 (1987)
40. Pellegrini, A.D.: Recess: Its role in education and development. Education Review, Reseñas Educativas (2006)
41. Pellegrini, A.D., Smith, P.K.: School recess: Implications for education and development. Review of Educational Research, 63(1), pp. 51−67 (1993)
42. Pellegrini, A.D., Bjorklund, D.F.: The role of recess in children's cognitive performance. Educational Psychologist, 32(1), pp. 35−40 (1997)
43. Potts, R., Morse, M., Felleman, E., Masters, J.C.: Children's emotions and memory for affective narrative content. Motivation and Emotion, 10(1), pp. 39−57 (1986)
44. Roaten, G.K.: Innovative and brain-friendly strategies for building a therapeutic alliance with adolescents. Journal of Creativity in Mental Health, 6(4), pp. 298-314 (2011)
45. Rosen, L. D., Lim, A. F., Carrier, L. M., & Cheever, N. A.: An empirical examination of the educational impact of text message-induced task switching in the classroom: Educational implications and strategies to enhance learning. Psicología educativa, 17(2), 163−177 (2011)
46. Salen, K., Zimmerman, E.: Game design and meaningful play. Handbook of computer game studies, 59, 79 (2005)
47. Sladkey, D.: Energizing brain breaks. Corwin Press (2013)
48. Sladkey, D.: Engaging Teaching Tools. Corwin Press (2014)
49. Schinnerer, J., Self, G. T.: The Face of Emotion: A Guide to Emotions. (2004)
50. Schlegel, K., Vicaria, I. M., Isaacowitz, D. M., Hall, J. A.: Effectiveness of a short audiovisual emotion recognition training program in adults. Motivation and Emotion, 41(5), 646−660 (2017)
51. Smith, P. K., Boulton, M.: Rough-and-tumble play, aggression, and dominance: Perception and behavior in children's encounters. Human Development, 33, 271−282 (1990)
52. Song, I., Larose, R., Eastin, M. S., Lin, C. A.: Internet gratifications and Internet addiction: On the uses and abuses of new media. Cyberpsychology & behavior, 7(4), 384−394 (2004)
53. Stafford, T. F., Stafford, M. R., Schkade, L. L.: Determining uses and gratifications for the Internet. Decision Sciences, 35(2), 259−288 (2004)
54. Stevenson, H. W., Lee, S. Y.: Concepts of achievement. Monographs for the Society for Research in Child Development, Serial No. 221, 55(1–2) (1990)
55. Stone, J.: Effectiveness of Brain Breaks on Concentration and Ability to Answer Higher Order Questions in a 7th Grade Language Arts Class. Doctoral dissertation, The William Paterson University of New Jersey (2015)

56. Toppino, T. C., Kasserman, J. E., Mracek, W. A.: The effect of spacing repetitions on the recognition memory of young children and adults. Journal of experimental child psychology, 51(1), 123−138 (1991)
57. Trimmel, M., Bachmann, J.: Cognitive, social, motivational and health aspects of students in laptop classrooms. Journal of Computer Assisted Learning, 20(2), 151−158 (2004)
58. Yarosh, S., Bonsignore, E., McRoberts, S., Peyton, T.: YouthTube: youth video authorship on YouTube and diversion. In: Proceedings of the 19th ACM Conference on Computer-Supported Cooperative Work & Social Computing, pp. 1423−1437, ACM (2016)
59. Yasutake, D., Bryan, T.: The influence of affect on the achievement and behavior of students with learning disabilities. Journal of Learning Disabilities, 28(6), 329−334.E (1995)
60. Watson, D., Clark, L. A., Tellegen, A.: Development and validation of brief measures of positive and negative affect: the PANAS scales. Journal of personality and social psychology, 54(6), 1063 (1988)
61. Waite-Stupiansky, S., Findlay, M.: The fourth R: recess and its link to learning. The Educational Forum, Vol. 66, No. 1, pp. 16−25 (2002)
62. Wiemeyer, J., Kliem, A.: Serious games in prevention and rehabilitation—a new panacea for elderly people?. European Review of Aging and Physical Activity, 9(1), 41 (2011)
63. Whitney-Vernon, K.: Think you know what makes a teenager tick? Better think again. Financial Post, April 26 (2004)

ISSN 1870-4069

Digital Circlism: Algorithm for Generation of Artistic Images by Human Computer Interface

Tirtha Prasad Mukhopadhyay, José Ruiz Pinales, Rafael Guzmán Cabrera

Universidad de Guanajuato
División de Ingenierías, Campus Irapuato-Salamanca
México

guzmanc@ugto.mx

Abstract. Algorithmic programming is being used recently to generate visual effects templates in place of existing platforms like ADOBE or COREL Painter used to simulate textures and visual transformation on two-higher preference for digital circlism in at least 3 categories while one category namely, dimensional input images. Recently the Coin Denominational algorithm for Packing Circles have been used to generate circle textures over input imagery. Some amount of human intelligence, heuristics and algorithmic packing may transform imagery to create the kind of art that has been counted among the prized collections of our heritage. Starting from the filled in segments of primitive petroglyphs, Roman mosaics, to the pointillism of Seurat and the cubists, texture has been central to the artistic discourse. More importantly, this project takes its departure from digital circlism to analyze and assess why it creates aesthetic effects.

Keywords: Digital circlism, algorithmic art, pointillism, texture, machine art.

1 Introduction

Digital circlism has emerged in recent years for enhancing basic input images. Such enhancements generate novel and exotic artistic effects for viewers (Demaine 2010; Bhowmik and De 2013). Packing produces better articulation and consequently complex artistic experiences for the viewer. In principle, it secures effects similar to those evoked by nineteenth century impressionists who used brushstrokes to articulate objects and perspectives. Similarly, we know that 'pointillism' evolved as a technique in which points or dots of paint filled up surface areas for denotation of features and colors on landscapes. We may say for example, that effects produced by circlism resemble the pointillistic color distribution of Georges Seurat's neo-impressionist classic *La Gran Jatteue* (1884), which essentially consists of dots with points of color to fill planar segments.

But given the smooth effects of organization brought around by Seurat's points of color (which have a distribution pattern similar to circle-filling in digital circlistic technique), what – we may ask – are the common cognitively incumbent factors for this often artistically satisfactory perception?

If circles, like points are being packed to create a visual surface: what are the reasons behind their perceptual success? Could we possibly suggest a computational model for better articulation of segments within a scheme?

There is no doubt that packing circles into segments creates texture and consequently increases the psychological (perceptual) effects of the image (Meihoefer 1973; Levi and Klein 2000). This visual process has been already exploited by professional artists who have mostly used software like Photoshop CS4, *Studio Artist* or *Corel Painter* to simulate textures having exotic and visually complex surface-features and effects. Experts on Photoshop *Filter Forge* have used exclusive filters for packing geometrical units and composites over image segments. Now NP-hard *Euclidean Distance Transform* algorithms helps in programming similar visual effects with great reduction in time and effort.

Whereas previously an immense amount of time was needed to fill up segment-planes in a manual manner now a predictive algorithm-based program (coupled with some human intelligence) can render the same effects very quickly. The artist does not need the time to fill up the space since the algorithm itself covers designated contour bound areas. That this represents a further step in the direction of *Machine Generated Visual Art* (henceforth MGVA) there is no doubt. We shall try to underscore how MGVA may be used to achieve better results on a scale of perceptual preference for *novelty* in visual images. Depending on the success of MGVA programs we should be able to suggest whether or not machines could be capable of feeding the hunger of innovations in visual art, a tendency which has also marked conventional practices art history.

Instances of 'circlist' or more precisely packing techniques are found way back in time in Roman mosaics - although they use mostly the square shaped tesserae, sometimes with curved edges to create constitutive color blocks. Circular tesserae appears in Aztec turquoise mosaics representing circular eyes or ornaments on animal and supernatural divinities in the Great Temple of Tenochtitlan (McEwan 2006).

Experience show that in most cases involving circlism both in portraits and landscapes digital circlism produces considerable cognitive harmony. Our objective here is to demonstrate that packing based improvisations could be quickly and effectively exploited for aesthetic consumptions. A set of conventional images from cross-cultural and (pre-)historical art specimens was used as sample for examining perceptual satisfaction following Cupchik (2009) and Bullot's research on aesthetic satisfaction (Bullot 2013). A whole range of images, which create effects similar to packing - from aboriginal 'dot art' to nineteenth century post-impressionist 'pointillism' are chosen for response elicitation.

Responses were collected from subjects who are mostly experts or well initiated in the discourse of arts. In the next step of our investigations, examples of circlist art generated with coin denominational circle packing techniques were used to test perceptual success achieved with human-computer MGVA. For this purpose, we developed a set of inclusive and representative visual effects with circle packing algorithm on coin denominated EDT programming developed at our laboratories. ANOVA findings were based on (a) experts opinion on effects of aesthetic value and satisfaction first for conventional art-historical images and then for (b) images simulated at the IIT labs.

A comparision of results indicates possibilities and future directions future directions of machine art (Sephar 1988 Güçlütürk 2016). The problem of effects achieved with digital circlism need not be addressed at the fundamental level of aesthetic 'emotions' elicited as Cupchik (2009) or Zeki suggests (Cupchik et al. 2009; Lengen 2015).

