Volume 7, Issue 12 — January — June — 2021

E

C

O

R

F

A

N

Journal-Democratic Republic of Congo

ISSN-On line 2414-4924

ECORFAN®

ECORFAN Journal - Democratic Republic of Congo, Volume 7, Issue 12, January-June 2021, is a journal edited semestral by ECORFAN. 6593 Kinshasa 31Rép.DémocratiqueduCongo.WEB:www.ecorfan.org/DemocraticRepublicofCongo/,journal@ec orfan.org. Editor in Chief: ILUNGA-MBUYAMBA, Elisée. MsC. ISSN On line: 2414-4924. Responsible for the latest update of this number ECORFAN Computer Unit. ESCAMILLA-BOUCHÁN, Imelda. PhD, LUNA-SOTO, Vladimir. PhD, 6593 Kinshasa 31 Rép. Démocratique du Congo, last updated June 30, 2021.

ECORFAN-Democratic Republic of Congo

Definition of Journal

Scientific Objectives

Support the international scientific community in its written production Science, Technology and Innovation in the Field of Physical Sciences Mathematics and Earth sciences, in Subdisciplines of image and signal processing, control-digital system-artificial, intelligence-fuzzy, logic-mathematical, modeling-computational, mathematics-computer, science.

ECORFAN-Mexico SC is a Scientific and Technological Company in contribution to the Human Resource training focused on the continuity in the critical analysis of International Research and is attached to CONACYT-RENIECYT number 1702902, its commitment is to disseminate research and contributions of the International Scientific Community, academic institutions, agencies and entities of the public and private sectors and contribute to the linking of researchers who carry out scientific activities, technological developments and training of specialized human resources with governments, companies and social organizations.

Encourage the interlocution of the International Scientific Community with other Study Centers in Mexico and abroad and promote a wide incorporation of academics, specialists and researchers to the publication in Science Structures of Autonomous Universities - State Public Universities - Federal IES - Polytechnic Universities - Technological Universities - Federal Technological Institutes - Normal Schools - Decentralized Technological Institutes - Intercultural Universities - S & T Councils - CONACYT Research Centers.

Scope, Coverage and Audience

ECORFAN-Democratic Republic of Congo is a Journal edited by ECORFAN-Mexico S.C in its Holding with repository in Democratic Republic of Congo, is a scientific publication arbitrated and indexed with semester periods. It supports a wide range of contents that are evaluated by academic peers by the Double-Blind method, around subjects related to the theory and practice of image and signal processing, control-digital system-artificial, intelligence-fuzzy, logic-mathematical, modeling-computational, mathematics-computer, science with diverse approaches and perspectives , That contribute to the diffusion of the development of Science Technology and Innovation that allow the arguments related to the decision making and influence in the formulation of international policies in the Field of Physical Sciences Mathematics and Earth sciences. The editorial horizon of ECORFAN-Mexico® extends beyond the academy and integrates other segments of research and analysis outside the scope, as long as they meet the requirements of rigorous argumentative and scientific, as well as addressing issues of general and current interest of the International Scientific Society.

Editorial Board

Arbitration Committee

Assignment of Rights

The sending of an Article to ECORFAN-Democratic Republic of Congo emanates the commitment of the author not to submit it simultaneously to the consideration of other series publications for it must complement the Originality Format for its Article.

The authors sign the Authorization Format for their Article to be disseminated by means that ECORFAN-Mexico, S.C. In its Holding Democratic Republic of Congo considers pertinent for disclosure and diffusion of its Article its Rights of Work.

Declaration of Authorship

Indicate the Name of Author and Coauthors at most in the participation of the Article and indicate in extensive the Institutional Affiliation indicating the Department.

Identify the Name of Author and Coauthors at most with the CVU Scholarship Number-PNPC or SNI-CONACYT- Indicating the Researcher Level and their Google Scholar Profile to verify their Citation Level and H index.

Identify the Name of Author and Coauthors at most in the Science and Technology Profiles widely accepted by the International Scientific Community ORC ID - Researcher ID Thomson - arXiv Author ID - PubMed Author ID - Open ID respectively.

Indicate the contact for correspondence to the Author (Mail and Telephone) and indicate the Researcher who contributes as the first Author of the Article.

Plagiarism Detection

All Articles will be tested by plagiarism software PLAGSCAN if a plagiarism level is detected Positive will not be sent to arbitration and will be rescinded of the reception of the Article notifying the Authors responsible, claiming that academic plagiarism is criminalized in the Penal Code.

Arbitration Process

All Articles will be evaluated by academic peers by the Double Blind method, the Arbitration Approval is a requirement for the Editorial Board to make a final decision that will be final in all cases. MARVID® is a derivative brand of ECORFAN® specialized in providing the expert evaluators all of them with Doctorate degree and distinction of International Researchers in the respective Councils of Science and Technology the counterpart of CONACYT for the chapters of America-Europe-Asia-Africa and Oceania. The identification of the authorship should only appear on a first removable page, in order to ensure that the Arbitration process is anonymous and covers the following stages: Identification of the Journal with its author occupation rate - Identification of Authors and Coauthors - Detection of plagiarism PLAGSCAN - Review of Formats of Authorization and Originality-Allocation to the Editorial Board- Allocation of the pair of Expert Arbitrators-Notification of Arbitration - Declaration of observations to the Author-Verification of Article Modified for Editing-Publication.

Instructions for Scientific, Technological and Innovation Publication

Knowledge Area

The works must be unpublished and refer to topics of Image and signal processing, control-digital system-artificial, intelligence-fuzzy, logic-mathematical, modeling-computational, mathematics-computer, science and other topics related to Physical Sciences Mathematics and Earth sciences.

Presentation of the Content

In the first article we present, *Comparison of Machine Learning algorithms for the Burnout projection*, by LARA-GONZALEZ, Luis Rey, DELGADO-LUNA, Martha Angélica, DE LEON-GALVAN, Beatriz Elena and VENEGAS-GUERRERO, José Carlos, with adscription in the Universidad Politécnica de Juventino Rosas, as the next article we present, *Enabling experimental greenhouse for high-tech application* by RODRÍGUEZ-FRANCO, Martín Eduardo, MALDONADO-RUELAS, Víctor Arturo, VILLALOBOS-PIÑA, Francisco Javier and ORTIZ-MEDINA, Raúl ArturoUniversidad Politécnica de Aguascalientes, with adscription in the Instituto Tecnológico de Aguascalientes, as the next article we present, *Statistical analysis and characterization of Landsat 8 satellite images of forest wildfires regions*, HERNANDEZ-LOPEZ, Sandra Paola, YAÑEZ-VARGAS, Juan Israel, GONZÁLEZ-RAMIREZ, Andrea and TORRES-ROMAN, Deni, with adscription in the Universidad Politécnica de Juventino Rosas and CINVESTAV del IPN, Unidad Guadalajara, as the next article we present, *Neural network for crop rotation and soil analysis in a Greenhouse*, by RAFAEL-PÉREZ, Eva, MONTERO-CORTÉS, Yeimi Yanet, RUIZ-RAMÍREZ, Alan Eduardo and MORALES-HERNÁNDEZ, Maricela, with adscription in the Instituto Tecnológico de Oaxaca.

Content

Comparison of Machine Learning algorithms for the Burnout projection

Comparación de algoritmos de Machine Learning para la proyección de Burnout

LARA-GONZALEZ, Luis Rey†, DELGADO-LUNA, Martha Angélica, DE LEON-GALVAN, Beatriz Elena and VENEGAS-GUERRERO, José Carlos

Universidad Politécnica de Juventino Rosas

ID 1st Author: *Luis Rey, Lara-González* / **ORC ID**: 0000-0002-0902-5955, **CVU CONACYT-ID**: 607818

ID 1st Coauthor: *Martha Angélica, Delgado-Luna* / **ORC ID**: 0000-0002-3749-6973

ID 2nd Coauthor: *Beatriz Elena, De León-Galván* / **ORC ID**: 0000-0002-8974-4561

ID 3rd Coauthor: *José Carlos, Venegas-Guerrero* / **ORC ID**: 0000-0003-0725-6730

DOI: 10.35429/EJDRC.2021.12.7.1.8 Received March 26, 2021; Accepted June 23, 2021

Abstract

The present study aims to carry out a projection of student burnout risk detection in young university students using Machine Learning technics (Neuronal Networks, KNN, SVM, Random Forest). A descriptive method was proposed, with a cross-sectional and stratified design in which a sample of 791 students from 4 different universities. This study opens up an innovative field of research by integrating resources from psychological evaluation and virtual resources, in addition, it would allow the generation of preventive actions to treat various implications of Burnout in school dropout and low academic performance through the analysis of information and the generation of algorithms that allow the projection of burnout risk. Due to the combination of experience of professionals in psychology, education and engineering, as well as the contribution to the projection of a syndrome that affects students, makes this article an innovative proposal.

Academic Burnout, Machine Learning, Students

Resumen

El presente estudio tiene por objeto realizar una proyección de detección de riesgo de burnout estudiantil en jóvenes universitarios utilizando algoritmos de Machine Learning (Neuronal Networks, KNN, SVM, Random Forest). Para esto se planteó una metodología de tipo descriptivo, con un diseño de corte transversal y estratificado en la que se toma una muestra de 791 estudiantes de 4 diferentes universidades. Este estudio abre un campo de investigación innovador al integrar recursos de la evaluación psicológica y de recursos virtuales, además de que permitiría generar acciones preventivas para tratar diversas implicaciones del Burnout en la deserción escolar y el bajo rendimiento académico a través del análisis de información y la generación de algoritmos que permitan realizar la proyección de riesgo de burnout. Por la conjunción de experiencia de profesionales de la psicología, de la educación y de ingeniería, así como el aporte a la proyección de un síndrome que afecta a los y las estudiantes, hace de este artículo una propuesta innovadora.

Burnout académico, Máquinas de aprendizaje, Estudiantes

Citation: LARA-GONZALEZ, Luis Rey, DELGADO-LUNA, Martha Angélica, DE LEON-GALVAN, Beatriz Elena and VENEGAS-GUERRERO, José Carlos. Comparison of Machine Learning algorithms for the Burnout projection. ECORFAN Journal-Democratic Republic of Congo. 2021, 7-12: 1-8

† Researcher contributing first author.

Introduction

The 2005 World Report of the United Nations Educational, Scientific and Cultural Organization (UNESCO), entitled "Towards knowledge societies" indicates that the new information and communication technologies have created the conditions for the emergence of knowledge societies (Forero de Moreno, 2009). In the current context, technology provides different possibilities to solve problems regarding the collection and analysis of information in the development of research, which range from google forms to the most sophisticated tools in quantitative analysis such as SPSS, R, Mintab, Stats and Excel, among others.

We see that technological advances can be a good support in the development of research, from the structuring of instruments, gathering information, to the systematization and analysis of data. It has been reported by several studies in different countries and in Mexico a syndrome that affects students, Burnout has been defined as a “loss of energy sources of the subject, so it can be defined as a combination of physical fatigue, emotional fatigue and cognitive fatigue (Rosales Ricardo & Rosales Paneque, 2013, p. 340).

In the academic field, young university students present difficulties that affect the phenomenon of academic abandonment and that are associated with high stress loads during their training process and that, in addition to the presence of avoidance or escape behaviors, in addition to feelings of not being able to give more of themselves, among others, make up the so-called academic burnout syndrome (Rosales Ricardo & Rosales Paneque, 2013).

The measurement of Burnout has been given through various studies and instruments, including scales, questionnaires, inventories, and others. Among these we can find the Maslach Burnout Inventory Student Survey or MBI-SS (Schaufeli, et al, 2002;) adapted from the Maslach Burnout Inventory General Survey (Maslach & Jackson, 1981); the Emotional Tiredness Scale or ECE (Ramos Campos, et al, 2005); the Engagement Scale (Caballero Domínguez, et al, 2006); and The Unidimensional Scale of Student Burnout or EUBE (Barraza Macías, 2011) among others.

Academic burnout, in education, is reported by Caballero (Caballero Domínguez, et al, 2012) who proposes that it be considered as a good predictor of the concurrence of anxiety symptoms, and to a lesser degree, depression, and that it is feasible constitutes a risk factor for the development of major conditions of mental disorder, especially clinically significant anxiety.

Therefore, Burnout is a variable that impacts the educational system, its study and deepening provide useful elements to institutions and in general to the educational system to generate strategies, programs and actions that support its reduction and have a favorable impact on permanence and education. academic performance of the student population.

This article presents the conjunction of the knowledge that intelligent systems contribute to the sciences of education, to project possibilities of suffering Burnout in the student population, which will allow to anticipate and generate preventive actions that avoid affectations in the academic trajectory.

Machine learning, translated into Spanish as “machine learning”, is a field derived from artificial intelligence that broadly consists of developing processes that allow machines to learn autonomously. Machines learn on their own from a set of data that an instructor first enters and then corrects manually. It is throughout this process that the computer extracts information that it transforms into knowledge based on experience (Siegel, 2013).

In the present work, an analysis of different algorithms is generated that, based on the data obtained from the application of the EUBE instrument (Barraza, 2011) in four universities, allows us to analyze the predictive power that will define the most appropriate algorithm for the projection of Burnout in the higher education student population.

The following algorithms are applied: neuronal networks, random forest, support vector machine and KNN (k-Nearby neighbors).

ISSN 2414-4924

Software used

Rstudio

RStudio is an integrated development environment (IDE) for the R programming language, dedicated to statistical computing and graphics. It includes a console, syntax editor that supports code execution, as well as tools for plotting, debugging, and workspace management.

R is a programming language used as software for statistical computing, which does not have a graphical interface, that is, when pressing a button in the RStudio environment which was developed for programming with this R language, it does not display a menu or a pop-up window. What makes this statistical analysis program so widely used is that it is free software and its codes are open, that is, they are available to any user (Celis, 2020).

For this analysis, machine learning tools were used using the R language libraries and algorithms, these algorithms are explained below.

The Neuronal Networks algorithm

Neural networks or also called annexation systems are an algorithmic model that is based on a large set of simple neural units, called artificial neurons, in a way that is very similar to the behavior of the axons of neurons that any biological organism has. Each neuronal unit connects with many others and the links between them can increase or inhibit the state of the neurons that are adjacent to it.

Each individual neuronal unit operates using addition operations. There may be a limiting function, a threshold function at each of the connections in the unit itself, so that the signal can pass a limit before propagating to another neuron.

Random Forest Algorithm

A Random Forest model is made up of a set (ensemble) of individual decision trees, each trained with a random sample extracted from the original training data by bootstrapping. This implies that each tree is trained with slightly different data.

In each individual tree, the observations are distributed by bifurcations (nodes) generating the structure of the tree until reaching a terminal node. The prediction of a new observation is obtained by adding the predictions of all the individual trees that make up the model.

The Support Vector Machine (SVM) algorithm

The classification-regression method Vector Support Machines (SVMs) was developed in the 90's, within the field of computational science. Although it was originally developed as a binary classification method, its application has been extended to multiple classification and regression problems. SVMs have turned out to be one of the best classifiers for a wide range of situations, which is why it is considered one of the benchmarks in the field of statistical learning and machine learning.

The KNN algorithm:

KNN (K-Nearest Neighbors, K-Neighbors) algorithm is one of the most popular neighborhood-based classifiers in machine learning (Kataria and Singh, 2013), given its simplicity and efficiency in detecting and classifying elements into categories. The parameter k in KNN refers to the number of neighbors with which the belonging to a category is defined, this parameter is usually determined empirically, depending on the problem it is tested with different values of K, choosing the parameter with the best performance in precision. The operation of the algorithm is based on calculating a distance matrix between all the points of the training dataset.

It is a supervised learning algorithm, that is, from an initial data set its objective will be to correctly classify all new instances. The typical data set for this type of algorithm is made up of several descriptive attributes and a single objective attribute (also called a class) (Ad Tech & Analytics, 2017). The objective of this study is to determine the most powerful algorithm to project Burnout in university students. Therefore, the central hypothesis that guides this research is that there is an algorithm that predicts the projection of presenting Burnout in university students above 95%.

In the presentation of the article, the methodology is developed where the steps that were followed for the development of the present study are specified, results where the predictive percentages of each of the algorithms are described, the discussion of the results, where the point out approaches derived from the results and the confirmation or not of the hypothesis. Finally, in the conclusions, the contribution of the present investigation is planned as well as some lines of investigation.

Methodology

All projects have a life cycle; that is, its realization comprises a series of logical stages that begins with the formulation of the original idea and the development of an activity plan, continues with the identification and verification of the capacities and needs of the interested parties and, finally, It comprises the design, implementation and evaluation stages. (Rice and Salinas, 1997).

Proposed model

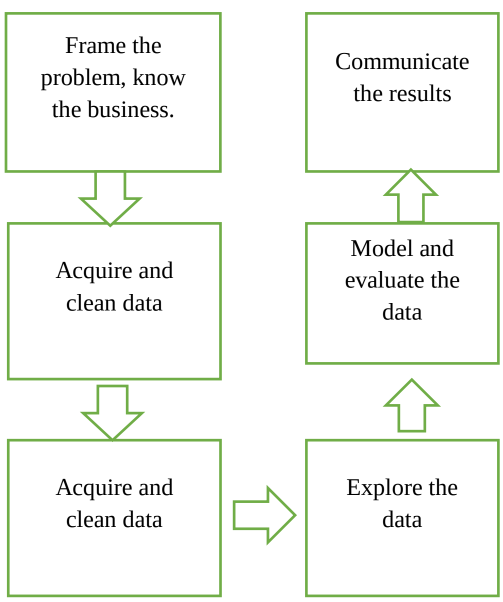


Figure 1

A scale created and validated by Dr. Arturo Barraza and collaborators (Barraza, 2008) of the Pedagogical University of Durango was applied, it consists of 15 items and reports a reliability level of 91 in Cronbach's alpha and 90 in reliability by halves according to the Spearman-Brown formula. This instrument measures the level of physical, emotional and cognitive exhaustion (Barraza Macías, 2011).

Due to its distinctive characteristics, the scale can be defined as self-descriptive (Anastasi & Urbina, 1998, in Barraza Macías, 2011) and domain-specific (Hogan, 2004, in Barraza Macías, 2011). It is an instrument that can be applied in any type of population, which makes it currently one of the most widely used instruments in Mexico and recovers the one-dimensional perspective of burnout (Rosales Ricardo & Rosales Paneque, 2013).