Questions of 'perceptual organization' are more immediately relevant to this process. Visual effects of creative surprise and attention elicited by such imagery may be measured within shorter temporal limits (Tschacher et al. 2012; Ostrovsky and Shobe 2015; Marin 2016).

A brief history of the literature on psychological models of aesthetic perception would show that we need to develop a new satisfaction scale (Appendix A and B). So far research on aesthetic effects concentrates on aesthetic preference (Ramachandran and Hirstein 1999), color (Zeki 1980) symmetry and also, what is more relevant for us, gestalt (Arnheim 1954;;Locher 2003). In this case, we are perhaps looking at a questionnaire incorporating Need for Cognitive Closure (NFC) patterns in digital circlist imagery (Wiersema 2012). We thus developed a new aesthetics questionnaire on a proto-Likert scale, as well as ANOVA for closure with circle geometry (Kovacs and Julesz 1993; Levi and Klein 2000).

2 Suggested Possibilities of Cognitive Success With Circle Packing

Designing output images by denominational incongruent circles is an NP hard problem that has already been dealt with in non-aesthetic packing problems (Fejes Toth 1967; Dickinson 2011; Melissen 1995). If we were to posit the question of how is it that circle packing could achieve a psychologically optimal viewing experience for images we would have to take more than one factors of perception into account. There is evidence in the literature of multiple levels of integration at work for any process of perceptual organization (Hochberg and McAlister 1953; Hochberg 1999). These are also precisely the factors we had to keep in mind in deciding to build a set of circle packing effects for a set of images forwarded for a relevant satisfaction test questionnaire.

A. Circles May Be Cognitive Primitives

One answer to this problem is perhaps implicit in the fact that circles offer better visual organization than any other geometrical or polygonal form (Chow et al 2002; Kovacs and Julesz 1993; Levi and Klein 2000). In any set of images that are therefore depicted with circlistic fillings what therefore are the mental structures that are identifiable.

1. The circlism algorithm is specially suited to address an intrinsic - and perhaps the most crucially intrinsic property of vision, namely the fact that circles (or near-circular shapes) are more abundant in natural settings, along with straight or curvilinear formations (Sigman et al 2001; Chow eta al, Drezhe and Chevez 2002).

2. However, mostly if circles are indeed more abundant in nature circular contours may be more easily available than any other Euclidean shape - and this might as well be a component of organization based on experience (Field et al 1992; Chow et al 2002; Hochberg 2007; Pinna 2011).

3. The fact that curvilinear boundaries of circle arcs bind in more readily with curvilinear borders and have an overlapping effect on perception. The problem was discussed already in statistical variance analysis of gabor patches by Marr

and Hildreth (1992) and Field (1992). Therefore, it is evident that circlism will generate better results of perceptual organization – rather than other polygons, but evidence from tesserae of mosaics in the Roman and Middle Eastern architectural samples leaves the question open for other Euclidean shapes. Experiments with polygons tend generally to show that polygon edge detection samples better congruence in perceptual organization for architectural objects and edifices (Crow 1977; Mumford et al. 1987).

B. Contour Appreciation

But beyond this edge detection problem the more immediate example to consider here is that of circle packing, and the organizing principle of packing for the formation of more defined shapes in the 'figure'/ 'ground' dualism, as much as contour detection and perceptual binding between arcs. We could therefore say that contour detection and perceptual continuity - what classical Gestalt philosophers called the law of "good continuation" (Hochberg and MacAlister 1973) in matters of circles filling near-circles and ovoids is an important strategy that explains the success of perceptual organization.

That digital circlism may be a product of syncretic contour detection in which perception of both a perimetric enclosing area may be coterminous with contour binding or edge-detection. Is co-circularity a viable theme here? (Edge detection may be simultaneous with enclosure perception [Koffka 1935]). The hypothesis of good continuation has been defended with the help of quantifying measures. Perhaps digital circlism also begs a quantifying invariance analysis on responses to edge detection and congruence distance between arcs in circlism.

2.1 Contour Appreciation Ratio for Curvilinear Outline of Segments

Reasonably we could still identify contour matching as an integral feature in the hierarchical mechanism of perceptual goodness for shape detection, and of course which is not as such exclusive.

It seems that the success achieved with an EDT circlism program arises out of contour binding (Kapadia, Ito, Gilbert & Westheimer, 1995, Gilbert, Das, Ito, Kapadia & Westheimer, 1996, Lamme & Spekreijse, 1998 and Polat, Mizobe, Pettet, Kasamatsu & Norcia, 1998). Circle arcs, when packed in increasing numbers, is also proportionally increasing the metrics of binding: perhaps there is a directly proportional differential reduction in cognitive stress factors or conversely - and more plausibly for the increase in spatial coherence achieved because of contour binding.

Binding is logically better achieved with a defined outline. How is the binding factor to be calculated at all? Weber's fraction may be used to calculate an ideal arc or radian distance of the curve. The threshold has to be maintained for any successful binding act - we need to consult the literature to see if any average circle to outline can be deployed. Once an average is determined we could calculate the differential rise in binding length depending on the increase in the number of circles that are getting packed.

The question is if in this manner the comparison of contour binding to the increased contour binding achieved with successive iterations of packing may help in determining if there is an optimal level being achieved.

From common sense perspective a positively increasing contour binding length (value) will generate smooth perception. This smoothness effect might have been intuitively grasped by Seurat in his pointillistic techniques.

In this context it is necessary to point out if a sensitivity index is at work, as the "summation: area increases (Redmond et al).

C. Articulation

Not only this, a second point in this perceptual organization is that algorithms using circles as fillers may produce significant harmony by *maximizing* the number of circles for objects in the foreground, and inversely produce harmony of vision by *minimizing* the number of circles for the backdrop. This principle of foregrounding with the help of increasing density in packing parallels what Gestalt psychologists called the 'ground' (Koffka 1935; Wertheimer 1938).

They also refereed to this fact of perceptual organization of components on two dimensional images as the figure-ground dynamics in the Gestalt school - one in which figures (in the foreground) against an usually distant backdrop (background). Once the foreground is defined by a selective maximization of packing density for individual segments foregrounding would subsequently anticipate an artistic *articulation* involving packing to the extent of defining an object or aspect of the image. Packing density may in principle be followed in digital circlism to create impressions of relative depths in the features of objects depicted (Bhowmick and De). In individual instances of algorithmic packing the artist would have to intelligently predict or 'check' a range of circle or dot sizes in any task.

Articulation of 'figure' is achieved by means of density of circles packed into enclosed shape. There may a predictive hunger for contour binding as circles keep filling inside of a given space. Testing algorithmic circlism for a given set of digitally augmentable images demonstrates that circles act as efficacious cognitive primitives as much as for appreciation of contour and of articulation. Articulation/density is one among other factors which helps in recognition of depth of features (along with luminance, color etc. [Buhmann et al.]).

More notably one way in which depth sense is achieved is by defining a visual of an object in the foreground - already shown by Gestalt school philosophers like Wertheimer (1938) and Koffka (1935) as constituting a 'figure', as against the backdrop or 'ground'.

We would posit that numerically increase in articulation or density produces or anticipates figure recognition and depth (Koffka 1935). Depth is therefore another feature of the success achieved with digital circlism that we would have to factor in for the cognitive mechanisms for circlistic enhancement of images.

Here we explore the correlation between digital circlism and success in perceptual organization for artistic effects.

Closed loops formed by enclosing *figural* areas within portraits and a directly proportional amount of contour binding offers closure, - especially seen in the kind of model generated by the EDT algorithm that enables packing of a larger number of incongruent circles for articulation of shape and contrast to figures in the foreground.

Related to the same process is the binary tendency of reducing the number of circles for better articulation of background region in a given image. Is there an inversely proportional relationship to packing parameters for the figural and background components of an image. This may be attributed again to the contour appreciation feature

achieved with congruent arcs (Fields et al. 2004), as is also the case with articulated contour binding processes.

3 Multiple Depth/Articulation and Contour Appreciation are Both at Work

Some general observations to detailed finding lead us to consider the problem of how Digital packing algorithms functions in order to create satisfactory perception. Perceptual satisfaction to say the least does not depend on mere association, as empiricists observe but in terms of relational ratios between visual domains. The classic formulation of the problem is in Wertheimer and Koffka, in the dynamic interrelations between enclosures within a two-dimensional visual plane. The problem was already set by Wertheimer, Kopfermann and Koffka in the early decades of the last century by the title of the figure ground problem. Computer vision algorithm has to negotiate the figure-ground problem on the basis of vision on a two-dimensional plane.

First, there is more reason to side with Hochberg's claim and later supported by other quantitative research on the problem of perceptual goodness (Hochberg and McAlister 1953; Hochberg 2007). Recommendation for a multi-level perceptual structure may be said to have a more plausible contribution to the perception of perceptual wholeness - and this may include experiential parameters as already underlined by Johansson, Hochberg and others. In case of circlism the same contention holds to a large degree, since under all nontrivial consideration of aspects demonstrate the importance.