For the systematization and analysis of the information, a data structure was taken that consisted of 791 samples obtained from the application of the instrument by Arturo Barraza et al. (2008), a total of 15 questions; each question is answered with these possible options “never, sometimes, almost always and always. The following figure shows an example of questions 12, 13, 14, and 15; The column "conclusion_b1" indicates the Burnout level that the respondent presents. In other words, the rows represent the respondents, and the columns represent each of the questions (b1_1 .. b1_15) questions asked with their respective answer and the last column (Conclusion.b1) shows the level of Burnout presented by the respondent (“never , sometimes, almost always and always).

b1_12	b1_13	b1_14	b1_15	Conclusion.b1
Never	Never	Usually	Never	Does not present
Never	Never	Never	Sometimes	Does not present
Never	Never	Never	Never	Does not present
Never	Never	Never	Never	Does not present

Results

Below is the application of each of the algorithms.

Random Forest algorithm

It implements the Breiman Random Forest algorithm (based on the original Fortran code from Breiman and Cutler) for classification and regression.

data = 791 = total sample
Training = 70% of the data
Ntree = Number of trees to grow. This should not be set to too small a number, to ensure that each input row is predicted at least a few times.
ntree = 500
target = conclusion.b1
target = conclusion.b1

ISSN 2414-4924

model = randomforest (Training, independent_variables, target, ntree)
Pred = generic function for predictions from the results of various model fitting functions.
Pred = (model, 30% remaining data, ”class”); class is the type of algorithm applied.

The result is as follows:

	Projection		
Current	Mild	Moderate	Does not present
Mild	66	0	6
Moderate	0	0	0
Does not present	2	0	162

Table 2

The algorithm predicts 66 cases correctly in the “SLIGHT” value, having a total of 6 non-projected errors. Also in the value "NOT PRESENT" it manages to project 162 cases and a total of 2 errors.

Projection percentage = 95.9%

Support Vector Machine algorithm

SVM is used to train a support vector machine. It can be used to perform general classifications and regressions (nu and epsilon), as well as to estimate density. A formula interface is provided.

Training = 70% of the data
target = conclusion.b1
target = conclusion.b1
model = svm (independent_variables, target)
Pred = (model, 30% remaining data,)
The result is as follows:

	Projection		
Current	Mild	Moderate	Does not present
Mild	63	0	9
Moderate	0	0	0
Does not present	11	0	153

Table 3

The algorithm predicts 63 cases correctly in the value "SLIGHT", having a total of 9 non-projected errors. Also in the value "NOT PRESENT" it manages to project 153 cases and a total of 11 errors.
Projection percentage = 91.5%

K-Nearest Neighbor Classification algorithm

k-nearest neighbor classification for the test set of the training set. For each row of the test set, the k closest training set vectors are found (in Euclidean distance) and the ranking is decided by majority vote, with randomly broken ties. If there are ties for the k-th closest vector, all candidates are included in the vote.

KNN requires that the independent or predictor variables be numeric. And the dependent variables or what I want to classify is a category.

Training = 50% of the data
Temporary = remaining 50% of Training data
Val = 50% of Temporal
Test = 50% of the rest of Temporal
Pred = knn (Training (independent_variables), Val, Training (category_variable, k = 1)

k = 1

	Projection		
Current	Mild	Moderate	Does not present
Mild	51	0	10
Moderate	0	0	1
Does not present	10	0	127

Table 4

k=2

	Projection		
Current	Mild	Moderate	Does not present
Mild	49	0	12
Moderate	0	0	1
Does not present	10	0	127

Table 5

k=3

	Projection		
Current	Mild	Moderate	Does not present
Mild	49	0	12
Moderate	0	0	1
Does not present	7	0	130

Table 6

Looking for the suitable value of k for the algorithm, we find that:

ISSN 2414-4924

k=4

Projection			
Current	Mild	Moderate	Does not present
Mild	54	0	7
Moderate	0	0	1
Does not present	5	0	132

Table 7

The algorithm predicts 54 cases correctly in the “SLIGHT” value, having a total of 7 non-projected errors. Also in the value "NOT PRESENT" it manages to project 132 cases and a total of 5 errors.

Projection percentage = 93.9.%

Neural Networks Algorithm

Training = 70% of the data
size = relation to input variables = 15
maxit = maximum convergences = 10000
decay = weight drop parameter = 0.001
range = range of initial weights close to 1 = 0.25
model = nnet (independent_variables, Training, size, maxit, decat, range)
Pred = (model, 30% of the remaining data)

It should be noted that this algorithm uses more computational processing time compared to other algorithms seen.

The result is as follows:

Projection			
Current	Mild	Moderate	Does not present
Mild	60	1	11
Moderate	0	0	0
Does not present	20	0	144

Table 8

The algorithm predicts 60 cases correctly in the value "SLIGHT", having a total of 12 non-projected errors. Also in the value "NOT PRESENT" it manages to project 144 cases and a total of 20 errors.

Projection percentage = 86.8%

Results and conclusions

The study of Burnout becomes relevant in higher education institutions, since these are usually highly stressful places. In these academic spaces, students face a series of demands on a daily basis that, under their own assessment, constitute stress-generating situations, which, being prolonged and frequent, can lead to burnout (Rosales Ricardo and Rosales Paneque, 2013).

Along with academic burnout, it is a good predictor of the concurrence of symptoms of anxiety, and to a lesser degree, depression, so it can become a risk factor for the development of major conditions of mental disorder, especially of clinically significant anxiety (Caballero (2012). Therefore, young university students may present difficulties that affect the phenomenon of academic abandonment (dropout) that is associated with high stress loads or as a consequence of presenting exacerbated symptoms of anxiety or depression during their training process In this sense, this research has an impact on the educational quality of Higher Level Institutions, particularly on the indicators of educational lag and terminal efficiency.

Although machine learning algorithms have advanced for years, it has only been used recently for behavioral sciences (DelPozo-Banos et al., 2018). For example, these algorithms are used in computational psychiatry to improve the diagnosis of mood disorders: stress (Silva et al., 2020), depression (Webb et al., 2020), and suicidal tendencies (Kessler et al., 2015), allow possibilities of obtaining detailed knowledge about diseases, disorders. These methods are important because they allow you to analyze data from different sources. For example, Kaczor and his colleagues used machine learning techniques to detect stressful situations using digital sensors used by emergency medicine physicians and a self-assessment questionnaire (Kaczor 2020).

The application of the algorithms allows us to project the Burnout results based on a percentage of the data (70%) which is taken as training data and the rest of the data (30%) are taken to make the prediction by applying the machine learning algorithms.

ISSN 2414-4924

Collecting the results of each of the algorithms used, we have:

Algorithm	% from Projection	Chosen one
Random Forest	95.9 %	x
KNN	93.9 %	
SVM	91.5 %	
NNET	86.8 %	

Table 9

It is observed that the algorithm with the highest percentage of predictive result is that of Random Forest with a 95.0% projection percentage with respect to the data provided based on the survey carried out.

Future work, since the type of input variable for all algorithms is categorical, remains to adjust the input parameters (size, maxit, decat, range) of the Neural Networks (NNET) algorithm, because Only settings that are suggested in the parameters of said algorithm were used, with the aim of analyzing whether it is possible to improve the prediction percentage.

There are other data from the respondents that were not taken into account in this research, such as age, gender, the study period in which data collection was applied, so future work would be to integrate these data as independent variables to provide greater elements for decision-making and characterizations of the academic burnout.

This study, then, could allow a projection of student burnout at the university level to be carried out and in this way generate strategies and actions focused on its prevention and / or intervention, for example, through Tutoring programs, which represent an element important innovator of Educational Quality and that contribute to “reduce dropouts and lag in higher education” (Romo López, 2011, p. 76)

References

Ad Tech & Analytics. (2017). El algoritmo K-NN y su importancia en el modelado de datos |Analítica web. Recuperado 13 de abril de 2021, de https://www.analiticaweb.es/algoritmo-knn-modelado-datos/

Anastasi, A. and Urbina, S. and Salinas, M.E.O.,isbn=9789701701867,url=https://books.google.com.mx/books?id=FV01zgFuk0cC,1998.Prentice-Hall

Barraza Macías, A. (2008). Escala Unidimensional del Burnout Estudiantil. Investigación Educativa Duranguense. 9. https://www.researchgate.net/publication/28237109_Escala_Unidimensional_del_Burnout_Estudiantil

Barraza Macías, A. (2011). Validación psicométrica de la escala unidimensional del burnout estudiantil. *Revista Intercontinental de Psicología y Educación. 13*(2). 51-74. http://www.redalyc.org/pdf/802/80220774004.pdf

Caballero Domínguez, C. C., Abello Llanos, R. y J. Palacio Sañudo. J. (2006). BURNOUT, ENGAGEMENT Y RENDIMIENTO ACADÉMICO ENTRE ESTUDIANTES UNIVERSITARIOS QUE TRABAJAN Y AQUELLOS QUE NO TRABAJAN. *Revista Psicogente, 9*(16), 11-27. https://www.researchgate.net/profile/Jorge_Palacio_Sanudo/publication/284701793_Burnout_engagement_y_rendimiento_academico_entre_estudiantes_universitarios_que_trabajan_y_aquellos_que_no_trabajan/links/568a75ec08ae1975839d84b2.pdf

Caballero Domínguez., C. C., Abello Llanos, R. y Palacio Sañudo, J. (2007). Relación del burnout y el rendimiento académico con la satisfacción frente a los estudios en estudiantes universitarios. *Avances en Psicología Latinoamericana*, *25*(2), 98-111. https://www.redalyc.org/articulo.oa?id=799/79925207

Caballero, C. (2012). El burnout académico: Pre-valencia y factores asociados en estudiantes universitarios del área de la salud de la ciudad de Barranquilla. Doctoral dissertation. Universidad del Norte, Barranquilla (Colombia).

Celis Mario A, 2020 Introducción a Rstudio, Recuperado 4/Mayo/2021, https://rpubs.com/Mariocelis25/603283.

ISSN 2414-4924

DelPozo-Banos, M., John, A., Petkov, N., Berridge, D. M., Southern, K., Loyd, K., et al. (2018). Using neural networks with routine health records to identify suicide risk: Feasibility Study. JMIR Mental Health, 5(2), e10144

Forero de Moreno, I. (2009). LA SOCIEDAD DEL CONOCIMIENTO. *Revista Científica General José María Córdova, 5*(7), 40-44. https://www.redalyc.org/articulo.oa?id=476248849007

Kaczor, E. E., Carreiro, S., Stapp, J., Chapman, B., & Indic, P. (2020). Objective measurement of physician stress in the Emergency Department using a wearable sensor. In Proceedings of the 53rd Hawaii International Conference on System Sciences, 2020 (pp. 3729–3738). Hawaii: University of Hawai'i at Mānoa.

Kessler, R. C., Warner, C. H., Ivany, C., Petukhova, M. V., Rose, S., Bromet, E. J., et al. (2015). Predicting suicides after psychiatric hospitalization in US Army soldiers: The Army Study to assess risk and resilience in servicemembers (Army STARRS). JAMA Psychiatry, 72(1), 49–57. https://doi.org/10.1001/jamapsychiatry.2014.1754.

Maslach, C. y Jackson, S. E. (1981) The measurement of experienced burnout. *Journal of Occupational Behaviour, 2*, 99-113. https://onlinelibrary.wiley.com/doi/abs/10.1002/job.4030020205

Ramos Campos, F. Manga Rodríguez, D. y Morán Astorga, C. (2005). ESCALA DE CANSANCIO EMOCIONAL (ECE) PARA ESTUDIANTES UNIVERSITARIOS: PROPIEDADES PSICOMÉTRICAS Y ASOCIACIÓN. *6 Congreso Virtual de Psiquiatría.* Interpsiquis. https://www.researchgate.net/publication/271846180_Escala_de_cansancio_emocional_ECE_para_estudiantes_universitarios

Rice and Salinas, 1997] Rice, F. P. and Salinas, M. E. O. (1997). Desarrollo humano: estudio del ciclo vital. Pearson Educación.

Romo López, A. (2011). *La tutoría: una estrategia innovadora en el marco de los programas de atención a estudiantes*. ANUIES.

Rosales Ricardo, Y. y Rosales Paneque, F. R. (2013). Burnout estudiantil universitario. Conceptualización y estudio. *Salud Mental, 36*(4). 337-345. http://www.redalyc.org/articulo.oa?id=58228969009

Silva, E., Aguiar, J., Reis, L. P., Sá, J. O. E., Gonçalves, J., & Carvalho, V. (2020). Stress among Portuguese Medical Students: The EuStress Solution. Journal of Medical Systems, 44(2), 1–6. https://doi. org/10.1007/s10916-019-1520-1.

Schaufeli, W. B., Martínez, I. M., Marques Pinto, A., Salanova, M. y Bakker, A. B. (2002). Burnout an engagement in univertity students. *Journal of Cross-cultural Psychology, 33*(5), 464-481. https://journals.sagepub.com/doi/10.1177/0022022102033005003

Siegel E., John Wiley & Sons. 2013 Predictive analytics : the power to predict who will click, buy, lie, or die. Hoboken : John Wiley & Sons, 2013.

Webb, C. A., Cohen, Z. D., Beard, C., Forgeard, M., Peckham, A. D., & Björgvinsson, T. (2020). Personalized prognostic prediction of treatment outcome for depressed patients in a naturalistic psychiatric hospital setting: A comparison of machine learning approaches. Journal of Consulting and Clinical Psychology, 88(1), 25–38. https://doi.org/10.1037/ccp0000451.

Article
ECORFAN Journal-Democratic Republic of Congo
June 2021 Vol.7 No.12 9-18

Enabling experimental greenhouse for high-tech application

Habilitación de invernadero experimental para aplicación de alta tecnología

RODRÍGUEZ-FRANCO, Martín Eduardo[1]†*, MALDONADO-RUELAS, Víctor Arturo[1], VILLALOBOS-PIÑA, Francisco Javier[2] and ORTIZ-MEDINA, Raúl Arturo[1]

[1]*Universidad Politécnica de Aguascalientes*
[2]*Instituto Tecnológico de Aguascalientes*

ID 1st Author: *Martín Eduardo, Rodríguez-Franco* / **ORC ID**: 0000-0002-6804-4777, **Researcher ID Thomson**: T-1539-2018, **CVU CONACYT ID**: 660892

ID 1st Coauthor: *Víctor Arturo, Maldonado-Ruelas* / **ORC ID**: 0000-0003-2125-1557, **Researcher ID Thomson**: I-2774-2018, **CVU CONACYT ID**: 209649

ID 2nd Coauthor: *Francisco Javier, Villalobos-Piña* / **ORC ID**: 0000-0003-1053-5642

ID 3rd Coauthor: *Raúl Arturo, Ortiz-Medina* / **ORC ID**: 0000-0002-3790-3807, **Researcher ID Thomson**: H-9584-2018, **CVU CONACYT ID**: 878025

DOI: 10.35429/EJDRC.2021.12.7.9.18 Received March 28, 2021; Accepted June 25, 2021

Abstract

This work exposes the conditioning of the zenith greenhouse of the Polytechnic University of Aguascalientes for its conformation as a high-tech entity, through the adaptation of sensors, actuators and a controller, which ensure the supervision of the environmental conditions inside, mainly established by the variables of temperature and humidity. The development and application of a computer graphical interface is presented as an intuitive tool for monitoring and controlling the field devices used, and therefore, the environmental conditions provided or recorded from their activation. Likewise, the use of the open communication standard OPC is demonstrated as an alternative for effective interaction between the LabVIEW software, from which the management interface was developed, and the PLC, used as the system controller. The results achieved provide proof of the adequate operation of the devices adapted in the greenhouse installation, the compilation of the information associated with the performance of their task and the manipulation of their operation or reading, from the graphical interface developed for this purpose.

High-tech greenhouse, Programmable logic controller, Graphical interface for management

Resumen

Este trabajo expone el acondicionamiento del invernadero cenital de la Universidad Politécnica de Aguascalientes para su conformación como un ente de alta tecnología, a través de la adaptación de sensores, actuadores y un controlador, que aseguren la supervisión de las condiciones ambientales al interior, principalmente establecidas por las variables de temperatura y humedad. Se presenta el desarrollo y la aplicación de una interfaz gráfica por computadora como una herramienta intuitiva para el monitoreo y control de los dispositivos de campo empleados, y por ende, de las condiciones de entorno aportadas o registradas a partir de su activación. Asimismo, se demuestra el uso del estándar de comunicación abierta OPC, como una alternativa para la interacción efectiva entre el software LabVIEW, a partir del cual fue desarrollada la interfaz para gestión, y el PLC, utilizado como controlador del sistema. Los resultados alcanzados brindan constancia de la adecuada operación de los dispositivos adaptados en la instalación del invernadero, la recopilación de la información asociada al desempeño de su tarea y la manipulación de su operación o lectura, desde la interfaz gráfica desarrollada para tal fin.

Invernadero de alta tecnología, Controlador lógico programable, Interfaz gráfica para gestión

Citation: RODRÍGUEZ-FRANCO, Martín Eduardo, MALDONADO-RUELAS, Víctor Arturo, VILLALOBOS-PIÑA, Francisco Javier and ORTIZ-MEDINA, Raúl Arturo. Enabling experimental greenhouse for high-tech application. ECORFAN Journal-Democratic Republic of Congo. 2021, 7-12: 9-18

* Correspondence to Author (e-mail: mc190002@alumnos.upa.edu.mx)
† Researcher contributing first author.

Article ECORFAN Journal-Democratic Republic of Congo
June 2021 Vol.7 No.12 9-18

Introduction

The state of Aguascalientes is characterized by having a temperate semi-dry climate in about 80% of its territory, with a dominance of semi-arid soil (De la Cerda Lémus, 2011); Despite this, agriculture constitutes one of the main economic activities in the state, to which around 14% of its surface is allocated (CPLAP, 2019). The most widely used cultivation system is temporary, with 84% of the territory occupied; which portrays the climatic dependence of agricultural practice in the state, which together with the scarce sources of financing and the lack of technological application, have limited the evolution of the production and commercialization of the crops obtained (Borja Bravo, Rodríguez Licea, Osuna Ceja, & López Aguilar, 2016).

The practice of protected agriculture, from the introduction of greenhouses, has recently been adopted by producers of the entity; with a rapid acceptance and expansion, from 87.1 hectares destined in 2013 to 102.8 hectares in 2015 (SIAP, 2015). Currently, this option of cultivation is present in all the municipalities of the state, being Pabellón de Arteaga, Calvillo and San Francisco de los Romo those that concentrate about 50% of the total production, consisting mainly of red tomato, seedling and strawberry (SIAP , 2014).

Therefore, this agricultural scheme raises the need to diversify the production of vegetables, in search of promoting technological development that allows efficient cultivation systems, in order to guarantee greater production and quality (Borja Bravo, Rodríguez Licea, Osuna Ceja , & López Aguilar, 2016).

Thus, the preservation of environmental conditions inside a greenhouse is essential for the proper development of the crops produced under this scheme (Çaylı, 2020). A large number of variables determine the growth of the plant in the confined space, however, those with greater dominance are usually associated with the surrounding climate (Ghani, et al., 2019), established mainly by temperature (Baglivo, et al., 2020).) and humidity (Amani, Foroushani, Sultan, & Bahrami, 2020).

Thus, the adaptation of technological means and devices that allow the monitoring and regulation of the magnitude acquired by such variables, will promote their establishment at optimal values, depending on the type of crop that is owned or desired to be produced (Iddio, Wang , Thomas, McMorrow, & Denzer, 2020).

Background

The Polytechnic University of Aguascalientes has two greenhouses located east of Building 4; of these, the exposed intervention was applied in the greenhouse with the largest dimension, which is of the zenith type (figure 1). It is worth mentioning that the physical installation of this greenhouse had to be rehabilitated in its entirety, since it was in disuse. And, since the conditions of the deterioration suffered during a considerable period without functionality were highly evident, it was necessary to cover the structure with plastic, as well as the placement of actuators to perform the functions of heating, air recirculation and operation of the Windows.

Figure 1 Zenith greenhouse of the Polytechnic University of Aguascalientes
Source: Own Elaboration, 2021

Inside the greenhouse, on most of the isolated soil, some furrows were formed, as can be seen in Figure 2. Such alignments will allow the sowing and cultivation of different plant species, whose physiological properties are ideal for the tasks to be carried out in the Research Laboratory of the university itself, on which this facility depends, in its orientation towards agricultural experimentation. Thus, in order to facilitate the movement and maneuvering of people inside the greenhouse, as a support for the preservation of its function, a corridor was enabled that crosses the confined space throughout; which was later properly constituted with cement.

Figure 2 Interior of the zenith greenhouse
Source: Own Elaboration, 2021

The proposed organization of the surface for cultivation in four quadrants and, of these, in two areas (Figure 3), favored the distribution of the devices used to cover the entire installation; in addition, it will contribute to the establishment of a certain space for the sowing of a particular species, once in operation. Likewise, the electrical wiring was adapted, in proximity to the side walls of the greenhouse, to provide an electrical supply to the field devices that require it, or to guide the information coming from them to a concentrator. There was also a tank for storage and supply of water to the irrigation system, as well as a pressurizer, for dispersing and applying it, in the form of steam, to the crops, to complete the rehabilitated agricultural facility.

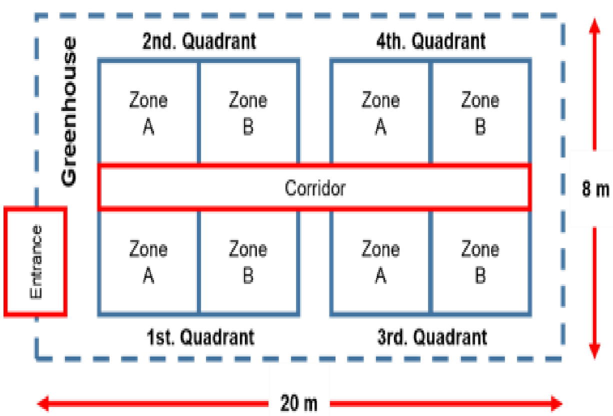


Figure 3 Organization of the space inside the greenhouse
Source: Own Elaboration, 2021

It was a priority of the present study to combine the functionality of all the field devices adapted to the interior of the greenhouse, after its habilitation; through the configuration of a central controller within the installation itself.

Such a controller establishes communication with a graphical computer interface, developed for the management of the components and equipment used in the confined space; which is executed from a nearby location, through serial communication. It is worth highlighting the delimitation in the preservation of the environmental conditions inside the greenhouse, from the exclusive effect of the temperature and humidity variables; which tend to have greater dominance in the environment surrounding the crop, determining its optimal growth (Shamshiri, et al., 2018).

Installation of actuation devices

After fitting out the greenhouse, we proceeded to install the devices that would affect any change in the confined environment; which leads to the preservation of specific conditions for the proper development of the crops to be introduced. Although, there was an environment isolated from the outside climate, whose internal effect could be regulated by the manual opening or closing of the windows, which led it to be categorized as a low-tech greenhouse, it was necessary to adapt devices that allowed to reach a level of medium or high technology; in accordance with the objectives set for this intervention.

Under the proposed technological variation scheme, the need to install elements for the coordinated regulation of the main environmental factors inside the greenhouse was determined. Therefore, when these conditions are established, especially due to the variables of temperature and humidity, it was necessary to consider components that allow a homogeneous thermal distribution throughout the confined space, supply water to the crops or inject the appropriate dose of steam to the environment.

This while providing feedback to the user on the condition reached. It is worth mentioning the use of the drip irrigation technique to make the use of water more efficient, by directing it effectively towards the root of the plant. The elements considered for the defined performance functions are listed in table 1.

Quantity	Device
1	System energized indicator light.
1	System stopped indicator light.
1	System in operation indicator light.
4	Solenoid valve for activation of the irrigation system.
1	Set of nebulizers for humidity regulation in the environment.
4	Motor relays for driving the side windows.
1	Heater.
1	Air recirculator.
1	Pump for filling supply tank for irrigation system.

Table 1 Actuation devices
Source: Own Elaboration, 2021

For activation and management of the aforementioned devices, the electrical panel of Figure 4 was adapted, in which the necessary connections converge to achieve such functions. However, since the operation of each actuator was originally carried out separately, a different actuation, usually manual, was available to enable each one; which highlighted the lack of coordination between the multiple elements, for the joint management of the environmental conditions inside the greenhouse. Only for the irrigation system was there a timer that can govern its operation based on schedules and time periods established by the user.

Figure 4 Control panel interior
Source: Own Elaboration, 2021

Adaptation of the perception system

From a perception system, the provision of information related to the status of the control elements and the condition of the environment inside the greenhouse, encourages the decision-making process on the parameters that need to be modified to achieve an environment that contributes to the development of crops. Therefore, from the data collected from the confined environment, it is possible that the contemplation of the actions to be carried out may be left to an operator, or it may be carried out automatically by the system controller itself, as considered. .

Because the functionality of the greenhouse will largely depend on the magnitudes of temperature and humidity registered indoors, the need to identify the index of the first variable in the environment surrounding the crops is established; while the second variable can be measured both in the environment and in the soil, in proximity to the root of the plant. Likewise, other elements are considered that allow the activation or suspension of the central control task, the activation of the side windows of the greenhouse and the verification of the water content in the tank that supplies the irrigation system. The devices considered for the recording of the described signals are shown in Table 2.

Quantity	Device
4	Analog sensor of temperature and humidity in the environment surrounding the plant.
8	Analog soil moisture sensor close to the root of the plant.
1	System stop button
1	System start button
1	Selector for activating side windows
1	Water level sensor in the tank to supply the irrigation system.

Table 2 Perception devices
Source: Own Elaboration, 2021

Process controller integration

Once the devices for recording information related to the condition of the process had been contemplated, as well as those that affect the change in its present operating state, a controller was selected that would concentrate the action of both types of elements, to automate greenhouse function.

Being possible to develop a proposal that promotes the application of a variety of devices, but ensuring that their functionality is not compromised by exposure to an environment of high humidity and prone to corrosion or electric shock; so the use of a programmable logic controller (PLC) is chosen as the brain of the process.

An Allen Bradley brand Micrologix 1500 PLC (Figure 5), has been considered as manager for the automation of the greenhouse; it is a device with 12 digital inputs and 12 digital outputs. The inputs can be configured to sink or source, depending on the type of sensor or element used, while the outputs are to relay, which does not condition the use of any particular magnitude or type of electrical supply; which will depend on each device to connect. Communication with the PLC, for its programming, management or data exchange, is possible through the use of two serial ports, mindin and DB9, arranged. While the use of expandable modules extends the functionality of the PLC, by adding a greater number of analog or digital inputs and outputs, as needed.

Figure 5 PLC Micrologix 1500 Allen Bradley
Source: www.rockwellautomation.com, 2021

In this case, the adaptation to the PLC of different 1769-IF4XOF2 expansion modules, also of the Allen Bradley brand, was required; This module is shown in Figure 6. The function of this device is the interpretation of the information coming from the temperature and humidity sensors arranged inside the greenhouse, whose signal emitted is analog. In total there are 12 entries of this type, divided into three required modules.

Each module is equipped with four inputs with a reading range, in voltage from 0 to 10 V and in current from 0 to 20 mA, and two analog outputs from 0 to 10 V; at 16-bit signed resolution in both cases. It is worth mentioning that no analog output was used in this application.

Figure 6 1769-IF4XOF2 Analog Input Module
Source: www.rockwellautomation.com, 2021

With regard to the action units to be managed, which are exclusively digital, a total of 15 outputs are counted to be used; between devices for the preservation of the temperature and humidity conditions inside the greenhouse, as well as for the indication of the state of the process. However, considering that the proposed PLC only has 12 available spaces, it was necessary to consider the use of a 1769-OW16 expansion module, also from the Allen Bradley brand, for the connection of the remaining elements. This module, shown in Figure 7, has 16 relay outputs; for which, as with the PLC outputs, the connection of loads in alternating current or direct current will be indistinct.

Figure 7 1769-OW16 Digital Output Module
Source: www.rockwellautomation.com, 2021

ISSN 2414-4924

Having established the modules that will house the physical inputs and outputs in addition to those available in the PLC to be used, it is proposed to organize them in tables 3 and 4, respectively.

In such tables, in addition to presenting the number of devices related to a particular function, they are assigned a specific address, either of the PLC or of the module, to which they will be connected to fulfill the corresponding reading or writing task. It is worth mentioning the indication of the location, inside the greenhouse, of each of the sensors or actuators used, based on the sectioning previously proposed in Figure 3.

Quantity	Device	Address
4	Analog sensor of temperature and humidity in the environment surrounding the plant.	I:1.0 (quadrant 1) I:1.1 (quadrant 2) I:1.2 (quadrant 3) I:1.3 (quadrant 4)
8	Analog soil moisture sensor close to the root of the plant.	I:2.0 (quadrant 1, section A) I:2.1 (quadrant 1, section B) I:2.2 (quadrant 2, section A) I:2.3 (quadrant 2, section B) I:3.0 (quadrant 3, section A) I:3.1 (quadrant3, section B) I:3.2 (quadrant 4, section A) I:3.3 (quadrant 4, section B)
1	System stop button.	I:0/0
1	System start button.	I:0/1
1	Selector for activating side windows.	I:0/2
1	Water level sensor in the tank for the irrigation system.	I:0/3

Table 3 Description of inputs for the PLC
Source: Own Elaboration, 2021

Quantity	Device	Address
1	System energized indicator light.	O:0/0
1	System stopped indicator light.	O:0/1
1	System in operation indicator light.	O:0/2
4	Solenoid valves for activation of the irrigation system.	O:0/3 (quadrant 1) O:0/4 (quadrant 2) O:0/5 (quadrant 3) O:0/6 (quadrant 4)
1	Nebulizers for humidity regulation in the environment.	O:0/7
4	Motor relays for driving the side windows.	O:0/8 (window opening 1) O:0/9 (window closure 1) O:0/10 (window opening 2) O:0/11 (window closure 2)
1	Heater.	O:1/0
1	Air recirculator.	O:1/1
1	Pump for filling supply tank for irrigation system.	O:1/2

Table 4 Description of outputs for the PLC
Source: Own Elaboration, 2021

Description of outputs for the PLC
Source: Own elaboration, 2021

Since this implementation covers the validation of the operation of the greenhouse intervened as a high-tech entity, the communication system for managing it from a computer was provisional. This determination was made in consideration of the fact that, given the environmental conditions that will prevail inside the greenhouse, once it is in operation, it is not advisable to manage its condition from inside the installation itself, proposing the adaptation of some means that enables timely supervision of the variables to be analyzed and the devices used, remotely. This mode of management enables the continuity of this work.

In this case, the tests for the operation of the greenhouse were developed from the access section, in which the environmental conditions are isolated from those present in the main space using a second door.

In addition, if the functionality of the controller is validated from the data acquired from the sensors, the emission of the respective signals to the actuators; as well as in the performance of the tasks of sending and receiving data from it to the computer used. It is worth mentioning that for the tests carried out, it was not necessary to invest a considerable time that implied a prolonged exposure of the computer equipment to the conditions even in the isolated space.

Communication between the PLC and the computer was established through a 1761-CBL-PM02 serial cable in conjunction with a RS232-USB serial adapter. For its part, an application developed from a virtual instrument in LabVIEW software manages the variables of interest within the greenhouse; this through the presentation of the data acquired by the sensors and the possibility of entering the values destined for the actuators. Therefore, the interaction between PLC and computer is completed through the use of an OPC (OLE for process control) utility. Figure 8 shows the relationship between the elements of the communication system developed.

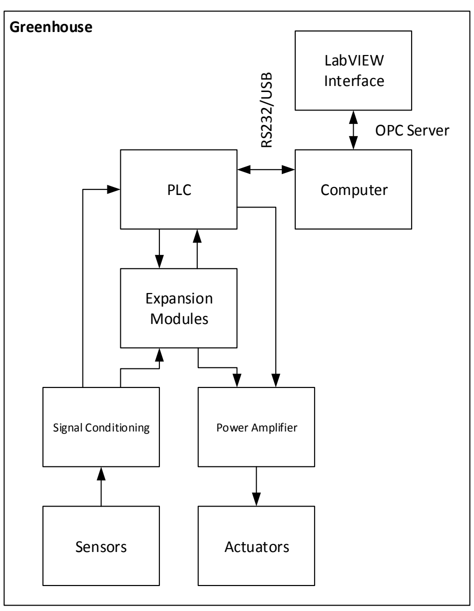


Figure 8 Interaction between components of the communication system
Source: Own Elaboration, 2021

OPC is an open standard for the interconnection of applications based on the Windows operating system and process control hardware, such as a PLC (Rodríguez Penín, 2013).

Thus, the use of OPC allows access to the registers of the variables stored in the memory of a PLC, and allocate such information to a software application executed on a computer or; failing that, it is also possible to modify the data present in said registers, and the reassignment of information by means of the software application used. The realization of both functions is possible through a specific link software utility.

In this case, the own LabVIEW OPC Server was used for the direct exchange of information with the PLC, performing both the reading of the data provided by each sensor inside the greenhouse, as well as the writing of those that are intended for each actuator used. . Thus, the virtual instrument developed in LabVIEW for managing the functionality of the greenhouse was divided according to the signals acquired or emitted, as the case may be, into: side windows, irrigation system, heat and humidity exchange, tank level, system status, ambient temperature and humidity, and soil moisture, as shown in Figure 9.

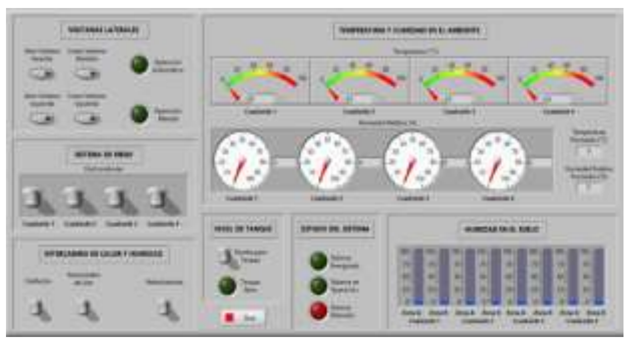


Figure 9 LabVIEW interface for managing environmental variables and devices inside the greenhouse
Source: Own Elaboration, 2021

The developed interface was divided into seven sections. In the upper right portion are located the buttons that allow the activation of the side windows of the greenhouse, in case it is decided to manipulate them manually, by choosing such a configuration from the selector provided. Likewise, the signaling elements corresponding to the mode of operation are located: manual or automatic. Below are the controls that activate the irrigation system for each quadrant, as required. While, in the lower right portion there are the buttons for the action of the heater, the recirculator and the nebulizers.

ISSN 2414-4924

On the other hand, in the upper left section of the interface, the indicators of the variables of temperature and humidity in the environment are shown, arranged in each quadrant of the greenhouse, which are represented in degrees Celsius and in percentage, respectively. The measurement of humidity in the soil, corresponding to each zone, is displayed in the lower left portion, whose representation is also in percentage. Likewise, in the lower middle section of the interface, the indicators referring to the operation of the system are located: energized, in operation or stopped; as the element for the activation of the tank filling and its respective indicator.

Field device operation

The validation of the proper functioning of the system for managing the environmental conditions inside the greenhouse was carried out gradually. In this way, it began by verifying the signals associated with the variables of interest directly in the devices from which they came, or towards those to which they were destined, as the case may be. Thus, it was observed that the digital type sensors used, such as the buttons, the selector and the water level sensor in the tank, emitted a change in their operating state when they were activated. Thus, as if it conserved such signal during the time that they were intervened; yielding satisfactory results.

Regarding analog type sensors, specifically temperature and humidity in the environment, it was validated that these could describe a variable behavior within the ranges of 15 to 35 ° C, for temperature, and 50 to 85% relative humidity. Said variation of conditions was induced by the activation of the nebulizers, for the progressive humification of the place where the reading was taken, this in the case of relative humidity, while the heater and the air recirculator were used to affect the temperature.

Such actions also made it possible to verify the correct operation of the actuators on which the homogenization of temperature and humidity inside the greenhouse will depend, once in operation; and that, however, for now, they were operated manually.

The behavior of humidity in the soil could only be identified by activating the irrigation system, by the action of the solenoid valves that establish its operation; Through which, the soil surrounding the sensor could be moistened, also progressively, and the associated signal appreciated. Regarding the pump that supplies water to the tank, its operation was also corroborated from the water level captured by the sensor arranged for this purpose, being able to characterize its activation, once the sensor stops detecting the liquid at the height at which it has been placed inside the tank, to preserve its filling.

Likewise, the proper operation of the side windows was confirmed, through the use of the selector provided, in manual mode, and the direct energization of the gearmotors that led to the opening or closing of each of these, as required, allowing the indistinct modification between both actions. Finally, the activation of the lamps used to signal the status of the system was validated, once constituted, for the management of the greenhouse.

Controller operation and management interface

After characterizing the expected response in both the sensors and the actuators used, even manually, they continued to be connected to the input and output terminals of both the PLC and the built-in expansion modules. Validating that the union between the conductors and terminals of the PLC was adequate, prior to its energization. To later carry out a reading test of all the sensors used, inducing a variation in the operating state of each one, regardless of its type, from the activation of the actuators, just as it was done during the performance of the previous tests, only in this case, combining the function of both types of devices from the loaded program to the PLC.