4 Experiments

4.1 Objectives of the Experiments

But why does algorithmic digital circlism create artistic effects? Could we possibly trace how or why algorithmic circlism generates effects typical of good aesthetic perception. How could such strong effects be generated? Perhaps the effects could be secured with human intelligence (heuristic) contributing to effective choice in increasing density for packing circles. There is a human element involved in what is an NP hard problem. But this heuristic anticipation could generate figural goodness by predicting circles on the basis of the figure ground problem in gestalt theory. Given our psychological enquiry into aesthetic textures we could possibly identify some of the sources of numerically denominated optimal circle packing algorithms for a successful generation of painting effects.

In this paper therefore we shall investigate an algorithm of packing incongruent circles for surface segments of images. The target of such algorithm is to *optimize* the number of circles within defined contours for achieving satisfactory visual experience for both specific enclosures and for total effects - perhaps in keeping with a statistical record of perceptions for a proto-Likert Primary Factor satisfaction scale (Michailidou et al. 2008; Godey 2009; Jin 2015).

The best model for assessment of the suggested good continuation method of perceptual organization should be to measure the variances of satisfaction generated in

terms of circles. Good continuation theory presupposes an increase in density. Circlism achieved with the Bhowmick algorithm for example demonstrates on a layman's observable level that increasing the number of circles in the definitive inner or geometrically smaller areas is creating better perceptual continuity.

A second parallel feature of perceptual organization is reflected in the manner in which contiguous and geometrically larger areas achieve perceptual organization with minimal overlap.

5 Method

5.1 Procedure

The basic experiment consists therefore of ascertaining the degree of *perceptual satisfaction* achieved with interactive human-computer execution on task, in this case already defined as circlist filling of segments by EDT. EDT gives a measure for introducing circles with projected radii - which again creates a feedback for the designer participant. A selection of four categorical image enhancement input correlates were fed with EDT algorithm, the quadruple being selected on the art historical practices of (a) tessaraed mosaic (b) prehistoric filled-in image prototypes - as in Australian dot painting (e) pointillism (d) popular celebrity circlism on PhotoShop and Corel generated celebrity portraits. A reasonably narrow range of conventionally enhanced input prototypes were chosen to facilitate contextual recognition for algorithm based digital circlist imagery generated specifically for the experimental verification of aesthetic value and satisfaction.

Four similar categories of input images were chosen for Digital Circlist application b the EDT Coin denomination algorithmic program - and the rsultant imagery was again subjected to a sensitivity and perceptual satisfaction scale. Any measures of such activities may also be scrutinized with the help of brainwave entrainment for uch experiences and a certain exact curve of interests generated.

The differences in the responses to these two separate categories were take into account to measure the deviation in perceptual preference for two kinds of targets.

Our solution Compute Euclidean distance transform (EDT) Use EDT to pack denomination circles in different segments. DP technique of solving the coin denomination problem.f Recompute the EDT of a segment after packing a circle and then greedily check feasibility of placing the next circle.

5.2 Participants

The maximum number of participants were selected from an arts backdrop with a considerable expertise in matters of execution as well as perception (xx being expert designers, academic evaluators, xx were students from final year of graduation in an arts and technology curriculum as well as a high). The standard deviation for age, gender, expertise counted in terms of number of years of exposure to visual art prototypes generated for the experiment.

Equipment description, program etc. Elaborated in terms of bhowmick and de 201. Random space filling: Attempts to solve the problem by iterative filling. Problems

Table 1. Average of responses to images of paintings and digital circlism by participants in perception test (n = 103).

	Clarity		**Color**		**Organization**		**Preference**	
	Paintings	**Digital**	**Painting**	**Digital**	**Painting**	**Digital**	**Painting**	**Digital**
Age > 21	1.2114	1.3286	1.1829	1.5143	1.2457	1.4657	1.1114	1.3857
Age ≤ 21	1.6361	1.8814	1.6631	1.9677	1.7358	1.9407	1.5957	1.9299
Digital Artists	1.5125	1.6281	1.5193	1.7483	1.5624	1.7075	1.3946	1.6485
Art Lovers	1.6008	1.7143	1.6321	1.8552	1.7299	1.8278	1.5519	1.7691
Computer Users	1.5616	1.7217	1.5813	1.7660	1.6010	1.7709	1.4360	1.7143

Table 2. P value tests for preferences to questions of clarity, color, organization and genera preference for individual images.

	P- Value for individual image pairs									
	1	2	3	4	5	6	7	Ho= Ha	Painting · Dig. Circlism	Dig. Circlism · Painting
Clarity	0.0809	0.0438	1.98E-11	0.1746	0.040451474	0.000647458	0.744597617	3	3	1
Color	0.0002	0.0923	5.50E-08	0.5171	0.000260736	0.003156185	0.147026698	3	3	1
Organization	0.0014	0.144204535	8.43E-10	0.0677	0.006086769	0.005267851	0.782426134	3	3	1
Preference	0.0003	0.651946506	2.32E-09	0.5549	0.002167947	0.016333574	0.319414029	3	3	1

Table 3. Art Lovers prefer more DC than conventional painting.

	To	Prom	P-V	Ar Lo>Ar Di
Digital Artists	63	1.683106576	0.02067807	True
Conventional Artists	73	1.791585127		

Increasing inefficiency as more and more circles are packed. Situation worsens in case of region with an arbitrary shape—a usual outcome of natural object segmentation.

6 Results

Two sets of statistical measures were obtained. In keeping with Sephar's more general claim in relation to sensitivity experiments for design with increasing complexity.

7 Conclusion

An understanding of cognitive preferences explains why packing of circles or polygonals based on segment recognition decisions will not alienate artists, but greatly reduce time and optimize the visual experience of finished products. Participants were asked to respond to a images of painting and digital circlism. Scores for at least four aspects clarity, color, organization and general visual preference were collected. Wilcox Rank sum test indicates that conventional artists have higher preference for digitl circlism.

References

1. Buhmann, J.M., Malik, J., Perona, P.: Image recognition: Visual grouping, recognition, and learning. In: Proceedings of the National Academy of Sciences, 96(25), pp. 14203–14204 (1999)
2. Bullot, N.J., Reber, R.: The artful mind meets art history: Toward a psycho-historical framework for the science of art appreciation. Behavioral and Brain Sciences, 36, pp. 123–137 (2013)
3. Cattell, H.E.P., Schuerger, J.M.: Essentials of 16PF Assessment. Hoboken, NJ: John Wiley & Sons, Inc. (2003)
4. Chow, C.C., Jin, D.Z., Treves, A.: Is the world full of circles?. Journal of vision, 2(8), pp. 4–4 (2002)
5. Crawford, P.V.: Perception of grey-tone symbols. Annals of the Association of American Geographers, 61(4), pp. 721–735 (1971)
6. Crawford, P.V.: The perception of graduated squares as cartographic symbols. The Cartographic Journal (2013)
7. Crow, F.C.: Shadow algorithms for computer graphics. ACM Siggraph Computer Graphics, 11(2), pp. 242–248 (1977)
8. Cupchik, G.C., Vartanian, O., Crawley, A., Mikulis, D.J.: Viewing artworks: contributions of cognitive control and perceptual facilitation to aesthetic experience. Brain and Cognition, 70(1), pp. 84–91 (2009)
9. Field, D.J., Hayes, A., Hess, R.F.: Contour integration by the human visual system: evidence for a local. Association Field Vision Res, 33(2), pp. 173–193 (1993)
10. Dickinson, W., Guillot, D., Keaton, A., Xhumari, S.: Optimal packings of up to six equal circles on a triangular flat torus. Journal of Geometry, 102(1/2), pp. 27–5 (2011)
11. Dubejko, T.: Infinite branched circle packings and discrete complex polynomials. Journal of the London Mathematical Society, 56(2), pp. 347–368 (1997)
12. Ekman, G., Lindman, R., Olsson, W.W.: A psychophysical study of cartographic symbols. No. TSN6. Stockholm Univ (Sweden) (1961)
13. Elder, J.H., Goldberg, R.M.: Ecological statistics of Gestalt laws for the perceptual organization of contours. Journal of Vision, 2(4), pp. 5–5 (2002)
14. Fejes-Tóth, L.: Minkowskian circle-aggregates. Mathematische Annalen, 171(2), pp. 97–103 (1967)
15. Graham, R.L., Lubachevsky, B.D., Nurmela, K.J., & Östergård, P.R.: Dense packings of congruent circles in a circle. Discrete Mathematics, 181(1-3), pp. 139–154 (1998)

16. Godey, B., Lagier, J., Pederzoli, D.: A measurement scale of aesthetic style applied to luxury goods stores. International Journal of Retail & Distribution Management, 37(6), pp. 527–537 (2009)
17. Grüsser, O.J., Selke, T., Zynda, B.: Cerebral lateralization and some implications for art, aesthetic perception, and artistic creativity. In: Beauty and the brain, pp. 257–293, Birkhäuser Basel (1988)
18. Güçlütürk, Y., Jacobs, R.H., Lier, R.V.: Liking versus complexity: decomposing the inverted U-curve. Frontiers in Human Neuroscience, 10(112) (2016)
19. Hochberg, J.: Levels of perceptual organization. In the Mind's Eye: Julian Hochberg on the Perception of Pictures, Films, and the World, 275 (2007)
20. Hochberg, J., McAlister, E.: A quantitative approach, to figural goodness (1953)
21. Koffka, K.: Principles of Gestalt psychology. 44, Routledge (2013)
22. Kovacs, I., Julesz, B.: A closed curve is much more than an incomplete one: Effect of closure in figure-ground segmentation. Proceedings of the National Academy of Sciences, 90(16), pp. 7495–7497 (1993)
23. Levi, D.M., Klein, S.A.: Seeing circles: what limits shape perception? Vision research, 40(17), pp. 2329–2339 (2000)
24. Marin, M.M., Leder, H.: Effects of presentation duration on measures of complexity in affective environmental scenes and representational paintings. Acta Psychol., 163, pp. 38–58 (2016)
25. McEwan, C.: Mosaics from Mexico. Duke University Press (2006)
26. Michailidou, E., Harper, S., Bechhofer, S.: Visual complexity and aesthetic perception of web pages. In: Proceedings of the 26th annual ACM international conference on design of communication, pp. 215–224 (2008)