Thus, the modification of the values acquired from the sensors, in addition to the manipulation of the actuators from the PLC's own programming, managed from the respective computer software, made it possible to ensure the required behavior in these. Therefore, the assembly of the graphical interface for the manipulation of the PLC registers, where the values that represent the data derived from the reading and writing of the field devices are stored, as the case may be, was ensured without complications.

Thus, from the LabVIEW interface it was possible to know the values read by each sensor used, in addition to manipulating the arranged actuators; with which, the variation in the operation of the latter favored the change in the readings made.

Conclusions

The intervention described allows to have a fully rehabilitated greenhouse, and installed electrical, electronic and electromechanical devices and equipment inside, which will enable it to be used in small-scale cultivation or experimentation tasks. Although the regulation of the environmental conditions inside said space is still carried out in an open loop, by the action of an operator from the developed graphical interface, the installation that is now available will allow the incorporation, in the short term, of strategies for the automatic control of the implicit temperature and humidity variables. Such assertion is based on the fact of having sensors, actuators and a controller in continuous interaction with the environment confined in the greenhouse and with each other, the corroboration of its adequate operation and the concentration of the data exchanged within the PLC used as controller.

The full identification of the type of signals coming from the sensors, as well as those that would be emitted to the actuators, led to the adequate organization of the input and output terminals required in the PLC. On the other hand, the adaptation of the expansion modules contemplated, both for analog inputs and digital outputs, allowed the provision of additional terminals to those originally established in the PLC, for the connection of all the devices used. Thus, the use of expansion modules assumed the connection of analog sensors, for the management of this type of reading, in addition to the connection of other digital actuation devices that could not be directly connected to the PLC due to lack of terminals.

On the other hand, the adaptation of the graphical computer interface, for the management of the functions of the devices inside the greenhouse, has promoted a fast, intuitive and comfortable way to interact with such elements, for the modification or recording of the conditions. associated environmental conditions.

The communication between the LabVIEW virtual instrument, the basis of the management interface, and the PLC, based on the use of the open OPC standard, has been very useful for the success of this application; so that it was not necessary to use any other device, connection or communication protocol for the exchange of data between both elements; which, without a doubt, sped up the validation process performed.

Thus, the aspects described give proof of the qualification and conditioning of the zenith experimental greenhouse of the Polytechnic University of Aguascalientes, for its operation as a high technology system; with the objective of completing this technological scheme in the short term, from the closure of the control loop or feedback in it. Such purpose provides the necessary motivation to give continuity to the work developed up to this point. It should be noted that, since its establishment, the greenhouse has been gradually used in the cultivation of plants for the extraction of essences, for which, for now, it is expected to solve the demand necessary for this purpose..

References

Amani, M., Foroushani, S., Sultan, M., & Bahrami, M. (2020). Comprehensive review on dehumidification strategies for agricultural greenhouse applications. *Applied Thermal Engineering*, 115979.

Baglivo, C., Mazzeo, D., Panico, S., Bonuso, S., Matera, N., Congedo, P. M., & Oliveti, G. (2020). Complete greenhouse dynamic simulation tool to assess the crop thermal well-being and energy needs. *Applied Thermal Engineering*, 115698.

Borja Bravo, M., Rodríguez Licea, G., Osuna Ceja, E. S., & López Aguilar, L. (2016). Importancia económica y competitividad de las cadenas agropecuarias en Aguascalientes, México. *Investigación y Ciencia*, 5-12.

Çaylı, A. (2020). Temperature and relative humidity spatial variability: An assessment of the environmental conditions inside greenhouses. *Fresenius Environmental Bulletin*, 4954-4962.

CPLAP, C. G. (Septiembre de 2019). *Datos Aguascalientes.* Obtenido de Gobierno del Estado de Aguascalientes: https://www.aguascalientes.gob.mx/cplap/Docs/datos/DATOS.pdf

De la Cerda Lémus, M. E. (2011). La familia Burseraceae en el estado de Aguascalientes, México. *Acta botánica mexicana*, 1-25.

Ghani, S., Bakochristou, F., Mohamed, E., ElBialy, A. A., Mahmoud, S., Gamaledin, A., . . . Ismail, S. M. (2019). Design challenges of agricultural greenhouses in hot and arid environments - A review. *Engineering in Agriculture, Environment and Food*, 48-70.

Iddio, E., Wang, L., Thomas, Y., McMorrow, G., & Denzer, A. (2020). Energy efficient operation and modeling for greenhouses: A literature review. *Renewable and Sustainable Energy Reviews*, 109480.

Rodríguez Penín, A. (2013). *Sistemas SCADA.* México D.F.: Alfaomega Grupo Editor.

Shamshiri, R. R., Jones, J. W., Thorp, K., Ahmad, D., Che Man, H., & Taheri, S. (2018). Review of optimum temperature, humidity, and vapour pressure deficit for microclimate evaluation and control in greenhouse cultivation of tomato: A review. *International Agrophysics*, 287-302.

SIAP, S. d. (2014). *Cultivos de agricultura protegida 2014.* Obtenido de Datos Abiertos: http://infosiap.siap.gob.mx/gobmx/datosAbiertos.php

SIAP, S. d. (2015). *Superficie cubierta y número de instalaciones de agricultura protegida (2015).* Obtenido de Datos Abiertos: http://infosiap.siap.gob.mx/gobmx/datosAbiertos.php

ISSN 2414-4924

Article ECORFAN Journal-Democratic Republic of Congo
June 2021 Vol.7 No.12 19-28

Statistical analysis and characterization of Landsat 8 satellite images of forest wildfires regions

Análisis estadístico y caracterización de imágenes de satélite Landsat 8 sobre regiones con incendios en bosques

HERNANDEZ-LOPEZ, Sandra Paola †*[1], YAÑEZ-VARGAS, Juan Israel[1], GONZÁLEZ-RAMIREZ, Andrea[2] and TORRES-ROMAN, Deni[2]

[1]*Universidad Politécnica de Juventino Rosas, Master's degree in intelligent systems engineering, Mexico.*
[2]*CINVESTAV del IPN, Unidad Guadalajara, Telecommunications Laboratory, Mexico*.

ID 1st Author: *Sandra Paola, Hernández-López* / **ORC ID:** 0000-0003-2312-2695 **CVU CONACYT ID:** 1002324

ID 1st Coauthor: *Juan Israel, Yañez-Vargas* / **ORC ID:** 0000-0001-5749-8442, **CVU CONACYT ID:** 295711

ID 2nd Coauthor: *Andrea, Gonzalez-Ramirez* / **ORC ID:** 0000-0001-9961-4763, **CVU CONACYT ID:** 1001207

ID 3rd Coauthor: *Deni, Torres-Roman* / **ORC ID:** 0000-0002-9813-7712, **CVU CONACYT ID:** 20075

DOI: 10.35429/EJDRC.2021.12.7.19.28 Received March 28, 2021; Accepted June 20, 2021

Abstract

The increase in the increase in wildfires throughout the world is largely due to increases in temperature and even to an increase in the carelessness of the population in leaving a large amount of the garbage in forests. Using Python and Matlab programs were as working medium. We performed the preprocessing on multispectral images obtained by the Landsat 8 satellite with and without wildfires, which consists of three steps: alignment, characterization and normalization, with the intention of standardization the images. From obtaining the spectral signatures of wildfires and metallic structures, boxes and whiskers diagrams, Shannon entropy and mutual information from the images, there are similar behavior in bands 6, 7, 8, 10 and 11, with more relevant information, taking into account that each image is formed by 11 bands, and in bands 1, 2, 3, 4, 5, 8 and 9 there is less information, SVD decomposition allows to have the best k-rank approximation to the original data matrix. The purpose of this analysis is to reduce the computational complexity.

Landsat 8, Wildfires, Characterization, Data analysis

Resumen

El incremento en el número de incendios forestales a lo largo del mundo se debe en gran medida a los aumentos de la temperatura e incluso al incremento de los descuidos de la población al dejar una gran cantidad de basura en bosques. Utilizando los programas de Python y Matlab como medio de trabajo, se realizó el pre procesamiento en imágenes multiespectrales obtenidas por el satélite Landsat 8 con y sin incendios, el cual consiste en tres pasos: alineación, caracterización y normalización, esto con la intención de estandarizar las imágenes. A partir de obtener las firmas espectrales de incendio y estructuras metálicas, los diagramas de cajas y bigotes, la entropía de Shannon e información mutua de las imágenes, se tienen similares comportamientos en las bandas 6,7,10 y 11, con mayor información relevante, tomando en cuenta que cada imagen está formada por 11 bandas, y en las bandas 1,2,3,4,5,8 y 9 se tiene una menor información, la descomposición SVD permite tener la mejor aproximación de rango-k de la matriz de datos originales. Al realizar este análisis se busca reducir la complejidad computacional.

Landsat 8, Incendio, Caracterización, Análisis de datos

Citation: HERNANDEZ-LOPEZ, Sandra Paola, YAÑEZ-VARGAS, Juan Israel, GONZÁLEZ-RAMIREZ, Andrea and TORRES-ROMAN, Deni. Statistical analysis and characterization of Landsat 8 satellite images of forest wildfires regions. ECORFAN Journal-Democratic Republic of Congo. 2021, 7-21: 19.28

* Correspondence to Author (e-mail: shernandezl_pa@upjr.edu.mx)
† Researcher contributing first author.

1. Introduction

The number of wildfires around the world are caused by increases in temperature and even by carelessness of the population leaving a large amount of garbage in the forest. For this reason, in recent years, the nations in the world have been focused on studies that seek on time wildfires detections, to arrive before the fires consume more hectares of forest. Several techniques have been used to accomplish wildfire studies, among them the use of Remote Sensing (RS) (Lira Ch-Vez, 2012).

Therefore, multispectral images from RS systems has shown to be a more complete system in studies of detection and classification of earth elements. One of the clearest examples is “Landsat 8 was launched on February 11, 2013”(USGS Science for a changing world, 2021)

In the study by (Corrales Andino, 2017) a model is developed for the correction of images with the values of Digital Numbers (DN) to the physical parameters as a satellite reflectance, which allows the reduction of errors caused by atmospheric effects. The methodology applied was the calculation of physical magnitudes for the conversion top-of-atmosphere (TOA) reflectance with angular correction. They mention that the model will be used for satellite images calibration of the Landsat sensor Operational Land Imager (OLI) program, to validate the model they perform comparative with a research work in the postgraduate. Master’s Degree in Land Planning and Management of the Faculty of Space Sciences, under the ítem: Multitemporal Analysis of the Land Cover of the R Sub-basin

(Simonetti et al., 2015) Developed a fully automatic phenology-based synthesis (PBS) classification algorithm, which performs a mapping of terrestrial coverage. The seasonality of the vegetation in the dry regions is made the classification, with conventional classifiers, using images of the same dates in which they carry out the preprocessing, where they apply reflectance to, the part in which they mention that they did not process bands 1 and 9, thermic and panchromatic. A PBS has been developed for the Landsat 8 sensor and works fully automatically without additional input requirements, as supplementary images or training data.

PBS implementation in Google Earth Engine (GEE) provides a fast and efficient mapping tool applicable.

Remote Sensing

“Remote Sensing (RS) obtaining information about a scene, using visible light, infrared and microwave radiation, by means of automated analysis of data obtained from a distance using a system formed by a group of remote sensors” (Lira Ch-Vez, 2012)

RS provides a temporary overview in large areas: this allows us to observe changes over time that could range from minutes to years. This can be used to study changes in the stage of the earth’s surface and atmosphere as mentioned by (Curlander, 1991)

Landsat 8

“Landsat 8 (formally the Landsat Data Continuity Mission, LCDM) was launched on February 11, 2013 from Vandenberg Air Force Base, California on an Atlas-V 401 rocket, with the extended payload fairing (EPF) from United Launch Alliance, LLC” (USGS Science for a changing world, 2021)

“The Landsat 8 satellite payload consists of two science instruments: the Operational Land Imager (OLI) and the Thermal InfraRed Sensor (TIRS). These two sensors provide seasonal coverage of the global landmass with a spatial resolution of 30 meters (visible, Near Infrared Red (NIR), Short-Wave-Infrared (SWIR)), 100 meters (thermal), and 15 meters (panchromatic)”. The spectral bands of the OLI sensor are an improvement over previous Landsat instruments, with the addition of two additional spectral bands: a visible deep blue channel (band 1) specially designed for water resources and coastal zone research, and new shortwave infrared channel (band 9) (Landsat Science, 2021).

2. Contribution

In previous works, normalization is only performed in the preprocessing part, in the present work, characterization and alignment of the images are added to the preprocessing step, by combining these three aspects, a more appropriate image for the classification process is obtained.

ISSN 2414-4924

In this study case, the classes of wildfires and metallic structure pixels is more concentrated.

3. Problem Statement

Given $\boldsymbol{\mathcal{X}}$ where $\boldsymbol{\mathcal{X}} \in R^{I_1 \times I_2 \times I_3}$ is a third-order tensor, representing the multispectral image, which is obtained no aligned, unclassified. Using algorithms of alignment, atmospheric correction and normalization, you will get a new tensor $\boldsymbol{\mathcal{X}}$ aligned, calibrated and normalized, in turn, to see the possibility of verifying a decrease of error in the classification in addition to having images standardization.

4. Pre-Processing

"Image Processing is the set of techniques applied to digital images in order to improve their quality", it encompasses a series of techniques that comprise operations where the origin is an image, and the result is another, already processed image. (Gonzalez, 2017)

The images obtained from the Landsat 8 system must have the necessary characteristic to be able to stand processed, that is to say they must have the following steps to be used, which are: alignment, characterization and normalization.

Image alignment

Because the sensors located on the satellite have a different capture distribution and the angle of incidence of the signals, it is sometimes necessary to record the images so that the 11 bands provided by a single multispectral image have the objects in the same positions by (James Storey, 2016). When performing the alignment between the bands, a test difference is performed, then the alignment between the bands is done and configured according to following the parameters.

Normalization

"An alternative approach to Z-score normalization (or standardization) is the so-called Min-Max scaling (often also simply called normalization a common cause for ambiguities). In this approach, the data is scaled to a fixed range, usually 0 to 1".

Is a process that changes the range of pixel intensity values, in contrast to standardization is that we will end up with smaller standard deviations, which can suppress the effect of outliers (Raschkan, 2014)

$$Xnorm = \frac{X - X_{min}}{X_{max} - X_{min}} \quad (1)$$

Where X is an original value, $Xnorm$ is the normalized value, X_{min} is the minimum value of the variable and X_{max} is the maximum value of the variable.

Radiometric correction in Landsat 8 images

Landsat is a passive satellite that emits signals at certain frequencies and the captures the bounces of the signals, so those signals come with errors due to disturbances of the environment, including the sum of signals caused by the radiation from the sun, therefore the images must be adjusted according to the radiation characteristics of the sun, inclination and even the temperature, so the process is called calibration.

"The data from the OLI sensor can be converted to reflectance values, Top-Of-Atmosphere (TOA) in the ceiling of the atmosphere, using the reworked reflectance coefficients provided in the product metadata file (MTL file). The following equation is used to convert DN digital levels to reflectance values for those obtained by the OLI sensor" (Geospatial, 2021):

$$\rho\lambda' = M\rho Qcal + A\rho \,, \quad (2)$$

where "$\rho\lambda'$ this is TOA planetary reflectance, without correction by solar angle. Note that $\rho\lambda'$ does not contain a correction for the solar angle, $M\rho$ is the Band-specific multiplicative rescaling factor from the metadata, it $Qcal$ quantized and calibrated standard product pixel values (DN)".

This value refers to each of the bands of the image and $A\rho$ is the specific scaling additive factor per band obtained from the metadata (Using the USGS Landsat Level-1 Data Product, s. f.).

ISSN 2414-4924

5. Data analysis

Spectral Signature

The spectral signatures refer to the quantitative measurement of object properties in spectral bands, which refer to the variation of the reflectance or radiance emitted by objects, all geographic elements (forest, crops, rivers, lakes, buildings, etc.) each of the materials has a unique signature

Box and Whiskers

A box and whiskers diagram (or box plot) is a graphical representation of data, showing some of its key statistical features. The lines that extend parallel are whiskers, are used to indicate the variability outside the lower and upper quartiles (3d,3e), the first quartile has the lowest 25% of the data instances (3a), Median or also second quartile has 50% (3b) (the distribution of data is divided into two equal parts the distribution), and the third quartile has the lowest 75% of the data instances (3c) (Chalmers & Gilbey, 2018).

Quartiles

First Quartile (Q_1) = (N+1)/4 (3a)

Second Quartile = N/2 (3b)

Third Quartile (Q_3) = 3(N+1)/4 (3c)

Lower and upper admissible limits (LI y LS)

$$LI = Q_1 - 1.5 * IQR \quad (3d)$$

$$LS = Q_3 + 1.5 * IQR, \quad (3e)$$

where N = number of data instances and IQR = interquartile range. Using the box and whiskers diagrams, you get a lot of information from a probability distribution. This type of graph can identify outliers, at the same time making a distribution comparison.

Entropy

"The entropy which is a measure of the uncertainty of random variable. Let X be a discrete random variable with alphabet X and probability mass function $p(x) = Pr\{X = x\}, x \in X$.

We denote the probability mass function by $p(x)$ rather than $p_x(x)$, for convenience. Thus, $p(x)$ and $p(y)$ refer to two different random variables and are in fact different probability mass functions" (Cover, 2006).

The Shannon entropy $H(X)$ of a discrete random variable X is defined by

$$H(X) = -\sum_{x \in X} p(x) \, logp(x) \,. \quad (4)$$

We also write $H(p)$ for the above quantity. The log is to the base 2, then the entropy is expressed in bits. If the log is taken to be the natural log, then entropy is expressed in nats. Where $x \in X$ possible results belonging to X,

Mutual Information

"Consider two random variables X and Y with a joint probability mass function $p(x, y)$ and marginal probability mass function $p(x)$ and $p(y)$. The mutual information $I(X; Y)$ is the relative entropy between the joint distribution and the product distribution $p(x)\, p(y)$" (Cover, 2006).

$$I(X;Y) = \sum_{x \in X} \sum_{y \in Y} p(x, y) \, log \, \frac{p(x,y)}{p(x)p(y)} \quad (5)$$

With the equation 5 can be written

$$I(X;Y) = H(X) - H(X|Y) \quad (5a)$$

6. Singular Value Decomposition (SVD)

"The Singular value decomposition (SVD) is a theorem of linear algebra, where it mentions that a rectangular matrix A can be broken down into the product of the three matrices – an orthogonal matrix U, a diagonal matrix S, and the transpose of an orthogonal matrix V, where $m \times n$ size of the matrix, where the matrix S is the matrix of singular values, which ordered identify the direction of greatest variance, as well find the best approximation to the original data using fewer dimensions" (Decomposition, 2021, chapter-4).

$$A_{m \times n} = U_{m \times m} S_{m \times n} V_{n \times n}^T, \quad (6)$$

ISSN 2414-4924

where $U^T U = I, V^T V = I$; the columns of U are orthonormal eigenvectors of AA^T, the columns of V are orthonormal eigenvector of $A^T A$, and S is a diagonal matrix containing the square roots of eigenvalues from U or V in descending order (tutorial, 2021).

7. Methodology

In this work, the normalization, radiometric correction and data analysis algorithms were applied. Using two images with wildfires that occurred in Mendocino County (California USA) in 2018 with a difference of one week between the images, a third image of the same region, but without wildfires, was obtained by the Landsat 8 satellite.

The images were obtained from the website United States Geological Survey (USGS), for the pre-processing of multispectral images which have a resolution of 7750 x 7530. In this work on the images, a cut was made of the area where the fire is located. We will be working on 512 x 512 images of the wildfires zone.

Alignment

The images are not aligned; this is because the sensors located on the satellite have a different capture distribution and the angle of incidence, the signals have, it is sometimes necessary to record the images so that the 11 bands provided by a single multispectral image have the objects in the same positions.

Figure 1 shows an example of an image where the non-alignment with the images can be seen.

Figure 1 Non-alignment of the images (PARROT)

The non-alignment is found in the obtained images, as a first step in the preprocessing, the alignment of the images is applied. Figure 2 shows an example of the aligned image.

Figure 2 Alignment image (PARROT)

Atmospheric correction (characterization)

With the images aligned, Top- of- Atmosphere (TOA) surface reflectance will allow for improvement when comparing multiple images of the same region, considering the atmospheric effects of aerosol dispersion and thin clouds, the correction helps in detecting and characterization of surface changes. Which is the light reflected by the earth's surface.

It is a relationship between surface radiance, surface irradiance and as such has no units, it has values between 0 and 1. By which you will be applying the equation (2) of TOA reflectance described above.

Normalization

The previously aligned and characterized images will be normalized through equation 1, before applying the formula, the maximum value, and the minimum value of each of the bands are obtained, then we apply the equation 1.

Data analysis

The images are preprocessed and the analysis of the data, in this case the images, is then carried out. In which spectral signatures, box and whiskers diagram, Shannon entropy and mutual information of the bands will be obtained.

Spectral Signature: The first step is to obtain the spectral signatures of the classes: wildfires, vegetation, smoke, water and metallic structure, to observe the behavior and similarity between the wildfires and metallic structure.

Boxers and Whiskers diagram: The second step is to create the Boxer and Whiskers graphic according to the pixel values in each multispectral band with the wildfire's scene.

Entropy: The third step is to calculate the Shannon entropy for each image bands using the equation 4.

Mutual Information: The fourth step is to compute the mutual information of each pair bands, applying the equation 5.

SVD

After the characterization and analysis of an image, perform the singular value decomposition of this image selecting *k* singular values to construct a new image of rank *k*.

8. Results

Figure 3 shows the images of the Mendocino wildfires, obtained by the Landsat 8 satellite, which has a size of 512x512 pixels, and in figure, 5 images were obtained of the same area of Mendocino without wildfires.

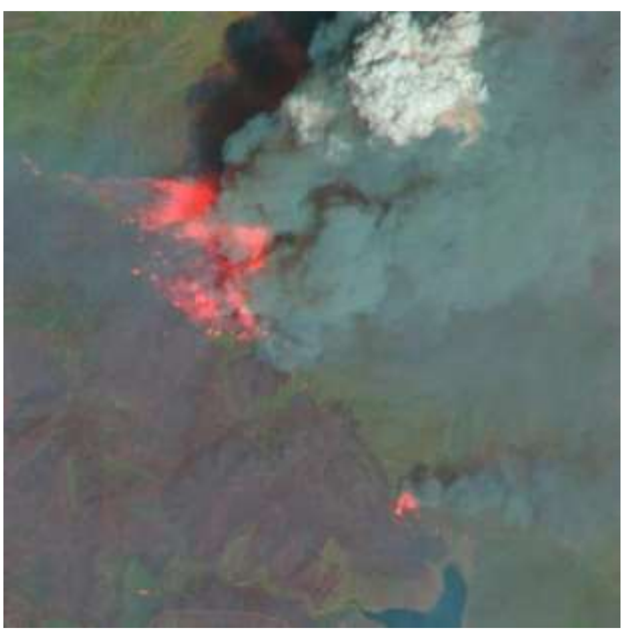
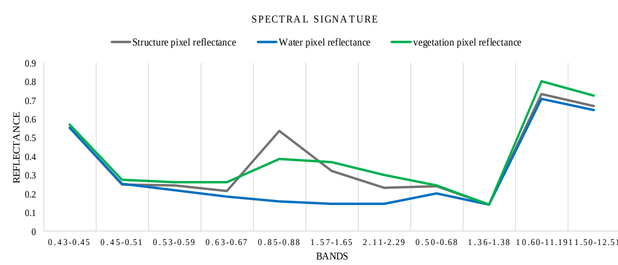


Figure 3 Images with wildfires (Landsat 8) https://earthexplorer.usgs.gov/.

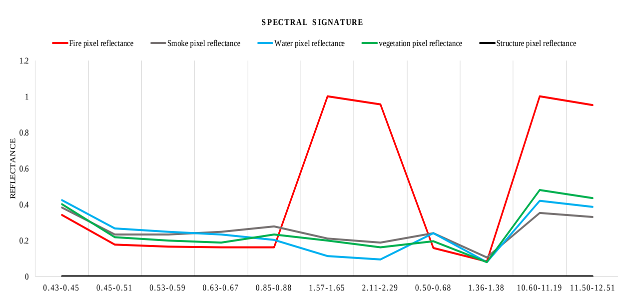
Figure 4 Images without wildfires (Landsat 8) https://earthexplorer.usgs.gov/

Graph 1 shows the spectral signatures of Figure 4 with three classes: vegetation, water and metallic structure, showing that the metallic structure has a higher reflectance in bands 6, 7 and 10.



Graph 1 Spectral Signature images without wildfires
Own Source [Excel]

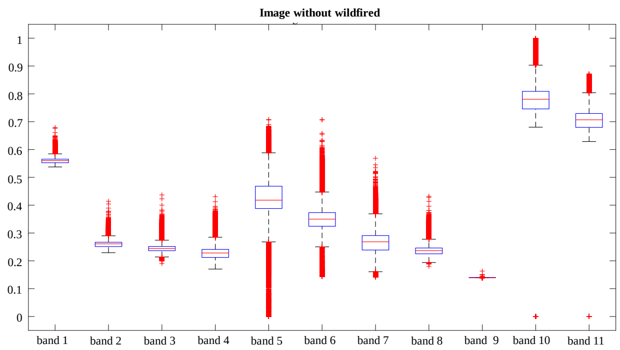
Graph 2 shows the spectral signatures of Figure 3 with five classes: wildfire, smoke, vegetation, water and metallic structure, which indicates that the wildfires show high reflectance values in band 6, 7, 10 and 11.



Graph 2 Spectral Signature images with wildfires
Own Source [Excel]

ISSN 2414-4924

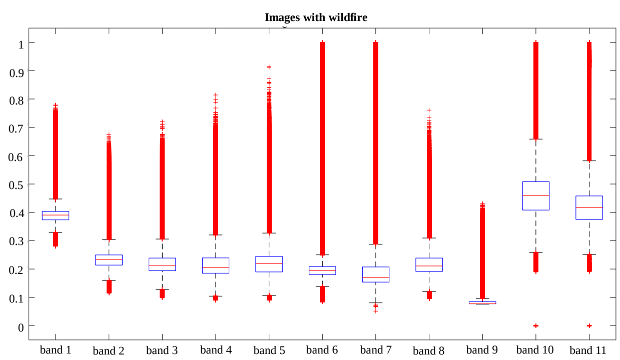
Graph 3 presents the box and whiskers diagram of the without wildfires image, showing a distribution of outliers across the 11 bands.



Graph 3 Box and whiskers image without wildfires
Own Source [Matlab]

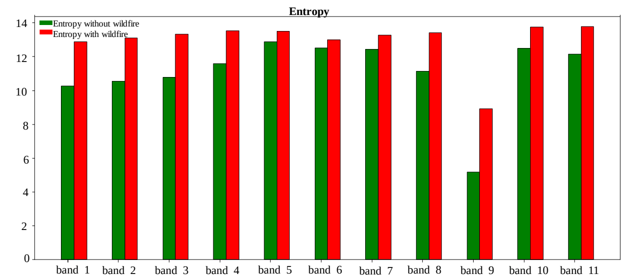
Graph 4 presents the box and whiskers diagram of the images with wildfires, where more outliers are obtained throughout the 11 bands, with a higher concentration in bands 6,7,10 and 11.

Graph 4 presents the box and whiskers diagram of the images with wildfires, where more outliers are obtained throughout the 11 bands, with a higher concentration in bands 6,7,10 and 11.



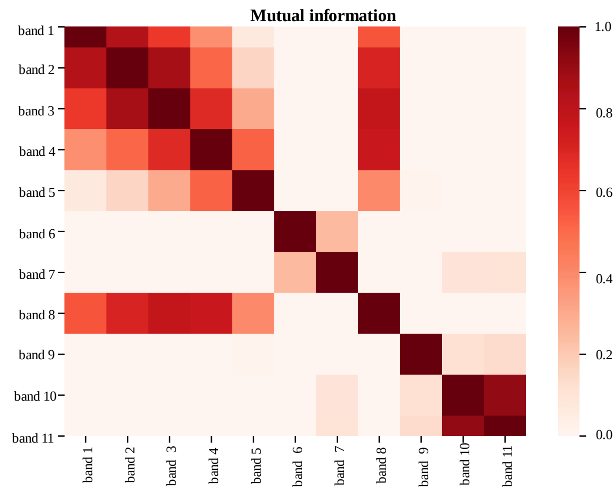
Graph 4 Box and whiskers image with wildfires
Own Source [Matlab]

Graph 5 illustrates the Shannon entropy of the images with and without wildfires where we observe the variation of the uncertainty from one image to the other, which gives more information in the image with wildfires.



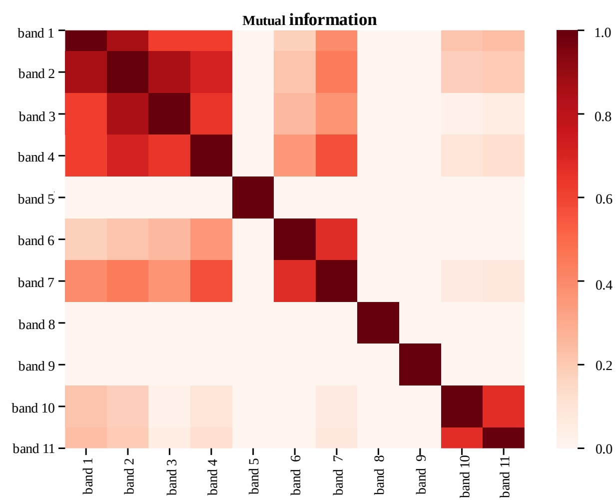
Graph 5 Shannon entropy
Own Source [Python]

Graph 6 illustrates the mutual information of the images with wildfires, where there is a greater similarity from band 1 to band 5, and band8.



Graph 6 Mutual information image with wildfires
Own Source [Python]

Graph 7 shows the image without wildfires, where there is a greater similarity from band 1 to band 4, and bands 6, 7, 10 and 11.



Graph 7 Mutual information without wildfires
Own Source[Python]

For each 512x512 image, its SVD was calculated. For a few singular values, the images do not have a good clarity, but the higher the number of singular values, the better image clarity, as shown in figures 5 and 6.

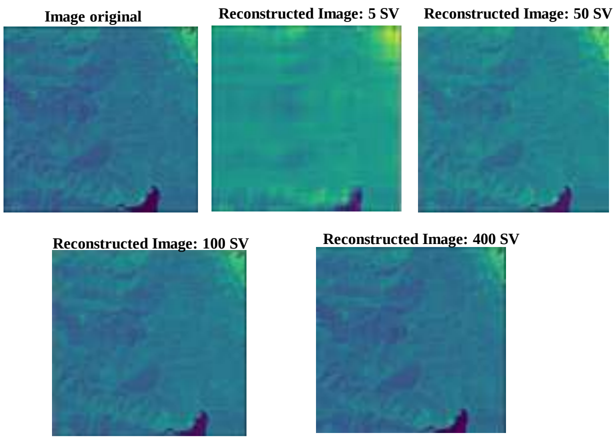


Figure 5 Singular values, image without wildfires

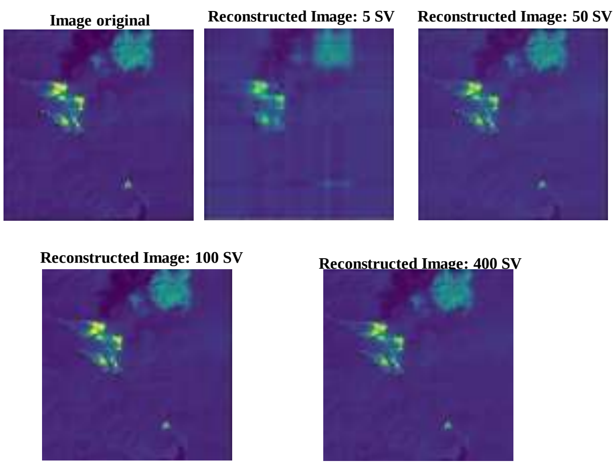


Figure 6 Singular values image with wildfires

Figure 7 it is observed that there is a difference in the singular values between the images with and without wildfires, and also from the image with wildfires more singular values can be used to work with a modified image in which not enough information will be lost.

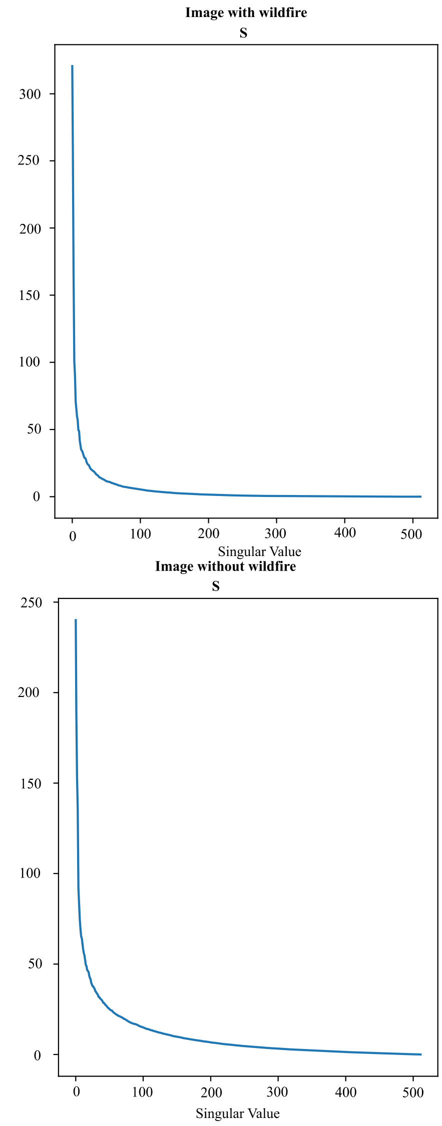


Figure 7 Singular Values
Own Source

9. Conclusions

This paper shows that when working with multispectral images obtained from the satellite Landsat 8, an alignment between the 11 bands must be performed. The characterization is also performed using the atmospheric reflectance correction to obtain an image in physical reflectance parameters from digital image values (DN), the normalize the images.

When obtaining the spectral signatures of the classes: wildfires, vegetation, smoke, water and metallic structure, it is observed that the reflectance of the wildfires and metallic structure pixels have the same behavior in bands 6,7,8,10 and 11, the spectral signatures shows in which bands there is a greater visualization of the wildfires and metallic structure pixels, this will allow us to reduce the classification error percentage of the classes in future works, when working with the classification algorithms.

Statistical analysis visualizes the behavior of the data in the image with and without wildfires, as shown in the box and whiskers diagram, Shannon entropy and mutual information of the images, helps us to know the amount of information provided by each of the bands, to discard the images where the information is minimal in the image with and without wildfires. From the image with wildfires in band 8 there is less information compared to band 6, 7, 8, 10 and 11 where there is more information. By using SVD a representation of the best approximation the original data.

In previous work, the preprocessing is perform by applying the atmospheric correction or normalization. What is done with the present work by adding in the preprocessing the steps of alignment, atmospheric correction and normalization to obtain a standardized image, at the same time it is sought to reduce the computational complexity.

10. Open issues

- Apply an exhaustive study in image processing information theory.
- To carry out a study of detection/classification algorithms and their subsequent implementation.

11. Acknowledgements

The authors would like to thank the CINVESTAV del IPN, Unidad Guadalajara, Telecommunications Laboratory, Mexico. And the Universidad Politécnica de Juventino Rosas

Reference

Corrales Andino, R. O. (2017). Calculation of reflectance in Landsat OLI-8 images, on the central region of Honduras, using fre software SEXTANTE. *Ciencias especiales*, 81-96. doi: https://doi.org/10.5377/ce.v9i1.3127

Chalmers,D., & Gilbey, J.(2018). *Cambridge International as & a Level Mathematics probability & Statistics 1 Coursebook with Cambridge Online Mathematics* (2 years) [Electronic book]. Cambridge University Press.

Cover, T.M. (2006). *[Elements of Information Theory] [By: Cover, Thomas M.] [July, 2006](SECOND EDITION)*[Electronic book]. Wiley-Interscience.

Curlander, J. &. (1991). *Synthetic Aperture Radar: Systems and Signal Processing.* Wiley-Interscience.

Decomposition, S. V. (09 de 05 de 2021). *Singular Value Decomposition*. Obtained from https://www.cs.cmu.edu/~venkatg/teaching/CStheory-infoage/book-chapter-4.pdf

Geospatial, L. H. (8 de April de 2021). *Radiometric Calibration*. Obtenido de L3 Harris Geospatial: https://www.l3harrisgeospatial.com/docs/radiometriccalibration.html

Gonzalez, R. &. (2017). *Digital Image Processing.* Pearson.

James Storey, D. M. (2016). A note on the temporary misregistration of Landsat-8 Operation Land Imager (OLI) and Sentinel-2 MultiSpectral Instrument (MSI) Imagery. *Remote Sensing of Enviroment*, 1221-122. doi:https://doi.org/10.1016/j.rse.2016.08.025

Landsat Sciencie. (7 de April de 2021). *Landsat Sciencie*. Obtenido de Landsat Sciencie: https://landsat.gsfc.nasa.gov/landsat-8/landsat-8-overview

Lira Ch-Vez, J. (2012). *The Remote Perception (Spanish edition).* Paperback.lulu.com.