ISSN 1870-4069

Prototipo de sistema para la clasificación de reseñas de películas

Abdiel Reyes-Vera[1], Francisco Javier Aguilar-Tecuapan[2], Juan Pablo Francisco Posadas-Durán[2], Grigori Sidorov[1]

[1] Instituto Politécnico Nacional, Centro de Investigación en Computación, Ciudad de México, México

[2] Instituto Politécnico Nacional, Escuela Superior de Ingeniería Mecánica y Eléctrica Zacatenco, de México, México

abdielreyes81@gmail.com, javiertecuapan@gmail.com, posadas.esimez@gmail.com, sidorov@cic.ipn.mx

Resumen. Clasificar es una tarea que consiste en ordenar información de una manera correcta, si no se tienen los conocimientos necesarios será difícil, por ejemplo, a una persona común si se le dan unos libros de filosofía los clasificaría a su propio entendimiento, lo cual sería muy diferente si fuera una persona docta en el tema, pero aun teniendo los conocimientos, si la cantidad de documentos, libros o textos es grande, una persona no lo podría hacer por sí misma, aun con la ayuda de un grupo de expertos esta tarea sigue siendo larga y fatigante llegando a consumir días, meses, incluso años. En este sentido muchas empresas que ofrecen servicios a través de la web como Netflix, Uber, Amazon, etc. tienen la problemática de manejar comentarios en sus productos o servicios, los cuales, al carecer de una clasificación adecuada, no son tomados en cuenta, además teniendo miles de comentarios por producto hacen que la tarea de revisar los comentarios sea abrumadora. Debido a que estas empresas dependen de la satisfacción del usuario respecto a sus servicios o productos, se ven en la necesidad de revisar los comentarios para tener una retroalimentación, teniendo una mejora continua, por lo que se ven obligados a tener un método para poder clasificarlos eficientemente.

Palabras clave: Clasificación, grandes volúmenes de información, satisfacción del usuario, máquinas de vectores de soporte.

System Prototype for Classification of Movies' Reviews

Abstract. Classifying is a task that consists of ordering information in a correct way, if you don't have the necessary knowledge, it will be difficult, for example, for a person common if you give him some philosophy books he would classify them to his own understanding, which would be very different if he were a learned person on the subject, but even having the knowledge, if the amount of

documents, books or texts is large, a person she could not do it herself, even with the help of a group of experts, this task it is still long and tiring, consuming days, months, even years. In this sense many companies that offer services through the web like Netflix, Uber, Amazon etc. have the problem of managing comments on their products or services, which, lacking an adequate classification, are not taken into account, also having thousands of comments per product make the task of reviewing the comments are overwhelming. Because these companies depend on satisfaction of the user regarding their services or products, they are in need to review the comments to have feedback, having continuous improvement, so they are forced to have a method to classify them efficiently.

Keywords: Classification, large volumes of information, user satisfaction, support vector machines.

1. Introducción

Servicios como Netflix, Crackle, Ebay, Mercado Libre, entre otros, ocupan los comentarios de la gente para poder retroalimentarse, sabiendo que les interesa a sus usuarios pueden mejorar la calidad de sus servicios o productos y a la vez mejorando sus ventas.

Si bien es cierto que estas páginas tienen métodos para categorizar sus artículos, la mayoría de estos métodos son escalas de estrellas de 1-5, donde 5 es el valor más alto, cuando ponemos cantidades cercanas como 2 o 3, hace que cambie la percepción, no permitiendo un juicio más preciso entre un valor y otro, en otros casos poner valores extremos hace pensar que realmente el producto fue una maravilla o una catástrofe, no dejando percibir realmente la opinión del usuario. Para estas empresas es necesario saber que desean u opinan sus clientes, por lo cual tener una aplicación para clasificar los comentarios o reseñas, sería de inmenso valor para las mismas.

Muchas empresas que han dejado de lado la opinión de los usuarios han tenido una tendencia de que vayan a la quiebra, un ejemplo de esto es Televisa, que durante años ignoró la opinión de sus consumidores, actualmente la empresa se encuentra al borde de la quiebra, todo esto por seguir con los viejos modelos, por el otro lado empresas que han escuchado abiertamente las opiniones de sus consumidores han avanzado de forma exponencial. Un ejemplo de lo dicho en el punto anterior fue que en 2004 se estrenó *Lemony Snicket's A Series of Unfortunate Events*, ésta es una serie de libros que fue adaptada a película teniendo un gran éxito, pero debido a problemas internos de la distribuidora que tenía los derechos, no se pudo seguir con las secuelas ya programadas, a partir de esa fecha muchos seguidores de la franquicia hicieron una petición en la página change.org para continuar con la saga, lo cual no ocurrió. No fue sino hasta diez años después que Netflix consideró el relanzar la saga, pero ahora en su propio formato, lanzó una encuesta para saber si el público realmente la deseaba, la respuesta fue masiva y Netflix confirmo la serie, la cual al paso del tiempo se ha convertido en una de las más importantes series hechas por parte de la compañía.

Unos meses atrás se supo de un caso en un Uber, donde el conductor acoso sexualmente de su pasajera, esta persona tenía varias calificaciones negativas, pero solamente estaban representadas por una escala de 1-5, al cometer el acto varias víctimas alzaron la voz en contra del agresor, reconociendo acoso por parte del

conductor a varias mujeres que viajaban solas. Algunas de ellas habían hecho una queja en la aplicación, quejas que estaban en proceso de revisión. Aquí se puede demostrar que el uso de este tipo de clasificación es muy ambiguo e inútil para los tiempos actuales.

2. Trabajos relacionados

El proyecto tomó su principal inspiración en el trabajo del Dr. Maas [1] donde en su trabajo su equipo buscó derivar un modelo probabilístico de documentos que aprende representaciones de palabras. Este componente hace que se no requiera datos etiquetados, y comparte su base con modelos de temas probabilísticos como LDA. Los componentes de sentimiento del modelo utilizan anotaciones de sentimiento para restringir palabras que expresan similares sentimientos y así evitar tener representaciones similares. Esto permite aprender eficientemente los parámetros para el objetivo conjunto función utilizando maximización alterna.

Esta idea que utilizo el doctor fue bien llevada a cabo, pero para propósitos de nuestra investigación optamos por otras opciones, por ejemplo, el trabajo del Dr. Sidorov [3] donde su equipo muestra que al considerar la similitud entre características para el cálculo de similitud de objetos en el Modelo de espacio vectorial (VSM) para algoritmos de aprendizaje automático y otras clases de métodos que implican similitud entre objetos. Aquí se asume que conocemos la similitud entre las características de varias palabras, por lo cual hace innecesario aprender de los datos. Dentro de esto, entendemos que hay palabras que mantienen una correlación, por ejemplo, las palabras comida y comer no significan lo mismo, pero de la misma forma sabemos que tienen cosas en común, son diferentes pero relacionados. Cuando no hay similitud entre las características, nuestra medida de similitud suave es igual a la similitud estándar. Para esto, generalizamos la conocida medida de similitud de coseno en VSM mediante la introducción de lo que llamamos "medida de coseno suave".

Dentro del trabajo se propuso varias fórmulas para el cálculo exacto o aproximado de la medida del coseno suave. Por ejemplo, en uno de ellos se consideró para VSM un nuevo espacio de características que consiste en pares de las características originales ponderadas por su similitud. Nuevamente, para las características que no tienen similitud entre sí, las fórmulas se reducen a la medida estándar del coseno. Los experimentos muestran que la medida suave del coseno proporciona un mejor rendimiento en nuestro estudio de caso: los exámenes de ingreso responden a la tarea de respuesta en CLEF. En estos experimentos, se utilizó n-gramos sintácticos como características y la distancia de Levenshtein como la similitud entre n-gramos, medidos en caracteres o en elementos de n-gramos.

Estos trabajos utilizaron métodos diferentes, por lo cual consideramos prudente utilizar los métodos convencionales.

3. Artefactos propuestos

Basándonos en el problema planteado, se pensó en buscar diversas bases de datos, al final se utilizó la desarrollada por Andrew Maas [1]. Esta base de datos es un conjunto

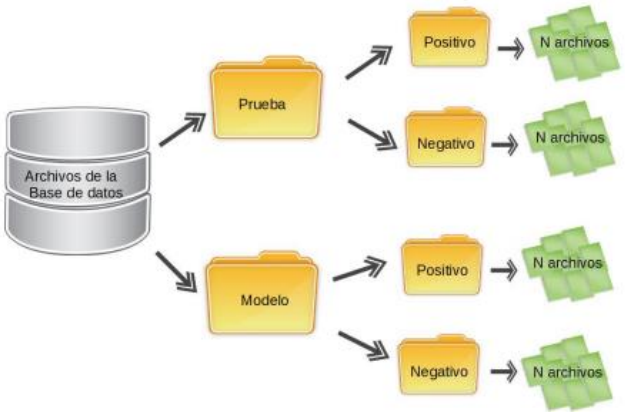


Fig. 1. Estructura de la base de datos.

Tabla 1. Texto antes y después de procesarlo.

Texto sucio	Once again Mr. Costner has dragged out a movie for far longer than necessary. Aside from the terrific sea rescue sequences, of which there are very few I just did not care about any of the characters. Most of us have ghosts in the closet, and Costner's character are realized early on, and then forgotten until much later, by which time I did not care. The character we should really care about is a very cocky, overconfident Ashton Kutcher. The problem is he comes off as kid who thinks he's better than anyone else around him and shows no signs of a cluttered closet.His only obstacle appears to be winning over Costner. Finally when we are well past the half way point of this stinker, Costner tells us all about Kutcher's ghosts. We are told why Kutcher is driven to be the best with no prior inkling or foreshadowing. No magic here, it was all I could do to keep from turning it off an hour in.
Texto limpio	Once again Mr Costner has dragged out movie far longer than necessary Aside the terrific sea rescue sequences which there are very few I just did not care any the characters Most us have ghosts in the closet Costner's character are realized early then forgotten much later which time I did not care The character we should really care is very cocky overconfident Ashton Kutcher The problem is he comes kid who thinks he's better than anyone else around him shows no signs cluttered closet His only obstacle appears be winning Costner Finally we are well past the half way point this stinker Costner tells us all Kutcher's ghosts We are told why Kutcher is driven be the best no prior inkling foreshadowing No magic here it was all 1could do keep turning it hour in

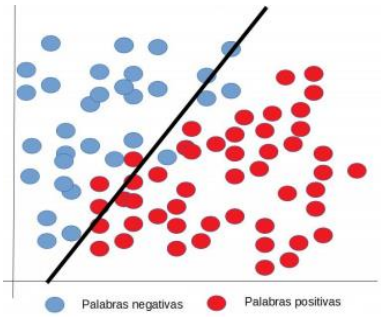


Fig. 2. Representación de las palabras.

de reseñas binarias, esto quiere decir, que le gustó la película o no le gustó a la persona. Además de ser tomadas de la página *MovieDataBase*, sin ser retocadas o corregidas esas reseñas. Ya que, así como las escribió el usuario así se ingresaron a los archivos de la base de datos. En conjunto las reseñas que contienen son 50,000 de las cuales 25,000 son de prueba y 25,000 son de entrenamiento. Estos archivos están distribuidos de maneras iguales para que la carga del modelo esté balanceada.

Generando 2 clases es el método que utilizaremos, ya que utilizaremos el modelo de la base de datos. Generando a su vez dos carpetas, la primera con la información que debe tener los datos, con los que se va a generar el modelo y la segunda con los datos de prueba, que sirven para saber la efectividad del modelo. En estas carpetas se debe tener una muestra del mismo número de archivos tanto en la primera carpeta como en la segunda carpeta, como muestra en la figura 1.

En la etapa se procede a la limpieza de datos, lo que se hace es leer la información con la que desea trabajar, que en nuestro caso es la base de datos, analizando qué palabras son las que no sirven para la creación del modelo. Este análisis se basa en eliminar de la semántica de los textos los signos de puntuación ya que no aportan nada al contenido, también etiquetas *HTML* que vienen en algunos archivos como por ejemplo *
, <br/>, etc* y algunas preposiciones que consideramos poco importantes y que no alteran el sentido o la raíz del mensaje en inglés.

Otras palabras que son eliminadas son las preposiciones ya que afecta muy poco la sintaxis del texto. Se generan versiones depurada de las reseñas (eliminación de etiquetas *HTML*) de la base de datos que se identifican por la extensión pre. Para ilustrar este punto se cita el siguiente texto almacenado en la base de datos con la que se está trabajando y fue sacado al azar. En el siguiente texto que tomamos de la base de datos, se marcará con negritas y se subrayarán las palabras que serán eliminadas en la versión preprocesada. Haciendo hincapié que utilizamos la librería *NLTK*, para toda la limpieza de los archivos, ver Tabla 1.

Los resultados de la metodología usada, constó de 20 experimentos diferentes, de los cuales nos basamos para decir que es la mejor propuesta o forma de tratar un problema similar al nuestro. Siempre y cuando se trate de clasificar datos con máquinas de soporte vectorial con representación lineal que fue el modelo con el mejor accuracy alcanzando. Hicimos una representación de los datos en la siguiente imagen. Ver figura 2.

Tabla 2. Resultados sin lematización.

Método	Lematización	Porcentaje	N-gramas	Tamaño vector
Liblinear	No	88.516	1	(24999, 111684)
Logical regresion	No	86,424	1	(24999, 111684)
Liblinear	No	87,036	2	(24999, 1595609)
Logical regresion	No	84,468	2	(24999, 1595609)
Liblinear	No	81,532	3	(24999, 3396177)
Logical regresion	No	78,392	3	(24999, 3396177)
Liblinear	No	75,8	4	(24999, 3748630)
Logical regresion	No	74,892	4	(24999, 3748630)
Logical regresion	No	69,34	5	(24998, 4431288)
Liblinear	No	69,284	5	(24998, 4431288)

En la línea que los separó se puede observar que nuestro modelo pretende trazar una línea que muestre de manera gráfica cómo los comentarios positivos o negativos pueden ser confundidos y al limpiar de la manera propuesta la tesis se puede compensar este error.

En esta etapa se probó formar diferentes vectores que se iban a procesar, donde variaba la longitud del vector pese a ser el mismo archivo precompilado y el mismo número de archivos tratados. En este caso que fueron de 12,500 archivos positivos y 12,500 negativos. Que se usaron para la creación del modelo matemático y otros 12,500 archivos negativos y positivos respectivamente. Dando un total de 100,000 archivos con aproximadamente 4,431,288 palabras.

Que es una cantidad abismal de texto para leer, ya que un novela consta de 40,000 hasta 90,000 palabras que según [2] es el numero promedio. Dentro de los modelos que se utilizaron fueron *logical regression y liblinear*, todos utilizando el modelo de *bag of word*. Estos vectores de palabras variaron sus parámetros de n-gramas de 1 hasta 5 dando como resultado que mientras mayor fuera el tamaño del n-grama perdía efectividad, ver tabla 2.

Cabe mencionar que el *accuracy* logrado fue mayor que al utilizar la lematización, por lo cual no presentamos esos resultados. Además de mostrar que el vector se hace más chico porque es más probable que se repita una palabra, a una secuencia de palabra, demostrando que entre más pequeño es el vector mejor resultado obtenemos.

Por el otro lado observamos que el hacer *n-gramas* de mayor tamaño, significa aumentar el tamaño del vector, dificultando la coincidencia con otros textos haciendo

que la frecuencia disminuya en los *n-gramas* dando como resultado un valor más burdo. Introduciendo en la máquina de soporte vectorial que exista una línea muy estrecha y mezclando las clases en el hiperplano aumentando el error de las predicciones. De los modelos que se usaron se concluye que el mejor es *Liblinear* por tener mejor efectividad que lógica de regresión con todos los experimentos realizados organizados de mayor efectividad a menor y se presentan qué técnicas se usaron. Poniendo en claro la ventaja de *liblinear* ya que ganó en los primeros cinco puestos de esta tabla usando diferentes técnicas. Ver tabla 3. Esto se debe a la sobre estimación de datos que genera el modelo de análisis de lógica de regresión. Por ende, nuestro prototipo solo cuenta con *liblinear*, *n-gramas* de tamaño 1 y sin lematización.

Tabla 3. Todos los resultados logrados.

Método	Lematizacion	Porcentaje	N-gramas	Tamaño vector
liblinear	no	88,516	1	(24999, 111684)
liblinear	si	88,292	1	(24999, 106814)
liblinear	si	87,14	2	(24999, 1528771)
liblinear	no	87,036	2	(24999, 1595609)
logical regresion	no	86,424	1	(24999, 111684)
logical regreslon	si	86,324	1	(24999, 106814)
logical regresion	si	84,488	2	(24999, 1528771)
logical regresion	no	84,468	2	(24999, 1595609)
liblinear	si	81,74	3	(24999, 3353022)
liblinear	no	81,532	3	(24999, 3396177)
logical regresion	Si	78,392	3	(24999, 3353022)
logical regresion	**no**	78,392	3	(24999, 3396177)
liblinear	Si	75,872	4	(24999, 3737830)
liblinear	no	75,8	4	(24999, 3748630)
logical regresion	si	75,02	4	(24999, 3737830)
logical regreslon	no	74,892	4	(24999, 3748630)
liblinear	si	69,548	5	(24998, 4428725)
logical regresion	si	69,512	5	(24998, 4428725)
logical regresion	no	69,34	5	(24998,4431288)
liblinear	no	69.284	5	(24998, 4431288)

Respecto a otros trabajos que podemos comparar seria el mismo hecho por Maas [1] que dentro de sus resultados obtuvo un resultado menor que el nuestro en varios casos, por ejemplo, Maas en su mejor resultado obtuvo 88.89 eso sin utilizar las etiquetas hechas por él, y con las etiquetas 88.33, ya que nuestro proyecto es el de clasificar las películas comparamos nuestro resultado respecto a este último *accuracy*, ya que nosotros ganamos por 88.55%.