Raschkan, D. (11 de July de 2014). *Dr.Sebastian Raschkan*. Obtenido de About Feature Scaling and Normalization: https://sebastianraschka.com/Articles/2014_about_feature_scaling.html#about-min-max-scaling

Raschkan, D. S. (11 de july de 2014). *About Feature Scaling and Normalization.* Obtenido de About Feature Scaling and Normalization.: https://sebastianraschka.com/Articles/2014_about_feature_scaling.html#about-min-max-scaling

Simonetti, D. &. (2015). First Result From the Phenology-Based Synthesis Classifier Using Landsat 8 Imagery. *IEEE Geoscience and Remote Sensing Letters*, 12(7),1496-1500. doi:https://doi.org/10.1109/lgrs.2015.2409982

Simmotti, D., Simonetti, e., Szatoi, Z., Lupi, A., & Eva, H.D. (2015) First Result From the Phenology-Base Sythesis Classifier Using Landsat 8 Imagery.*IEEE Geoscience and Remote Sensing Letters*, *12(7)*, 1496-1500. https://doi.org/10.1109/lgrs.2015.2409982.

Tschannerl, J. R. (2019). MIMR-DGSA: Unsupervised hyperspectral band selection based on information theory and modified discrete gravitational search algorithm. *Information Fusion,*, 189-200. doi:https://doi.org/10.1016/j.inffus.2019.02.005

tutorial, S. V. (09 de 05 de 2021). *Singular Value Decomposition (SVD) tutorial*. Obtenido de Singular Value Decomposition (SVD) tutorial:https://web.mit.edu/be.400/www/SVD/Singular_Value_Decomposition.htm

USGS Science for a changing world. (7 de april de 2021). *Landsat Missions*. Obtenido de Landsat Missions: Landsat Missions. (s. f.).

USGS Science for a changing world. Recuperado 7 de abril de 2021, de https://www.usgs.gov/core-science systems/nli/landsat/landsat-8?qt-science_support_page_related_con=0#qt-science_support_page_related_con

USGS science for a changing world. (19 de junio de 2021): https://earthexplorer.usgs.gov/

Neural network for crop rotation and soil analysis in a Greenhouse

Red Neuronal para la rotación de cultivos y análisis de suelo en un Invernadero

RAFAEL-PÉREZ, Eva†*, MONTERO-CORTÉS, Yeimi Yanet, RUIZ-RAMÍREZ, Alan Eduardo and MORALES-HERNÁNDEZ, Maricela

Tecnológico Nacional de México/ Instituto Tecnológico de Oaxaca, Departamento de Sistemas y Computación. Avenida Ing. Víctor Bravo Ahuja No. 125 Esquina Calzada Tecnológico, Oaxaca, Oax., México. C.P. 68030

ID 1st Author: *Eva, Rafael-Pérez* / **ORC ID:** 0000-0003-2793-1254, **CVU CONACYT ID:** 905268

ID 1st Co-author: *Yeimi Yanet, Montero-Cortés /* **ORC ID**: -0000-0001-5510-7241 **CVU CONACYT ID:** 1148726

ID 2nd Co-author: *Alan Eduardo, Ruiz-Ramírez* / **ORC ID:** -0000-0001-9269-5951 **CVU CONACYT ID**: 1148734

ID 3rd Co-author: *Maricela, Morales-Hernández* / **ORC ID:** 0000-0002-3521-2041, **CVU CONACYT ID:** 731036

DOI: 10.35429/EJDRC.2020.12.7.29.41 Received March 28, 2021; Accepted June 30, 2021

Abstract

Currently, Artificial intelligence (AI) is a very important area, the way in which it has revolutionized has allowed it to be an essential part of technological evolution in different sectors of society such as agriculture, it is a fundamental activity in the development of our country, and one of the developing areas is implementation of greenhouse crop. This article describes the use of artificial intelligence for a greenhouse through an Artificial Neural Network (ANN) of the multilayer perceptron type using the BackPropagation algorithm. The main aim is obtain the most optimal type of crop to be sown by means of the crop rotation, which, supported by a data acquisition device through sensors, obtains the values of temperature and humidity of the environment and soil pH, with those data the ANN makes the soil analysis. Through the interfaces of the data analysis module and the measurement module, the data collection process, the calculation and the results produced by the artificial neural network are shown. For this project, the Prototype model was used using the Java programming language.

Artificial Neural Network, Crop rotation, Soil analysis

Resumen

La inteligencia artificial (IA) es un área importante en la actualidad, la manera en cómo ha revolucionado le ha permitido ser parte esencial de la evolución tecnológica en varios sectores de la sociedad como es la agricultura, actividad fundamental en el desarrollo de nuestro país que se ve implementada en la producción de cultivos bajo invernadero. El presente artículo describe el uso de la inteligencia artificial para un invernadero a través de una Red Neuronal Artificial (RNA) de tipo perceptrón multicapa utilizando el algoritmo de BackPropagation, con el objetivo de obtener el tipo de cultivo más óptimo a sembrar por medio de la rotación de cultivos, que apoyados de un dispositivo de adquisición de datos a través de sensores se obtuvieron los valores de temperatura y humedad del ambiente y pH del suelo para realizar el análisis del suelo. Mediante las interfaces del módulo de análisis de datos y del módulo de mediciones se muestra el proceso de obtención de datos, el cálculo y los resultados que arroja la red neuronal artificial. Para este proyecto se utilizó el modelo en Prototipos utilizando el lenguaje de programación Java.

Red Neuronal Artificial, Rotación de cultivos, Análisis de suelo

Citation: RAFAEL-PÉREZ, Eva, MONTERO-CORTÉS, Yeimi Yanet, RUIZ-RAMÍREZ, Alan Eduardo and MORALES-HERNÁNDEZ, Maricela. Neural network for crop rotation and soil analysis in a Greenhouse. ECORFAN Journal-Democratic Republic of Congo. 2021, 7-12: 29.41

* Correspondence to Author (e-mail: evarafaelperez@gmail.com)
† Researcher contributing first author.

Introduction

The incorporation of artificial intelligence has transformed the form and way of life in human beings, the way of production in agriculture has changed, currently agriculture considers various methods of production, efficient and high performance as protected agriculture, which is defined as a specialized agricultural system in which a certain control of the climatic environment is carried out, altering its conditions: soil, temperature, solar radiation, wind, humidity and atmospheric composition (Castellanos-Ramos, 2004). According to data from the Mexican Association of Protected Horticulture (AMHPAC), there are a total of 25,814 active protected agriculture facilities.

The project called Neural Network for Crop Rotation and Soil Analysis in a Greenhouse was developed with the objective of supporting the farmer in making a decision on the optimal type of crop to plant in the greenhouse. It is called optimal crop to the results that are thrown after having performed the soil analysis, taken measurements of temperature, humidity and pH of the soil through the data acquisition module, having selected the type of previous family that was planted based on the technique of crop rotation technique and the application and analysis of the neural network, i.e., once the process is done, the results generated are: The most optimal type of crop to be planted, the optimal humidity values and the ranges in which they should be, the optimal temperature for the type of crop to be planted and the ranges in which it should be and the corresponding family.

The production of crops under greenhouse is one of the most modern techniques currently used in agricultural production that is implemented through a greenhouse that provides an appropriate environment, both in the soil and in the air for the cultivation of plant species, which is supported by techniques to improve crop production.

In this case it was supported by the technique of crop rotation, which is an agricultural practice to increase the productivity of the land and optimize the use of resources by alternating different types of crops in the same soil, its use helps to reduce soil "fatigue" (Seminis, 2016).

Since through the neural network and soil analysis through the values of humidity and temperature of the environment, as well as soil pH, the type of the optimal crop to plant is determined, thus avoiding the risk of loss of production and unnecessary expenses for the farmer. The basic principle of rotations is that crops follow one another according to the characteristics between the preceding crop and the following one, waiting some time to replant a certain crop in the same plot. When designing a rotation, crops with different characteristics should be combined, always taking into account the effect that each crop produces on fertilization and soil structure.

This project was based on the technique of 4 groups of 8 families, starting with the Solanaceae family, then the Leguminosae family, then the Compositae family and finally the Umbelliferae family. For soil analysis, a data acquisition module was used, which consists of taking samples from the real world (analog system) to generate data that can be manipulated by a computer, it is composed of the breadboard, sensors, arduino and electrode.

It is worth mentioning that for the purposes of this work, only the data acquisition module will be explained in general terms, since it is a fundamental part to obtain the values for the measurement, perform the calculations and the results generated by the neural network. The detailed operation and design will be presented for the purposes of another future work.

Likewise, the expert system on which the neural network for crop rotation and soil analysis in its version 2.0 is based, for the purposes of this article will be explained only the functionality of the modules that were added such as: Soil Analysis and Measurements to explain the functionality of the neural network and the values generated by the data acquisition module.

Therefore, this article contains the problem statement, the data acquisition module including the materials and the circuit design; a section on the artificial neural network that covers the part of the operation, the design, the data of the Network and the BackPropagation Algorithm that was used for the neural network programming, another part of the work is the description of the phases for the learning and the presentation of the neural network.

A section of the crop rotation, the development methodology using the model in prototypes and the description of the stages, then the results of the soil analysis module, the functionality of the neural network and the data acquisition module, the acknowledgements and finally the conclusions and bibliographical references.

Problem Statement

The production of crops under greenhouse is one of the most modern techniques currently used in agricultural production, one of the main problems of any greenhouse is when the monoculture system is practiced, as it has certain disadvantages, the soil suffers a wear of nutrients because the same plant is planted in the same place which depletes the nutrients it needs, for example the lack of nitrogen in the soil prevents the growth of plants, The tendency towards erosion and drought, also with the production of a single crop there is a greater likelihood of soil impoverishment, since the same nutrients are abused, and greater exposure to pests and diseases, this creates a risk for the farmer because he bases his production on a single crop endangering his entire crop and therefore economic losses occur, or also that the product often has no quality.

Data acquisition module

For the correct operation of the neural network for soil analysis in the crop rotation in a greenhouse, it is necessary to rely on a data acquisition module; data obtained will be used for the training phase of the neural network, in addition to predicting whether the soil and environmental data are favorable for the harvest of plants of a specific family.

Materials

For the design of the data acquisition module, the following materials were used

- Dht11 (temperature and humidity sensor)
- Arduino Uno
- Protoboard
- Ph-4502C (pH sensor)
- Electrode

Circuit diagram

Figure 1 shows the design of the circuit diagram that was used to obtain data through the dht11 sensor which is used to obtain temperature and humidity from the environment in addition to the Ph-4502C sensor for pH values.

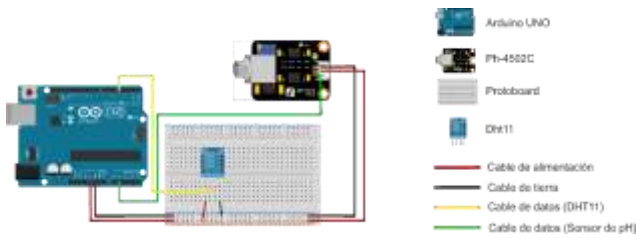


Figure 1 Circuit diagram
Source: Own Elaboration

Artificial Neural Network

Artificial Intelligence is an area with greater growth in recent years, for Iberdrola, (2019) AI is able to analyze data in large quantities, identify patterns and trends and, therefore, formulate predictions automatically, quickly and accurately, one of its areas are artificial neural networks.

Biological neuron, it was Santiago Ramón y Cajal (1888) who discovered the cellular structure (neuron) of the nervous system. He defended the theory that neurons interconnected with each other in parallel, consisting of a cell body (soma) of between 10 and 80 mm, from which a dense tree of branches (dendrites) and a tubular fiber (axon) of between 100 mm and one meter.

On the other hand, Anderson (1995) defines the artificial neural network as a computational model inspired by biological neural networks, which can be considered as an information processing system with a distributed structure of parallel processing, formed by processing elements that are the artificial neurons, which are interconnected by a large number of connections called synapses.

These connections are used to store information that is available for use. An artificial neuron is intended to mimic the most important characteristics of biological neurons. Figure 2 shows the comparison between the biological neuron and the artificial neuron.

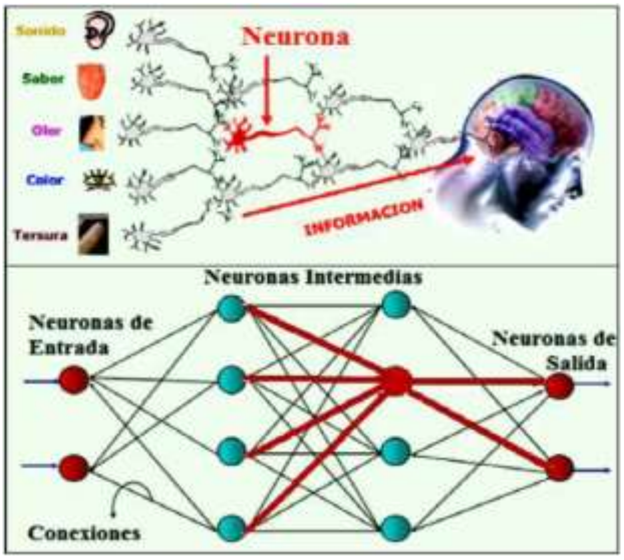


Figure 2 Comparison between biological and artificial neuron
Source: Hilera, J. and Martínez, V. 1995

Functioning of a Neural Network

A neural network is a set of artificial neurons divided into layers. Each neuron of a layer will be connected with all the neurons of the next layer by means of arcs with weights. The weights of these arcs will be modified during the learning phase of the neural network to achieve the desired results in the output of the network.

The layers of the network will be divided into three types: the input layer, the hidden layer(s) and the output layer. The input layer will be the first layer of the network and the data will be fed into the network through it. In this layer there will be as many neurons as the number of inputs required by the network. The hidden layer can be a single layer or there can be several hidden layers, depending on the problem and the design of the network. This layer will be in charge of carrying out the intermediate step or steps between the input layer and the output layer. (Valencia Reyes, Yañez Márquez, and Sánchez Chávez, 2006).

The output layer will be in charge of taking the results obtained to the outside. The number of neurons in this layer will be defined by the problem being solved.

Neural Network Design

The type of neural network used is a multilayer perceptron. Figure 3 shows the structure of the neural network on which the neural network design was based.

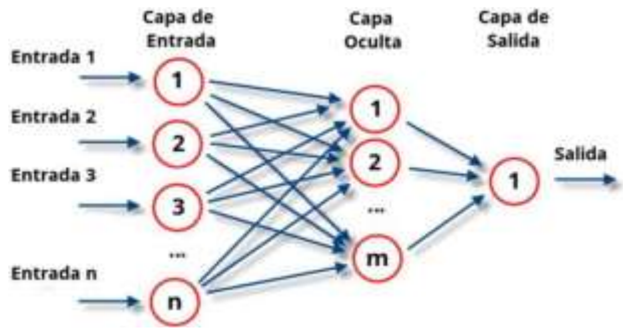


Figure 3 Neural network structure
Source: IBM Knowledge Center

Neural Network Data

The data that were used for the network are:

- An input layer of 5 neurons.
- Two hidden layers of 19 and 20 neurons respectively.
- An output layer with 51 neurons
- BackPropagation Algorithm

In 1986, Rumelhart, Hinton and Williams, formalized an algorithm for a neural network to learn the association that exists between input patterns and corresponding classes, using several levels of neurons.

Steps to apply the backpropagation algorithm

1. Initialize the weights of the network with random small values.
2. Present an input pattern and specify the desired output to be generated by the network.
3. Calculate the actual output of the network. To do this, the inputs to the network are presented and the output of each layer is calculated until the output layer is reached, this will be the output of the network.
4. Calculate the error terms for all neurons.
5. Update the weights: for this we use a recursive algorithm, starting with the output neurons and working backwards until reaching the input layer, adjusting the weights.
6. The process is repeated until the error term is acceptably small for each of the learned patterns.

The Java programming language was used to develop the neural network.

Neural network processing phases

A. Learning Phase

In this phase a network is initially generic and through a series of examples the weights of the arcs will be adapted in such a way that it produces the desired outputs.

Testing and learning of the neural network. A pattern recognition dataset (Iris) obtained from https://archive.ics.uci.edu/ml/datasets/iris was used for this process.

The dataset contains 50 samples of each of three species of Iris (Iris setosa, Iris virginica and Iris versicolor).

Neural network test values

- 4 input neurons
- 8 neurons in the hidden layer
- 3 neurons in the output layer
- Learning factor of 0.05
- Maximum allowed root mean square error 0.005

Figure 4 shows the result of the error percentage of the iris data set, once the neural network is trained, the data in the graph shows that the y variable does not vary as the x variable increases, which means that the maximum allowed mean square error percentage of 0.005 of the epoch variable is maintained. The Epoch variable: It is a complete iteration of the BackPropagation algorithm, this includes the data input, the forward propagation through all the layers of the neural network, the calculation of the error and the adjustment of the neuron weights for all the data of the training set.

Figure 4 Percent error of the iris data set
Source: Own Elaboration

Implementation of the Neural Network with the crop data set.

Data set

The dataset is composed of 8 data, which are:

1. Crop name
2. Crop family
3. Minimum humidity
4. Maximum humidity
5. Minimum temperature
6. Maximum temperature
7. Minimum PH
8. Maximum PH

Training

The values that were used for training the neural network are:

- An input layer of 5 neurons.
- Two hidden layers of 19 and 20 neurons respectively.
- An output layer with 51 neurons
- Learning factor 0.001
- Maximum allowed root mean square error 0.005

Figure 5 shows the result of the error percentage of the crop data set once the neural network is trained, the data of the graph shows that the variable y does not vary when increasing the variable x, which means that the maximum allowed mean square error percentage of 0.005 of the epoch variable is maintained. As already mentioned that the Epoch variable is a complete iteration of the BackPropagation algorithm, this includes data input, forward propagation through all the layers of the neural network, error calculation and adjustment of neuron weights for all the data in the training set.

Figure 5 Percentage error of crop set
Source: Own Elaboration

B. Presentation Phase:

In this phase the neural network is already trained and can be used to solve a given problem.This phase describes the operation of the Data Analysis and Measurement modules that were designed and coded using the Java programming language and that were added to the expert system version 2.0 for its operation, using the prototype model. It is important to emphasize that for the purposes of this work only the two modules will be described, as the functionality of the entire expert system version 2.0 will be the subject of future work.