4. Conclusiones y trabajo a futuro

Se logró un porcentaje de predicción mayor, que la lograda por el autor de la base de datos de 88.33 por ciento en el 2010. Al agregar una función que elimina puntos, comas, etiquetas HTML, algunas preposiciones, etc. Además de tratar de una manera convencional la bolsa de palabras, ya que el autor trataba de predecir posibilidades de palabras subsecuentes a la anterior generando ruido al sistema de clasificación. Además de ver el potencial que tiene este algoritmo ya que pueden ser usados otros idiomas como el español, el portugués o que tengan una estructura similar al inglés. Encontramos en este sistema de sugerencias una utilidad para trabajar con datos de gran tamaño y de manera rápida. Pudiendo dar soluciones en áreas de ventas, marketing, industrias, etc. En la minería de datos y análisis de la información de lo que opina un usuario de su producto o servicio. Haciendo más fácil la tarea de evaluar esa información, que resulta ser importantes para la mejora y creación de productos para los usuarios, por lo que muchas empresas pagan jugosas cantidades de dinero.

Como trabajo futuro, se plantea lo siguiente:

- Crear una base de datos en español, para que nuestro sistema sirva en español y no solamente en inglés.
- Compilar un conjunto de datos de prueba, para evaluar nuestro sistema en dicho idioma.
- Implementar un módulo que descargue información de la web para compilar bases de datos sobre reseñas.
- Probar otros clasificadores.
- Probar otras combinaciones de representaciones.
- Probar un diccionario de emoticones en diversos idiomas.

Agradecimientos. Agradecemos a CONACYT, SNI, IPN (SIP, COFAA), apoyo de proyectos SIP 20200859 y 20200797 y Conacyt A1-S-47854.

Referencias

1. Maas, A.L., Daly, R.E., Pham, P.T., Huang, D., Ng, A.Y., Potts, C.: Learning word vectors for sentiment analysis. 49th Annual Meeting of the Association for Computational Linguistics (ACL) (2011)
2. Freixinet, L.J.: Cuántas palabras tiene una novela. https://www.cafedelescritor.com/cuantas-palabras-tiene-una-novela/ (2020)
3. Sidorov, G., Gelbukh, A., Gómez-Adorno, H., Pinto, D.: Soft similarity and soft cosine measure: Similarity of features in vector space model. Computación y Sistemas, 18(3), pp. 491–504 (2014)

ISSN 1870-4069

Detección de humor en tweets en español utilizando clasificadores de Scikit-learn

Alexander Gelbukh, Francisco Hiram Calvo Castro,
Mitzy Gabriela Sánchez Sánchez

Instituto Politécnico Nacional,
Centro de Investigación en Computación,
México

gelbukh@gelbukh.com, hiramcalvo@gmail.com,
msanchezs1209@alumno.ipn.mx

Resumen. La identificación automática del humor resulta una tarea compleja, ya que lo que provoca el humor aún no está completamente caracterizado. Se han presentado varios enfoques para detectar humor siendo la mayoría en inglés [3]. Esta fue una de las razones por las que se presentó durante IberLEF2019 un reto que consistió en detectar humor en tweets en español [4]. En esta competencia se abordó la detección de humor como una tarea de clasificación de textos. Retomando algunas partes de este reto, en este trabajo se presenta la comparación del desempeño de varias técnicas de aprendizaje supervisado para detectar humor en tweets en español utilizando herramientas disponibles en scikit-learn.

Palabras clave: Detección de humor, aprendizaje supervisado, clasificación.

Humor Detection in Spanish Tweets Applying Scikit-learn Classifiers

Abstract. Automatic recognition of humor is a complex task, because humor is not yet fully characterized. Several approaches to detecting humor have been presented, most of them for English language [3]. This was one of the reasons, why a challenge was presented during IberLEF2019 that consisted of detecting humor in tweets in Spanish [4]. In this competition, humor detection was addressed as a text classification task. Taking up some parts of this challenge, this paper presents the comparison of the performance of various supervised learning techniques to detect humor in tweets in Spanish using tools available in Scikit-learn.

Keywords: humor recognition, supervised learning, classification.

1. Introducción

El humor puede definirse como la tendencia de ciertas experiencias que provocan diversión o risa. Identificar que provoca reír es una tarea compleja. A Platón y a Aristóteles, se les atribuye la "teoría de la superioridad", en la que establecen que la risa es provocada por un sentimiento de superioridad sobre otras personas o uno mismo en una situación pasada. En otras palabras, nos reímos con la desgracia ajena o propia. También, existe la "teoría del alivio" propuesta por Sigmund Freud, en la que explica que la risa es una forma de liberar energía reprimida de los pensamientos. Por otra parte, la "teoría de la incongruencia" propuesta por Blaise Pascal dice que la risa se provoca cuando las personas descubren una inconsistencia entre lo que esperan que pase y lo que en realidad pasa [1]. La teoría más reciente fue propuesta por el laboratorio de investigación sobre el humor de la universidad de Colorado, en la que explican que el humor solo ocurre cuando una situación que parece atemorizante o amenazante inmediatamente se vuelve confiable o segura. Esta teoría es conocida como la "teoría de la violación benigna" [2].

Desafortunadamente, no todas las personas se ríen en las mismas situaciones, ya que el humor es algo personal independiente del origen geográfico o cultural. Por esta razón, hacer que una computadora entienda lo que es el humor es complicado, ya que no queda claro como modelar las teorías descritas anteriormente. Se ha presentado evidencia de que se puede identificar humor con un enfoque computacional utilizando extracción de características en textos cortos en conjunto con métodos de clasificación [3].

Pero aún no está completamente especificado como tienen que ser estas características en especial para el idioma español. Esta fue una de las razones que motivo la competencia "Humor Analysis based on Human Annotation" (HAHA) en IberLEF2019 [4], la cual consistió en clasificar tweets en español como divertidos o no y asignarles un puntaje de diversión dado que el tweet fuera divertido.

Retomando la primera parte de la competencia, en este trabajo se presenta un análisis comparativo del desempeño de distintos clasificadores disponibles en la librería scikit-learn en la tarea de detección de humor en tweets en español.

2. Trabajos relacionados

Uno de los primeros trabajos para caracterizar e identificar humor, fue el presentado por Mihalcea y Strapparava [3]. Ellos trabajaron en textos breves conocidos como one-liners debido a la similitud estructural que existe entre los chistes cortos, los proverbios y encabezados de noticias. Hicieron su propio corpus extrayendo chistes de sitios de internet enfocados a humor, para conformar la parte de textos no humorísticos extrajeron títulos de noticias de Reuters, proverbios y enunciados del British National Corpus (BNC) y del Open Mind Common Sense (OMCS). Utilizaron tres técnicas para la clasificación automática: heurísticas basadas características de estilo específicas de humor, características basadas en el contenido y una combinación de las anteriores. En la primera técnica buscaron palabras específicas para identificar si alguno de los textos contenía antónimos, aliteraciones o groserías de modo que si se sobrepasaba de cierto umbral se le consideraba como humorístico o no.

Fig. 1. Metodología para la evaluación de clasificadores.

Tabla 1. Comparación de los resultados de los trabajos previos.

	Mihalcea y Strapparava [3]	**Castro et al. [5]**	**Adilism [6]**	**Kevin & Hiromi [7]**	**Bfarzin [8]**
Método	Extracción de características en conjunto con clasificadores de tipo NB y SVM	Extracción de características en conjunto con clasificadores de tipo SVM, DT, MNB y KNN	BERT ajustado en conjunto con un clasificador de tipo NB	Modelos utilizando BERT en conjunto con clasificadores de tipo NB y SVM	Modelo AWD-LSTM con QRNN
Datos	Encabezados de noticias, proverbios, oraciones del BNC y chistes de tipo *one-liners*	Corpus de tweets en español etiquetados como cómicos o no cómicos	Corpus de tweets en español etiquetados como cómicos o no cómicos proporcionado por la competencia		
F1-score	N/A	• 75.5% para SVM • 67% para DT • 70.3% para MNB • 73% para KNN	82.1%	81.6%	81%
Exactitud	• 96% para encabezados • 78.15% con oraciones del BNC. • 84.5% para proverbios	• 92.5% para SVM • 88.9% para DT • 91.4% para MNB • 91.7% para KNN	85.5%	85.4%	84.6%

En la segunda técnica abordaron la detección de humor como un problema de clasificación de textos utilizando un clasificador de tipo Naïve Bayes y uno de Máquina de Soporte Vectorial. Retomando las dos técnicas anteriores, en la última técnica crean un vector con las características identificadas en la primera técnica y lo utilizan para alimentar a un clasificador. En sus resultados, resaltaron que a pesar de que encontraron características que distinguen a los chistes de los textos no humorísticos, es necesario

profundizar en la búsqueda de estas características, por ejemplo, algunos chistes que contienen antónimos los tienen escondidos en el sentido de las frases y no solamente en palabras con significado contrario, algo similar sucede con frases ambiguas, incongruentes o que carecen de sentido común.

El primer intento de identificación automática de humor en español fue presentado por Castro et al. [5]. Ellos trabajaron con tweets en español asumiendo que la longitud de un tweet evita tener partes cómicas y no cómicas al mismo tiempo. El problema de detección de humor se abordó con un enfoque de aprendizaje supervisado, es decir que propusieron una función que identifica humor a partir de datos etiquetados. Probaron con Máquinas de Soporte Vectorial, Vecinos Cercanos, Árboles de Decisión y Naïve Bayes Multinomial. Recolectaron alrededor de 47,000 tweets provenientes de cuentas enfocadas a humor y cuentas de noticias o de datos curiosos, cada tweet fue etiquetado como cómico o no cómico. Sus resultados demostraron que utilizar Máquinas de Soporte Vectorial como la mejor técnica de clasificación obteniendo un 92.5% de exactitud.

Por otra parte, en la competencia presentada en IberLEF2019 [4], se consideró como ganador al equipo que consiguiera el mejor puntaje de F1. El primer lugar de la tarea de clasificación de humor utilizó un modelo mejorado de BERT en conjunto con un clasificador de tipo Bayesiano, obteniendo un puntaje de F1 de 82.1% y una exactitud de 85% [6]. El equipo quedo en segundo lugar presentó cinco modelos diferentes basados en redes neuronales utilizado la librería de fastAI y BERT para crear un modelo de lenguaje con clasificadores de tipo Naïve Bayes y Máquinas de Soporte Vectorial, obteniendo un puntaje de F1 de 81.6% y una exactitud de 85.4% [7]. Finalmente, en el equipo que ocupó el tercer puesto utilizó un modelo AWD-LSTM con redes cuasi recurrentes, obteniendo un puntaje F1 de 81% y una exactitud de 84.6% [8].

A continuación, en la tabla 1 se muestra una comparación de los resultados obtenidos en los trabajos mencionados previamente.

3. Clasificación

En este trabajo la detección de humor se abordó como un problema de clasificación de textos. Se proponen distintos clasificadores para identificar si un tweet es cómico o no y se compara su desempeño. En la figura 1 se presenta la metodología propuesta, ver por ejemplo [14].

3.1. Obtención de los datos

En la competencia HAHA se proporcionó un corpus con 27,000 tweets [9], los tweets provenían de cuentas humorísticas y cuentas normales. Cada tweet está etiquetado cómico o no cómico y tiene asignado un puntaje de diversión.

Las etiquetas fueron establecidas por un grupo de personas que identificaban según su criterio si un tweet parecía que tenía la intención de ser gracioso o no. Si resultaba ser gracioso le tenían que asignar un puntaje de 1 a 5 estrellas y con este número de estrellas se calcula con el promedio ponderado para obtener el puntaje de diversión. El fragmento que se utilizó contiene 6,000 tweets. En el cuál cada tweet cuenta con un id, el texto del tweet, la cantidad de estrellas que se le asignó a cada tweet y el puntaje de

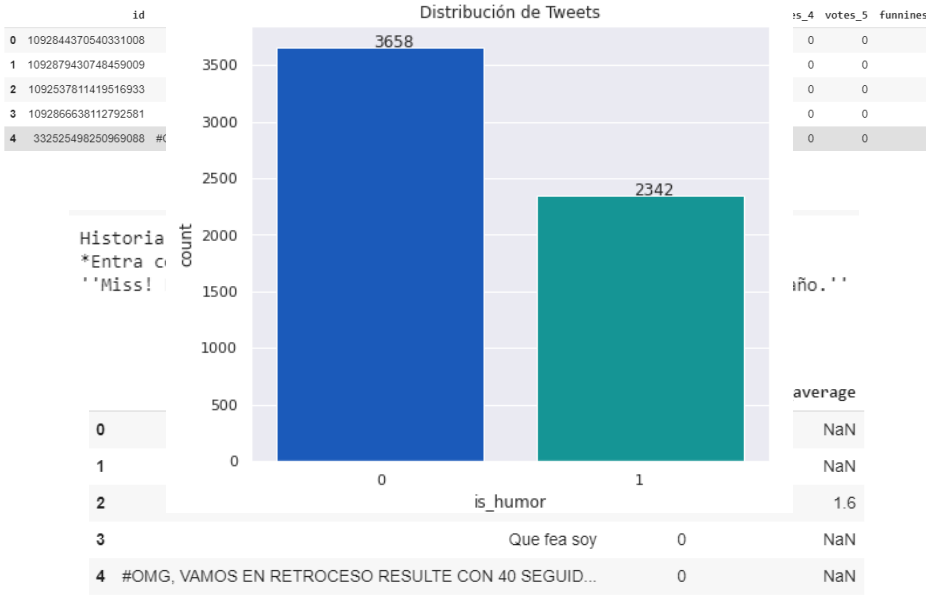


Fig. 4. DataFrame con los tweets y etiquetas.

diversión, como se observa en la figura 2. En la figura 3, se presenta un ejemplo de los tweets que contiene el corpus.

3.2. Preprocesamiento de los datos

El corpus se guardó como un DataFrame de pandas para poder manipular los datos. Pandas es una biblioteca que permite la manipulación y el análisis de datos en Python [10]. Se decidió trabajar con pandas ya que permite trabajar con distintos tipos de datos y almacenarlos en un DataFrame con el cual se pueden realizar varias operaciones.

Para este trabajo no son útiles las columnas que indican el "id" del tweet ni las que cuentan cuantas estrellas tuvo cada tweet. Por esta razón solo se conservan las columnas "text", "is_humor" y "funniness_average", como se observa en la figura 4.

Después se examinó el DataFrame en busca de datos faltantes. En la columna "funniness_average" es evidente que faltan datos, esto se debe a que los tweets que son considerados como no cómicos no tienen un puntaje de diversión asignado. Para evitar complicaciones se le asignó un puntaje de diversión de 0 a todos los tweets no graciosos. La distribución de las clases se obtuvo contando cuantos elementos hay en cada clase.

En la columna "is_humor" se puede observar que existen dos clases, el 0 representa que un tweet no es cómico y el 1 que un tweet es cómico. En la figura 5 se muestra un histograma de las clases donde se observa que hay más tweets no graciosos en el corpus. Los autores del corpus explican que esto se debe a que gran parte de los tweets extraídos de las cuentas humorísticas son chistes malos o tweets con la intención de atraer seguidores a la cuenta. En total se tienen 3648 tweets no cómicos y 2342 tweets cómicos.

El corpus se dividió en 70% para entrenar y 30% para prueba. Es decir, el conjunto de entrenamiento se conformó por 4200 tweets y el de prueba por 1800 tweets. El conjunto de características son los textos de los tweets y las etiquetas son las proporcionadas en la columna "is_humor". Se utilizó train_test_split de scikit-learn para dividir el corpus. sckit-learn es una biblioteca de Python que incluye varias herramientas de preprocesamiento, algoritmos de clasificación y métricas de desempeño [11].

Desafortunadamente, no se puede clasificar una sucesión de letras y símbolos ya que a la entrada de un clasificador se espera un dato de tipo numérico de longitud fija. Por esta razón se vectoriza los textos del corpus, de esta forma el corpus de tweets puede representarse mediante una matriz con una fila por tweet y una columna por token (palabra) en el corpus. Primero se tokeniza las palabras, después se cuenta el número de ocurrencias de cada token y finalmente se normaliza el conteo para que palabras, a este procedimiento se le conoce como "Bag of Words".

Si bien contar palabras es útil, los textos más largos tendrán valores de conteo promedio más altos que los textos más cortos, aunque hablen del mismo tema. Para evitar esto, se reducen los pesos de las palabras que aparecen con mayor frecuencia en los textos ya que proporcionan menos información que la que proporcionan las palabras que aparecen menos veces, a esta reducción se le conoce como "Term Frequency times Inverse Document Frequency" (tf-idf). En scikit-learn se utilizó la función TfidfVectorizer.

3.3. Selección de clasificadores

Los clasificadores fueron seleccionados en base a trabajos mencionados previamente. Se eligieron 5 clasificadores que vienen incluidos en la librería scikit-learn: Naïve Bayes Multinomial, Máquina de Soporte Vectorial, Árboles de Decisión, Vecinos Cercanos y Perceptrón Multi-Capa.

- Naïve Bayes Multinomial

  Es un clasificador basado en el teorema de Bayes haciendo la suposición de que cada característica es independiente de las demás características y la posición de la palabra no importa. Naïve Bayes Multinomial es frecuentemente utilizado en clasificación de textos [11,12].

- Máquina de Soporte Vectorial

  Es utilizado cuando se tiene dos grupos de datos que son linealmente separables. El algoritmo busca un hiperplano que sirve de límite, de forma que todos los puntos estén en promedio igual de separados de él y lo más separado que se pueda. Los puntos más cercanos al hiperplano se llaman vectores soporte [11,12].

- Árboles de Decisión

  Los árboles de decisión aprenden de los datos para aproximar una función con un conjunto de reglas de decisión si-entonces-otro (if-then-else). Cuanto más

profundo es el árbol, más complejas son las reglas de decisión y mejor se ajusta el modelo [11,12].