Crop rotation

The practice of planting different crops sequentially on the same piece of land to improve soil health, optimize nutrients, avoid pests, diseases and weeds. Figure 6 shows the 4-group 8-family crop rotation model that was used for the neural network tests.

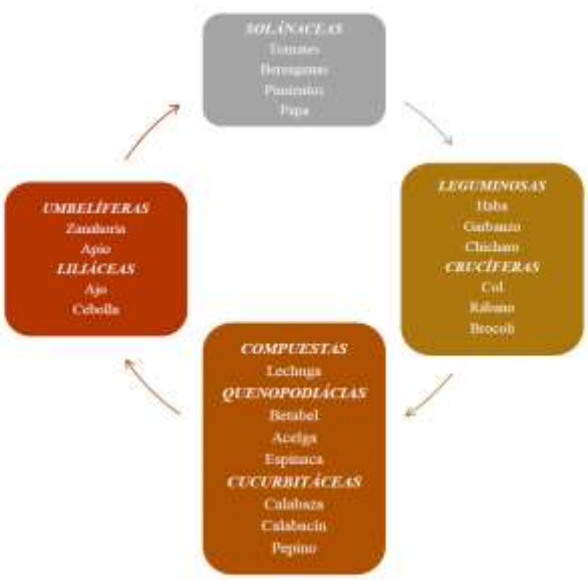


Figure 6 Crop rotation, 4 groups 8 crop families and rotations
Source: (Pellicer, 2015) https://blog.mundoikos.com/familias-de-cultivos-y-rotaciones/

Crop rotation description

The rotation cycle starts with the first crop of Solanaceae, a demanding family as it requires a large amount of nutrients, especially nitrogen(N). For this, if the soil is not rich in organic matter, it is advisable to add it, fertilizing it before sowing; once we have finished with the solanaceae, it is suggested to plant leguminous or cruciferous plants.

Both families are considered as improvers, mainly due to their characteristics in relation to the soil. Leguminous plants maintain a symbiosis in the soil with microorganisms of the Rhizobium genus, which fix atmospheric nitrogen and incorporate it into the soil, while crucifers are plants that improve soil structure due to their tap roots and also reincorporate sulfur (S) into the soil.

The next to be sown are the crops of medium demand, such as composites, quenopodiaceae or cucurbits.

Finally, there are the umbellifers and liliaceae, both of which are not very demanding at the nutritional level and leave the soil ready to be fertilized again and start the rotation cycle. (Pellicer, 2015).

Development Methodology

For the operation of the two modules the Prototyping model was used, this model aims at the direct participation of the customer in the construction of the required software, helps to improve the understanding of what is to be developed when the requirements are not clear and serves as a mechanism to identify and define the requirements of the software, also the prototype evolves through an iterative process, (Pressman, 2010, p. 37).

Figure 7 shows the stages: communication, rapid plan, rapid modeling and design, prototype construction, deployment, delivery and feedback.

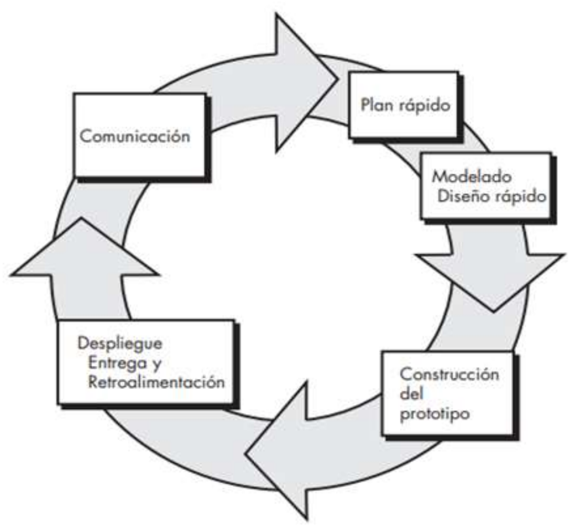


Figure 7 Model stages in prototypes
Source. (Pressman, 2010, p. 37)

Development of the stages

First iteration:

A. Communication stage, in this first stage interviews were conducted with the farmer to find out what were the real needs and problems presented, for example: identify manual processes, irrigation system, manual preparation of manure, fertilization, planting periods, harvesting, cutting, weather conditions in terms of humidity and temperature, type of crops planted, number of harvests, information that served to define the requirements, the definition of both general and specific objectives of the software, as well as users to interact with the system.

For the functionality of the modules, 3 types of users were identified with different roles and privileges to access the system:

– The Administrator user, who has full access to each of the modules, is in charge of adding data to the user system, new crops and new irrigation, soil analysis, measurements.

– The user Farmer, adds the data of sowings, harvests, process log, crops, history of sowings, harvests, crop rotation, soil analysis and measurements.

– The guest user can only view information about crops, plantings, harvests, crop rotation, soil analysis and measurements.

B. The Quick Plan stage is carried out when the project results of the previous stage are accepted, then an abbreviated representation of the requirements is developed. For this project, the Use Case technique was used to model the requirements of the data acquisition module, an example of a Use Case for obtaining sensor data is shown in Figure 8.

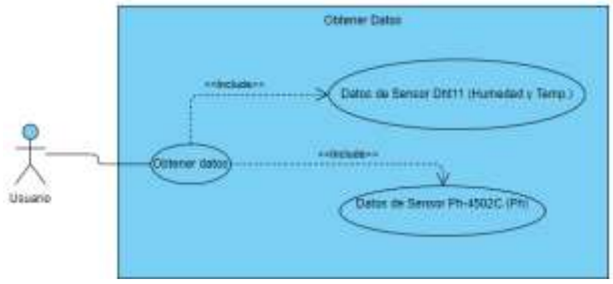


Figure 8 Sensor data collection use case
Source: Source: Own Elaboration

C. In the rapid design modeling stage, different models were designed that serve as the basis for the correct operation of the system, such as sequence diagrams, the entity-relationship model, the circuit diagram design and the graphical user interfaces. As an example, a sequence diagram to execute the data acquisition program is shown. See figure 9.

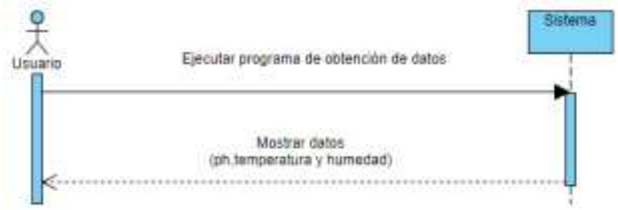


Figure 9 Sensor data collection use case
Source: Own Elaboration

D. In the rapid design modeling stage, different models were designed that serve as the basis for the correct operation of the system, such as sequence diagrams, the entity-relationship model, the circuit diagram design and the graphical user interfaces. As an example, a sequence diagram to execute the data acquisition program is shown. See figure 9.

Figure 10 Access to the system
Source: Own Elaboration

E. In this stage of construction of a prototype, the circuit was built, only shown in Figure 11, since the description of the functionality will be a topic to be discussed in the future as mentioned above.

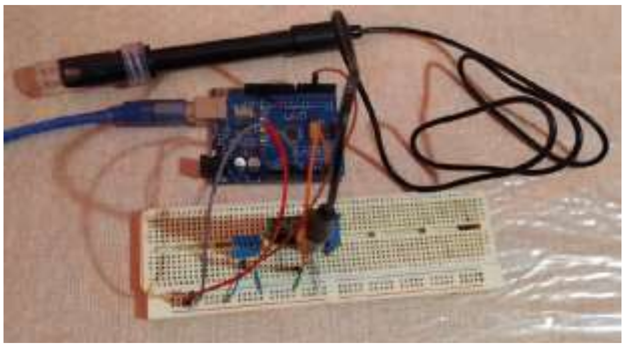


Figure 11 Circuits
Source: Own Elaboration

F. The last stage of deployment, delivery and feedback, the data acquisition module was tested with the variables of temperature, humidity of the environment and pH of the soil.

```
Prueba DHT11
Humedad: 18.00%  Temperatura: 25.00°C
```

Figure 12 Results of humidity and temperature of the environment
Source: Own Elaboration

Second Iteration module: Soil analysis

A. Communication stage, in which the requirements of the soil analysis module were analyzed, the integration of the neural network in the expert system, as well as the specification of the process to obtain the data taking into account the crop rotation technique.

B. In the Quick Plan stage, a representation of the requirements was made by means of use cases to model the requirements of the soil analysis module.

C. In the Rapid Design Modeling stage, sequence diagrams were designed, two databases were created, both local and remote databases using the MySQL database management system. The remote database serves as a backup for the local database, if there is any problem with it, it can be recovered through the backup, also the remote database is updated every time there is an internet connection adding the newest data. The graphical user interfaces were also designed.

D. Prototype construction stage, in this stage the Soil Analysis and Measurements modules were developed, and Java programming language was used for their coding. In relation to the operation of the Soil Analysis module, it is linked to the Data Acquisition module by means of the Take Measurements button to obtain temperature, humidity and pH measurements.

The last stage of Deployment, delivery and feedback of the system, the design, phases, training and functionality of the neural network was tested.

Results

The results of the modules: Data Acquisition, Soil Analysis, Measurements and the implementation of the Neural Network are described below.

– Access to the system, to enter the system a user name and password are required. See Figure 13.

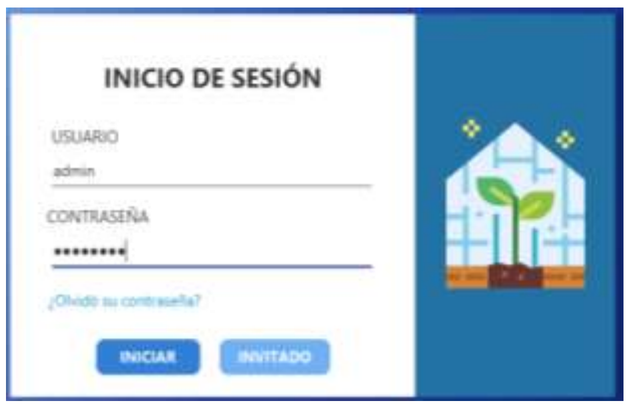


Figure 13 System access screen
Source: Own Elaboration

a) Results of the data acquisition module

To perform the tests correctly, the following steps need to be followed:

1. Make a solution with two portions of water and one portion of soil in a container.
2. Shake said solution and let it stand for at least 15 minutes.
3. Clean the electrode nozzle with a dry and soft cloth to remove any existing solution as it may contaminate the sample made.

4. After the 15 minutes of waiting, insert the electrode nozzle into the solution.
5. Run the data acquisition program.

Once the system is accessed, select the Soil Analysis module option, see Figure 14.

Figure 14 Soil analysis module
Source: Own Elaboration

When selecting the option, the system first validates that there is a connection with the data acquisition device, once validated, click on the Take measurements button to obtain the data, which internally takes 10 global measurements of temperature, humidity and pH and displays an average of the data obtained. See figure 15.

Figure 15 Take measurements button
Source: Own Elaboration

When clicking on the *Take measurements* button, the following message is displayed to the user, see figure 16.

Figure 16 Temperature, humidity and pH measurement message
Source: Own Elaboration

Figure 17 shows the values obtained from the data acquisition module:

– PH: This text field shows the PH of the soil obtained by the data acquisition device.
– Humidity: This field shows the humidity of the environment obtained by the data acquisition device.
– Temperature: This field displays the temperature of the environment obtained by the data acquisition device.

Figure 17 Values obtained
Source: Own Elaboration

b) Results of the implementation of the Neural network

When obtaining the data, it is necessary to select the previous family type that was previously seeded, when clicking on it, the 8 families are shown, for this example the Solanaceae family is chosen as shown in Figure 18.

Figure 18 Selecting the family type above
Source: Own Elaboration

Figure 19 shows the functionality of the neural network when clicking on the *CALCULATE* button, the neural network begins to perform the analysis and shows as a result the option of the most optimal type of crop to be planted.

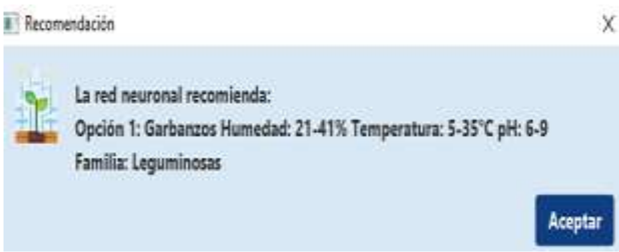


Figure 19 Result of the neural network functionality
Source: Own Elaboration

The results are:

- The most optimal type of crop to plant is Chickpea.
- Optimum moisture values should be in the range of 20 to 41%.
- The optimum temperature for the type of crop to be planted should be between 5 to 35 °C.
- The corresponding family is the legume family.

c) Results of the *Data Acquisition* module using the Measurements module

When clicking on the Measurements option, the system sends a message where the current measurements of temperature and humidity of the environment are being taken, see figure 20.

Figure 20 Measurement module
Source: Own Elaboration

The measurements show in real time the temperature and humidity values, see figure 21.

Figure 21 Measurements Module option
Source: Own Elaboration

Acknowledgments

To the Tecnológico Nacional de México/Instituto Tecnológico de Oaxaca for the facilities and spaces for the development of this research work. We are grateful for the collaboration and dedication of the authors of the article, professors and students who participated with responsibility in the research until the achievement of the results presented; the objective of this research is to disseminate the findings to the academic community and the general public about the work being developed at the Institution.

Conclusions

The neural network for crop rotation and soil analysis in a greenhouse was developed with the purpose of providing alternatives on the type of crop to be planted through crop rotation.

With the decision of the type of crop to be planted in the greenhouse, the risk of production loss can be reduced.

The solution to the problem posed is crop rotation, an alternative technique for the types of plants that are grown in the same place with the intention of not developing diseases that affect a specific family of crops and prevent the soil from being exhausted.

With the analysis of the optimal crop to be planted, the risk of loss of production would be considerably reduced, resulting in greater economic gains for the farmer.

The farmer is thus assured that his crop will obtain the best production according to the experience and knowledge of the neural network, in addition to optimizing the use of the soil and reducing the incidence of pests and diseases by interrupting their life cycles.

References

Ascencio Contreras, D. O. (2013). Evaluación del rendimiento de variedades de chile poblano en campo abierto y macrotunel. San Luis Potosí.

Barreto Barreto , A. (2006). Estudio de algunos componentes del comportamiento reproductivo del chile jalapeño. Coahuila .

Blanco M., C. (2017). Manual de producción de cebolla. Santiago: INIA.

Buschermohle, M., & Grandle, G. (2020). Controlling the Environment in Greenhouses Used for Tomato Production. Obtenido de Agricultural Extension Service / The University of Tennessee: https://www.plantgrower.org/uploads/6/5/5/4/65545169/w017.pdf

Castellanos, J. 2007. Perspectivas de la agricultura protegida en México. In: Segunda Reunión Nacional de Innovación Agrícola y Forestal. Guadalajara, México. http://www.rniaf.org.mx/2007/memoria/ponencias/protegida/p4_perspectivas1.pdf

Carter, y Gregorich. (2007). Soil Sampling and Methods of Analysis. 2nd. Edition.

Centro Regional Patagonia Norte. (2006). Producción de hortalizas bajo cubierta. Argentina.

Collado, J. A. (s.f.). La Universidad Virtual.

Recuperado el 24 de Septiembre de 2014, de Concepto de Sistema de Información en la organización: http://dpacomputacionunpa.files.wordpress.com/2011/10/1_conceptos_de_si_en_organizaciones.pdf.

Crawford L., H. (2017). Manual del manejo agronómico para el cultivo de melón. Santiago, Chile: Instituto de Investigaciones Agropecuarias (INIA).

Everardo, Z. (2016). El cultivo de la cebolla. Sonora: Universidad de Sonora.

FAO. (2013). El manejo del suelo en la producción de hortalizas con buenas prácticas agrícolas. Paraguay.

FAO. (2020). Producción Vegetal. http://www.fao.org/3/s8630s/s8630s08.htm

Fernández Fernández, M. M., Aguilar Pérez, M. I., Carrique Pérez, J. R., Tortosa Domingo, J., García García, C., López Rodríguez, M., y Pérez Morales, J. M. (2014). Suelo y medio ambiente en invernaderos. Sevilla: Consejería de Agricultura, Pesca y Desarrollo Rural

Gabino Alberto Martínez-Gutiérrez, René Díaz-Pichardo, Griselda Juárez-Luis, Yolanda D. Ortiz-Hernández, Juana Y. López-Cruz. Caracterización de las unidades de producción de tomate en invernaderos de Oaxaca. Instituto Politécnico Nacional. CIIDlR Unidad Oaxaca, Hornos 1003, C.P. 71230, Santa Cruz Xoxocotlán. Oaxaca. México

Gary W. Hansen, J. V. (2014). Diseño y Administracion de Bases de Datos. Mexico: Prentice Hall.

Geographic, N. (2011). Crops. Obtenido de National Geographic Society: https://www.nationalgeographic.org/encyclopedia/crop/

Giandin, R. S., & Pons, C. F. (2020). Relaciones entre Casos de Uso en el Unified Modeling Languaje. Revista colombiana de computación., 73-90.

Google Developers. (10 de Febrero de 2020). Redes neuronales de clases múltiples: Softmax. Obtenido de Redes neuronales de clases múltiples: Softmax: https://developers.google.com/machine-learning/crash-course/multi-class-neural-networks/softmax?hl=es

Horticultivos. (26 de Julio de 2017). Horticultivos. Obtenido de Principales tipos de invernaderos: https://www.horticultivos.com/featured/principales-tipos-invernaderos/

Hydro Evironment. (10 de Febrero de 2020). Hydroenv. Obtenido de ¿Qué es un invernadero?: https://www.hydroenv.com.mx/catalogo/index.php?main_page=page&id=44

Iberdrola. (2019). ¿Qué es la Inteligencia Artificial? Obtenido de ¿Somos conscientes de los retos y principales aplicaciones de la Inteligencia Artificial?: https://www.iberdrola.com/innovacion/que-es-inteligencia-artificial

Ing. Agr. MSc. Miserendino, E., y Ing. Agr. Astorquizaga, R. (2014). Invernaderos: Aspectos básicos sobre estructura, construcción y condiciones ambientales. Buenos Aires: INTA.

Juárez L., P., Bugarín M., R., Castro B., R., Sánchez M., A., L., Cruz C., E., Juárez R., C., R., Alejo S., G., Balois M., R. Estructuras utilizadas en la agricultura protegida.

Juganaru Mathieu, M. (2014). Introducción a la programación. México: Patria.

Martínez Ladrón de Guevara, J. (2014). Fundamentos de programación en Java. Madrid: EME.

Moreno Reséndez, Alejandro; Aguilar Durón, Juanita; Luévano González, Armando. Características de la agricultura protegida y su entorno en México

Mujica , A., Canahua, A., & Saravia, R. (2020). FAO . Agronomia del cultivo de la quinua: http://www.fao.org/tempref/GI/Reserved/FTP_FaoRlc/old/prior/segalim/prodalim/prodveg/cdrom/contenido/libro03/cap2.htm#:~:text=La%20siembra%20se%20debe%20realizar,la%20germinaci%C3%B3n%20de%20las%20semillas.

MySQL. (2020). MySQL Documentation. https://dev.mysql.com/doc/

Nevado, M. (2010). Introducción a Las Bases de Datos Relacionales. España: Visión Libros

Pellicer, P. (12 de Marzo de 2015). mundoikos. Obtenido de Familias de cultivos y rotaciones: https://blog.mundoikos.com/familias-de-cultivos-y-rotaciones/

Pressman S., R. (2010). Ingeniería de Software. New York: Mc Graw Hill.

Ramón López , J. (18 de Octubre de 2017). Catalunyaplants. Obtenido de La importancia de la luz en las plantas: https://www.catalunyaplants.com/la-importancia-de-la-luz-en-las-plantas/

Ramos, M. J., Ramos, A., & Montero, F. (2006). Gestores de bases de datos. Madrid: Mc Graw Hill.

Rangel Campos, L. (2016). Crecimiento del chile habanero. Coahuila.

Reveles Hernández, M., Huchín Alarcón, S., Velásquez Valle, R., Trejo Calzada, R., & Ruiz Torres, J. (2010). Producción de plántula de chile en invernadero. Durango: SAGARPA.

Revista Mexicana de Agronegocios, núm. 29, julio-diciembre, 2011, pp. 763-774. Sociedad Mexicana de Administración Agropecuaria A.C. Torreón, México

Rodale Institute. (12 de Enero de 2019). Rodale Institute. Obtenido de Crop Rotations: https://rodaleinstitute.org/why-organic/organic-farming-practices/crop-rotations/

Rojas Bertini, C. (2011). Cultivo de alcachofa. Arica, Chile: INIA.

Rusell, S. J., & Norving, P. (2004). Inteligencia Artificial. Pearson Eduación. Obtenido de https://www.ibm.com/support/knowledgecenter/es/SS3RA7_sub/modeler_mainhelp_client_ddita/components/neuralnet/neuralnet_model.html

Salcedo, J. M. (2020). Guías para la regeneración de germoplasma- Frijol común. Cali, Colombia: Oficina Regional para las Américas.

Secretaría de Desarrollo Agropecuario. (2020). Requerimientos agroecológicos de cultivos. Obtenido de http://sedea.queretaro.gob.mx/sites/sedea.queretaro.gob.mx/files/BETABEL.pdf

Snyder, R. G. (2016). Guía del cultivo del tomate en invernaderos . Extension of Mississippi State University.

Steven Perry, J. (3 de 12 de 2012). Conceptos básicos del lenguaje Java. Obtenido de Programación orientada a objetos en la plataforma Java: https://www.ibm.com/developerworks/ssa/java/tutorials/j-introtojava1/index.html

Unidad Académica de Agricultura, Universidad Autónoma de Nayarit, Departamento de Fitotecnia, Universidad Autónoma Chapingo

Universidad de Barcelona. (2020). OBS. Obtenido de ¿Qué son las metodologías de desarrollo de software?: https://obsbusiness.school/es/blog-project-management/metodologia-agile/que-son-las-metodologias-de-desarrollo-de-software

University of Massachusetts Amherst. (17 de Enero de 2013). Garlic Harvest, Curing and Storage. Obtenido de https://ag.umass.edu/vegetable/fact-sheets/garlic-harvest-curing-storage

Valencia Reyes, M. A., Yañez Márquez, C., & Sánchez Chávez, L. P. (2006). Algoritmo Backpropagation para Redes Neuronales: conceptos y aplicaciones. Instituto Tecnológico Nacional.

Villalobos Reyes, S., Guzmán Maldonado, S. H., Escobedo López , D., & Gonzaléz Pérez, E. (2018). Componentes agronómicos y diversidad en el patrón de ácidos grasos. Revista Mexicana de Ciencias Agrícolas.

Zárate Aquino, M. (2014). Manual de Hidroponia. Distrito Federal: Universidad Nacional Autónoma de México.

[Title in Times New Roman and Bold No. 14 in English and Spanish]

Surname (IN UPPERCASE), Name 1st Author†*, Surname (IN UPPERCASE), Name 1st Coauthor, Surname (IN UPPERCASE), Name 2nd Coauthor and Surname (IN UPPERCASE), Name 3rd Coauthor

Institutional Affiliation of Author including Dependency (No.10 Times New Roman and Italic)

International Identification of Science - Technology and Innovation

ID 1st Author: (ORC ID - Researcher ID Thomson, arXiv Author ID - PubMed Author ID - Open ID) and CVU 1st author: (Scholar-PNPC or SNI-CONACYT) (No.10 Times New Roman)

ID 1st Coauthor: (ORC ID - Researcher ID Thomson, arXiv Author ID - PubMed Author ID - Open ID) and CVU 1st coauthor: (Scholar or SNI) (No.10 Times New Roman)

ID 2nd Coauthor: (ORC ID - Researcher ID Thomson, arXiv Author ID - PubMed Author ID - Open ID) and CVU 2nd coauthor: (Scholar or SNI) (No.10 Times New Roman)

ID 3rd Coauthor: (ORC ID - Researcher ID Thomson, arXiv Author ID - PubMed Author ID - Open ID) and CVU 3rd coauthor: (Scholar or SNI) (No.10 Times New Roman)

(Report Submission Date: Month, Day, and Year); Accepted (Insert date of Acceptance: Use Only ECORFAN)

Abstract (In English, 150-200 words)

Objectives
Methodology
Contribution

Keywords (In English)

Indicate 3 keywords in Times New Roman and Bold No. 10

Abstract (In Spanish, 150-200 words)

Objectives
Methodology
Contribution

Keywords (In Spanish)

Indicate 3 keywords in Times New Roman and Bold No. 10

Citation: Surname (IN UPPERCASE), Name 1st Author, Surname (IN UPPERCASE), Name 1st Coauthor, Surname (IN UPPERCASE), Name 2nd Coauthor and Surname (IN UPPERCASE), Name 3rd Coauthor. Paper Title. ECORFAN Journal-Democratic Republic of Congo. Year 1-1: 1-11 [Times New Roman No.10]

* Correspondence to Author (example@example.org)
† Researcher contributing as first author.

Introduction

Text in Times New Roman No.12, single space.

General explanation of the subject and explain why it is important.

What is your added value with respect to other techniques?

Clearly focus each of its features

Clearly explain the problem to be solved and the central hypothesis.

Explanation of sections Article.

Development of headings and subheadings of the article with subsequent numbers

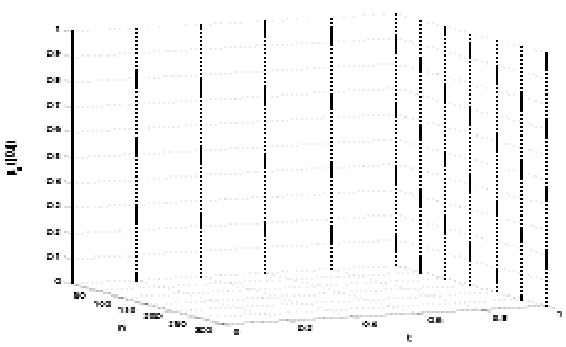
[Title No.12 in Times New Roman, single spaced and bold]

Products in development No.12 Times New Roman, single spaced.

Including graphs, figures and tables-Editable

In the article content any graphic, table and figure should be editable formats that can change size, type and number of letter, for the purposes of edition, these must be high quality, not pixelated and should be noticeable even reducing image scale.

[Indicating the title at the bottom with No.10 and Times New Roman Bold]



Graphic 1 Title and *Source (in italics)*

Should not be images-everything must be editable.

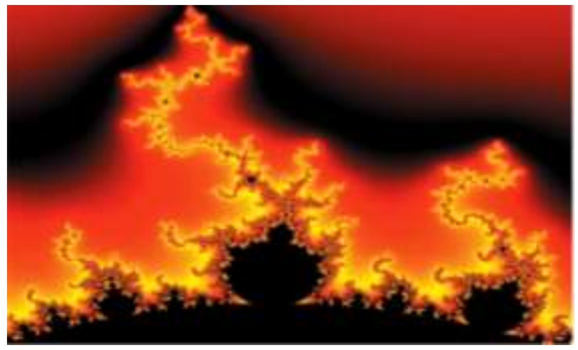


Figure 1 Title and *Source (in italics)*

Should not be images-everything must be editable.

Table 1 Title and *Source (in italics)*

Should not be images-everything must be editable.

Each article shall present separately in **3 folders**: a) Figures, b) Charts and c) Tables in .JPG format, indicating the number and sequential Bold Title.

For the use of equations, noted as follows:

$$Y_{ij} = \alpha + \sum_{h=1}^{r} \beta_h X_{hij} + u_j + e_{ij} \qquad (1)$$

Must be editable and number aligned on the right side.

Methodology

Develop give the meaning of the variables in linear writing and important is the comparison of the used criteria.

Results

The results shall be by section of the article.

Annexes

Tables and adequate sources

Thanks

Indicate if they were financed by any institution, University or company.

Conclusions

Explain clearly the results and possibilities of improvement.

ISSN 2414-4924

References

Use APA system. Should not be numbered, nor with bullets, however if necessary numbering will be because reference or mention is made somewhere in the Article.

Use Roman Alphabet, all references you have used must be in the Roman Alphabet, even if you have quoted an Article, book in any of the official languages of the United Nations (English, French, German, Chinese, Russian, Portuguese, Italian, Spanish, Arabic), you must write the reference in Roman script and not in any of the official languages.

Technical Specifications

Each article must submit your dates into a Word document (.docx):

Journal Name
Article title
Abstract
Keywords
Article sections, for example:

1. *Introduction*
2. *Description of the method*
3. *Analysis from the regression demand curve*
4. *Results*
5. *Thanks*
6. *Conclusions*
7. *References*

Author Name (s)
Email Correspondence to Author
References

Intellectual Property Requirements for editing:

-Authentic Signature in Color of Originality Format Author and Coauthors

-Authentic Signature in Color of the Acceptance Format of Author and Coauthors

Reservation to Editorial Policy

ECORFAN-Democratic Republic of Congo reserves the right to make editorial changes required to adapt the Articles to the Editorial Policy of the Journal. Once the Article is accepted in its final version, the Journal will send the author the proofs for review. ECORFAN® will only accept the correction of errata and errors or omissions arising from the editing process of the Journal, reserving in full the copyrights and content dissemination. No deletions, substitutions or additions that alter the formation of the Article will be accepted.

Code of Ethics - Good Practices and Declaration of Solution to Editorial Conflicts

Declaration of Originality and unpublished character of the Article, of Authors, on the obtaining of data and interpretation of results, Acknowledgments, Conflict of interests, Assignment of rights and Distribution

The ECORFAN-Mexico, S.C Management claims to Authors of Articles that its content must be original, unpublished and of Scientific, Technological and Innovation content to be submitted for evaluation.

The Authors signing the Article must be the same that have contributed to its conception, realization and development, as well as obtaining the data, interpreting the results, drafting and reviewing it. The Corresponding Author of the proposed Article will request the form that follows.

Article title:

- The sending of an Article to ECORFAN-Democratic Republic of Congo emanates the commitment of the author not to submit it simultaneously to the consideration of other series publications for it must complement the Format of Originality for its Article, unless it is rejected by the Arbitration Committee, it may be withdrawn.

- None of the data presented in this article has been plagiarized or invented. The original data are clearly distinguished from those already published. And it is known of the test in PLAGSCAN if a level of plagiarism is detected Positive will not proceed to arbitrate.

- References are cited on which the information contained in the Article is based, as well as theories and data from other previously published Articles.

- The authors sign the Format of Authorization for their Article to be disseminated by means that ECORFAN-Mexico, S.C. In its Holding Democratic Republic of Congo considers pertinent for disclosure and diffusion of its Article its Rights of Work.

- Consent has been obtained from those who have contributed unpublished data obtained through verbal or written communication, and such communication and Authorship are adequately identified.

- The Author and Co-Authors who sign this work have participated in its planning, design and execution, as well as in the interpretation of the results. They also critically reviewed the paper, approved its final version and agreed with its publication.

- No signature responsible for the work has been omitted and the criteria of Scientific Authorization are satisfied.

- The results of this Article have been interpreted objectively. Any results contrary to the point of view of those who sign are exposed and discussed in the Article.

Copyright and Access

The publication of this Article supposes the transfer of the copyright to ECORFAN-Mexico, SC in its Holding Democratic Republic of Congo for its ECORFAN-Democratic Republic of Congo, which reserves the right to distribute on the Web the published version of the Article and the making available of the Article in This format supposes for its Authors the fulfilment of what is established in the Law of Science and Technology of the United Mexican States, regarding the obligation to allow access to the results of Scientific Research.

Article Title:

Name and Surnames of the Contact Author and the Coauthors	Signature
1.	
2.	
3.	
4.	

Principles of Ethics and Declaration of Solution to Editorial Conflicts

Editor Responsibilities

The Publisher undertakes to guarantee the confidentiality of the evaluation process, it may not disclose to the Arbitrators the identity of the Authors, nor may it reveal the identity of the Arbitrators at any time.

The Editor assumes the responsibility to properly inform the Author of the stage of the editorial process in which the text is sent, as well as the resolutions of Double-Blind Review.

The Editor should evaluate manuscripts and their intellectual content without distinction of race, gender, sexual orientation, religious beliefs, ethnicity, nationality, or the political philosophy of the Authors.

The Editor and his editing team of ECORFAN® Holdings will not disclose any information about Articles submitted to anyone other than the corresponding Author.

The Editor should make fair and impartial decisions and ensure a fair Double-Blind Review.

Responsibilities of the Editorial Board

The description of the peer review processes is made known by the Editorial Board in order that the Authors know what the evaluation criteria are and will always be willing to justify any controversy in the evaluation process. In case of Plagiarism Detection to the Article the Committee notifies the Authors for Violation to the Right of Scientific, Technological and Innovation Authorization.

Responsibilities of the Arbitration Committee

The Arbitrators undertake to notify about any unethical conduct by the Authors and to indicate all the information that may be reason to reject the publication of the Articles. In addition, they must undertake to keep confidential information related to the Articles they evaluate.

Any manuscript received for your arbitration must be treated as confidential, should not be displayed or discussed with other experts, except with the permission of the Editor.

The Arbitrators must be conducted objectively, any personal criticism of the Author is inappropriate.

The Arbitrators must express their points of view with clarity and with valid arguments that contribute to the Scientific, Technological and Innovation of the Author.

The Arbitrators should not evaluate manuscripts in which they have conflicts of interest and have been notified to the Editor before submitting the Article for Double-Blind Review.

Responsibilities of the Authors

Authors must guarantee that their articles are the product of their original work and that the data has been obtained ethically.

Authors must ensure that they have not been previously published or that they are not considered in another serial publication.

Authors must strictly follow the rules for the publication of Defined Articles by the Editorial Board.

The authors have requested that the text in all its forms be an unethical editorial behavior and is unacceptable, consequently, any manuscript that incurs in plagiarism is eliminated and not considered for publication.

Authors should cite publications that have been influential in the nature of the Article submitted to arbitration.

Information services

Indexation - Bases and Repositories

RESEARCH GATE (Germany)
GOOGLE SCHOLAR (Citation indices-Google)
REDIB (Ibero-American Network of Innovation and Scientific Knowledge- CSIC)
MENDELEY (Bibliographic References Manager)

Publishing Services

Citation and Index Identification H
Management of Originality Format and Authorization
Testing Article with PLAGSCAN
Article Evaluation
Certificate of Double-Blind Review
Article Edition
Web layout
Indexing and Repository
ArticleTranslation
Article Publication
Certificate of Article
Service Billing

Editorial Policy and Management

31 Kinshasa 6593 – Republique Démocratique du Congo. Phones: +52 1 55 6159 2296, +52 1 55 1260 0355, +52 1 55 6034 9181; Email: contact@ecorfan.org www.ecorfan.org

Site Licences

03-2010-032610094200-01-For printed material ,03-2010-031613323600-01-For Electronic material,03-2010-032610105200-01-For Photographic material,03-2010-032610115700-14-For the facts Compilation,04-2010-031613323600-01-For its Web page,19502-For the Iberoamerican and Caribbean Indexation,20-281 HB9-For its indexation in Latin-American in Social Sciences and Humanities,671-For its indexing in Electronic Scientific Journals Spanish and Latin-America,7045008-For its divulgation and edition in the Ministry of Education and Culture-Spain,25409-For its repository in the Biblioteca Universitaria-Madrid,16258-For its indexing in the Dialnet,20589-For its indexing in the edited Journals in the countries of Iberian-America and the Caribbean, 15048-For the international registration of Congress and Colloquiums. financingprograms@ecorfan.org

Management Offices

31 Kinshasa 6593 – Republique Démocratique du Congo.

ECORFAN Journal-Democratic Republic of Congo

"Comparison of Machine Learning algorithms for the Burnout projection"
LARA-GONZALEZ, Luis Rey, DELGADO-LUNA, Martha Angélica, DE LEON-GALVAN, Beatriz Elena and VENEGAS-GUERRERO, José Carlos
Universidad Politécnica de Juventino Rosas

"Enabling experimental greenhouse for high-tech application"
RODRÍGUEZ-FRANCO, Martín Eduardo, MALDONADO-RUELAS, Víctor Arturo, VILLALOBOS-PIÑA, Francisco Javier and ORTIZ-MEDINA, Raúl Arturo
Universidad Politécnica de Aguascalientes
Instituto Tecnológico de Aguascalientes

"Statistical analysis and characterization of Landsat 8 satellite images of forest wildfires regions"
HERNANDEZ-LOPEZ, Sandra Paola, YAÑEZ-VARGAS, Juan Israel, GONZÁLEZ-RAMIREZ, Andrea and TORRES-ROMAN, Deni
Universidad Politécnica de Juventino Rosas.
CINVESTAV del IPN, Unidad Guadalajara

"Neural network for crop rotation and soil analysis in a Greenhouse"
RAFAEL-PÉREZ, Eva, MONTERO-CORTÉS, Yeimi Yanet, RUIZ-RAMÍREZ, Alan Eduardo and MORALES-HERNÁNDEZ, Maricela
Instituto Tecnológico de Oaxaca

ISSN 2414-4924

www.ecorfan.org