– Vecinos Cercanos

  Dado un conjunto de datos etiquetados se estima la clase a la que pertenece un dato sin etiqueta comparando ese dato con cada dato existente. Después se toman los datos más parecidos al dato desconocido y se observan sus etiquetas. Se toman los K (K<20) datos más cercanos y se busca la clase que tiene más elementos dentro de la selección, a esa clase se asigna el dato desconocido. El método es preciso, pero requiere de bastante carga computacional [11,12].

– Perceptrón Multi-Capa

  Las redes neuronales son un paradigma biológicamente inspirado que permite que una computadora pueda aprender a partir de un conjunto de datos. La suma de las entradas multiplicadas por sus pesos asociados determina el impulso nervioso que recibe la neurona. Este valor, se procesa mediante una función de activación que devuelve un valor que se envía como salida de la neurona [11,12].

El proceso de clasificación fue idéntico para cada clasificador, a continuación, se muestra el proceso para el clasificador de Naïve Bayes:

1. Crear el pipeline

```
text_clf_nb = Pipeline([('tfidf', TfidfVectorizer()), ('clf',
MultinomialNB())])
```

2. Ajustar el modelo

```
text_clf_nb.fit(X_train, y_train)
```

3. Hacer las predicciones

```
predictions = text_clf_nb.predict(X_test)
```

3.4. Calculo de las métricas de desempeño

Se utilizó la matriz de confusión para comparar los resultados obtenidos con cada clasificador ya que permite visualizar el desempeño de cada algoritmo. Como se trata de un problema de clasificación binaria, cada columna de la matriz representa el número de predicciones de cada clase, mientras que cada fila representa a las instancias en la clase real, como se muestra en la figura 6.

De esta forma el desempeño puede medirse en función del número de verdaderos positivos (VP), falsos positivos (FP), falsos negativos (FN) y verdaderos negativos (VN).

Al igual que en la competencia HAHA [4], se consideró como el mejor método clasificación al que tuvo el puntaje F1 más alto. Esta métrica porque combina precisión y sensibilidad, lo que resulta de utilidad cuando las clases no están bien distribuidas, ya que puede suceder que se obtenga un valor alto de precisión en la clase mayoritaria y sensibilidad baja en la clase minoritaria [13].

		Predicción	
		Positivos	**Negativos**
Observación	**Positivos**	Verdaderos Positivos (VP)	Falsos Negativos (FN)
	Negativos	Falsos Positivos (FP)	Verdaderos Negativos (VN)

Fig. 6. Matriz de confusión.

		Predicción	
		Positivo	Negativo
Real	Positivo	1051	51
	Negativo	460	238

Fig. 7. Matriz de confusión del clasificador de tipo Naïve Bayes Multinomial.

		Predicción	
		Positivo	Negativo
Real	Positivo	886	216
	Negativo	259	439

Fig. 8. Matriz de confusión del clasificador de tipo Máquina de Soporte Vectorial.

		Predicción	
		Positivo	Negativo
Real	Positivo	831	271
	Negativo	354	344

Fig. 9. Matriz de confusión del clasificador de tipo Árboles de Decisión.

		Predicción	
		Positivo	Negativo
Real	Positivo	1005	97
	Negativo	474	224

Fig. 10. Matriz de confusión del clasificador de tipo K Vecinos Cercanos.

		Predicción	
		Positivo	Negativo
Real	Positivo	825	277
	Negativo	267	431

Fig. 11. Matriz de confusión del clasificador de tipo Perceptrón Multicapa.

La matriz de confusión y el puntaje F1 se calcularon con las métricas de scikit-learn *"confusión_matrix"* y *"classification_report"*.

3.5. Comparación del desempeño

A continuación, en las figuras de la 7 a la 11 se muestran las matrices de confusión para cada clasificador. Se puede observar que con Naïve Bayes se pudieron identificar bien los tweets cómicos. De forma contraria, los tweets no cómicos fueron clasificados

Tabla 2. Comparación del desempeño de los clasificadores.

Clasificador	Exactitud	Precisión	Sensibilidad	F1-score
SVM	**0.736**	**0.67**	**0.63**	**0.648**
MLP	0.696	0.61	0.62	0.612
DT	0.654	0.56	0.50	0.514
NB	0.716	0.82	0.34	0.482
KNN	0.682	0.70	0.32	0.439

en su mayoría como cómicos, lo que provoca que la exactitud sea alta y el puntaje F1 sea bajo. Esto significa que este clasificador tiene problemas para diferenciar las clases, pero cuando identifica una es altamente confiable.

Con el clasificador de Máquina de Soporte Vectorial también se identifican bien los tweets cómicos y además también se clasificaron bien los tweets no cómicos. Con este resultado se espera que la precisión y la sensibilidad sean altas, lo que significa que el clasificador identifica bien ambas clases.

Con el clasificador de tipo Árboles de Decisión se observa un resultado similar al obtenido con SVM, pero no es tan bueno como el anterior ya que comente más errores lo que provoca que la exactitud y el puntaje F1 sean más bajos.

Con el clasificador de tipo Vecinos Cercanos se obtiene un resultado parecido al obtenido con Naïve Bayes, ya que el clasificador puede identificar bien los tweets cómicos, pero comete bastantes errores al identificar tweets no cómicos. Esto resulta en una precisión alta pero una sensibilidad baja lo que provoca un puntaje F1 bajo.

Con el Perceptrón Multicapa se pueden identificar bien ambas clases, desafortunadamente también se cometen varios errores al diferenciar las clases. Lo que provoca que el resultado de la clasificación sea bueno, pero no el mejor.

En la tabla 2, se muestra la comparación de las métricas de desempeño de cada clasificación. El clasificador de tipo Máquina de soporte vectorial resulto tener los mejores puntajes en todas las métricas, seguido por el Perceptrón Multicapa. Estos dos clasificadores diferencian bien ambas clases, a pesar de que el clasificador de tipo Naïve Bayes tiene una exactitud elevada, no se puede considerar como un buen clasificador porque detecta humor en tweets que no tenían la intención de ser cómicos.

4. Conclusiones y trabajo a futuro

De la comparación del desempeño de clasificadores para detección de humor, se observó que el clasificador de tipo Máquina de Soporte vectorial obtuvo el mejor puntaje de F1 con 64.8%. Este resulto ser el mejor clasificador ya que funciona bien para clasificadores binarios y tiende a no generalizar el error. Como el objetivo es identificar humor, según los resultados obtenidos no sería conveniente utilizar un clasificador de tipo Naïve Bayes, ya que clasifica una gran cantidad de tweets como cómicos cuando no lo son.

Es interesante que en este trabajo el clasificador bayesiano resultara entre los clasificadores de menor desempeño, cuando en los trabajos previos resulta ser uno de

los mejores clasificadores. Posiblemente se deba a que, en los otros trabajos a parte de la vectorización, se hace una extracción de características basada en el contenido.

Como trabajo futuro se propone trabajar la extracción de características, por ejemplo, tomar en consideración el número de veces que aparecen los signos de admiración, la cantidad de emojis utilizados o identificar las etiquetas con # que brinden más información acerca del contenido del tweet y a mejorar el desempeño de los clasificadores.

Referencias

1. Morreall, J.: Philosophy of humor. The Stanford Encyclopedia of Philosophy. Edward N. Zalta (ed.) (2016)
2. Humor Research: Benign Violation Theory. Lab at the University of Colorado. http://leeds-faculty.colorado.edu/mcgrawp/Benign_Violation_Theory.html (2016)
3. Mihalcea, R., Strapparava, C.: Learning to laugh (automatically): computational models for humor recognition. Computational Intelligence, 22(2), pp. 128–142 (2006)
4. HAHA@IberLEF: Human analysis based on human annotation (2016)
5. Castro, S., Cubrero M., Garat, D., Moncecchi, G.: Is This a Joke? Detecting humor in Spanish tweets. IBERAMIA, pp. 139–150 (2016)
6. Ismailov, A.: Humor analysis based on human annotation Challenge at IberLEF: First Place Solution (2019)
7. Bird, K.: High level HAHA architecture (2019)
8. Farzin, B., Czpla, P., Howard, J.: Applying a pre-trained language model to Spanish twitter humor prediction. IberLEF (2019)
9. Castro, S., Chiruzzo, L., Rosá, A., Garat, D., Moncecchi, G.: A crowd-annotated Spanish corpus for humor analysis. In: Proceedings of the 6th International Workshop on NLP for Social Media, pp. 7–11 (2018)
10. Pandas: The pandas development team. Zenodo, version 1.0.5 (2020)
11. Pedregosa, F. et al.: Scikit-learn: machine learning in python. JMLR, pp. 2825–2830 (2011)
12. Harrington, P.: Machine Learning in Action. NY, Manning (2012)
13. Barrios, J.: La matriz de confusión y sus métricas. Health Big Data (2019)
14. Sidorov, G.: Construcción no lineal de n-gramas en la lingüística computacional. SMIA, 166 p. (2013)

Electronic edition
Available online: http://www.rcs.cic.ipn.mx

ISSN: 1870-4069
http://rcs.cic.ipn.mx

Centro de Investigación
en Computación