Intelligent Web system for the management of pre-professional practices in a public university in Lima-Peru, using fuzzy logic in a Smart City enviroment*

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Abstract

In the university educational processes, one of the final processes is the completion of professional internships, which allow the student to carry out activities specific to his/her specialty. At the end of the procedure, a report is sent which is evaluated by 3 professors. The evaluations are mostly carried out qualitatively, which does not allow a final result for the student. The present research is carried out in order to analyze the qualitative results and transform them into a quantitative value, related to the approval or disapproval of the report, for which the fuzzy logic technique is used, with which we obtain a final grade. The proposal also includes a web system that can support the processes of student registration, entry of documents and final results, in such a way that they can be accessed without having to be on the university campus. The documentary processing processes are based on the ISO 25000 standard that ensures compliance with the standards of the University and the degrees and titles office, which is in charge of issuing conformity in the completion of professional internships. The proposal can be replicated and scaled to other processes related to the use of fuzzy logic.

Keywords

Smart Cities, university, process, standard, management, practice, management, practices.

1. Introduction

Managing smart city infrastructures in multi-tenant environments presents challenges in identifying problems and dysfunctions, as well as in integrating data and services accessible to different stakeholders. A unified knowledge model was proposed that allows smart city operators to manage and analyze data more efficiently, facilitating scenario creation and informed decision making, using data analytics processes, microservices, "what-if" analysis tools, and data storage to integrate contextual information on traffic, weather, and air quality, as well as critical events, achieving better traffic prediction and management, allowing operators to suggest alternative routes and act on road restrictions in real time. In addition, the communication of alerts and changes was improved through mobile applications and variable message boards; concluding that the proposed model improves the scalability and maintainability of smart city infrastructures, allowing more effective collaboration between different entities and optimizing the use of resources. This lays the foundation for the development of smarter and more reactive applications in the urban context [1]. The lack of comprehensive studies comparing the implementation of business models in various smart cities and the advantages they offer in each context, for which a narrative literature review and a comparative case analysis were used to investigate business models in smart cities, which are published in academic journals, conferences, books and reports; in addition, cases from London, Amsterdam and Berlin were analyzed, where several business models were identified, such as public-private partnerships (PPP), performance-based contracts,

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community-centered models, innovation centers, and asset monetization strategies, with variations in their implementation and advantages in each city. Concluding that the study highlights the importance of adapting business models to the specific context of each city to maximize their effectiveness. Directions for future research are suggested, including the impact of sustainability policies and emerging technologies [2].

The lack of practical application of Smart Heritage in heritage sites at area level, using open access data, for which a case study was conducted in Melbourne's Chinatown, using open access data and global best practices for Smart Heritage, where open data from the City of Melbourne were used, such as 3D models, pedestrian counting, and smart tourism practices from the European Smart Tourism Competition (ECST), where ways in which open data can support smart heritage transformation were identified, improving urban heritage management and visitor experience, concluding that open access data is essential for heritage conservation in urban contexts and can foster the sustainable development of historic areas [3].

The vulnerability of urban communities to natural disasters due to climate change and the lack of international standards for resilient infrastructure, for which existing ISO standards were reviewed and analyzed and highlighted the need for a holistic framework for smart and resilient community infrastructure, they employed an analysis of ISO and IEC standards, including those on emergency management, smart infrastructure and resilience, where gaps in standards coverage were identified in areas such as financing, information management, and lack of a comprehensive framework for resilient smart cities, concluding that international standardization can improve urban resilience to disasters, and the development of new standards can close critical gaps in disaster preparedness and response [4].

The need to better understand urban lifestyle patterns using mobile network data, while maintaining user privacy, for which the LEAF framework was created, which analyzes anonymous mobility data and integrates it with geographic and ontological information to model urban lifestyles, where mobility data from mobile networks, points of interest (PoI), and spatial analysis using a vector model were used, having as results the LEAF framework allowed to accurately model lifestyle patterns in urban areas, showing high consistency with survey data and an RMSE of 5.167, concluding that LEAF is a robust and accurate tool to understand the dynamics of urban lifestyles and support informed decision making in urban planning and resource allocation [5].

Concentrated loading areas in urban areas present challenges in logistics, such as the lack of adequate and optimized spaces for loading and unloading in cities, for which the integration of smart devices in loading areas was analyzed and proposed, including reservations, real-time monitoring and temporary storage, to improve efficiency and sustainability, with the incorporation of examples of technologies such as reservation systems, occupancy and load monitoring devices, and lockers for temporary storage in loading areas, resulting in the implementation of these technologies in urban loading areas improving space management, reducing unauthorized use and optimizing loading and unloading, favoring sustainability, concluding that the integration of smart devices in loading areas is key to improving urban logistics, but a unified regulatory framework and support in data collection are needed to optimize its operation [6].

The need to validate smart city interfaces from a user-centered design perspective, comparing low and high fidelity prototypes in physical and virtual reality environments, for which low fidelity physical prototype field tests and high fidelity tests in virtual reality environments were compared to evaluate realism, interactivity, presence and task difficulty, through the implementation of low and high fidelity prototypes, qualitative interviews and presence and interactivity analysis tools were used, involving design students and experts to obtain insights, resulting in that virtual reality

improves visual realism and discussion of user flows, although it has limitations to replicate realistic interactions and social contexts, compared to field tests, concluding that virtual reality is useful in the design process to visualize procedures and test complex user flows, but must be complemented with field tests to capture the context and real user interaction [7].

By reviewing various publications that focus on the use of the fuzzy logic technique for different problematic situations, we describe below the uses and applications, such as the application in the area of commercial law and corporate governance in Mexico, as well as in other international contexts. Key works are mentioned such as "Derecho Mercantil. Parte General y Sociedades" by Paredes and Meade, and "Ley General de Sociedades Mercantiles" by Macedo, which provide a solid foundation on Mexican commercial legislation. In addition, corporate governance issues are discussed, including the importance of internal control and best corporate practices, the research includes analysis on strategic diversification and business performance in Mexico, highlighting the relevance of corporate governance for risk mitigation in private companies. International principles and standards are cited, such as the OECD Principles of Corporate Governance and the Auditing Standards and Procedures of the Mexican Institute of Public Accountants, which underline the importance of transparency and responsibility in business management [8].

The application of the fuzzy model to assess the cost overruns in the healthcare sector due to treatment delays, in a context of the COVID-19 pandemic, where delays in healthcare have been significant. The proposed model uses fuzzy logic to handle the uncertainty and ambiguity inherent in cost assessment in complex and variable situations. The model describes the implementation of the model, such as the need for experts for quantification and the difficulty of obtaining accurate data. To mitigate these problems, a final stage is suggested in which the data is automatically updated each time the model is applied. This proposal seeks to improve accuracy and reduce the costs associated with the involvement of experts, thus facilitating a more efficient and continuous assessment of the cost overruns in the healthcare sector due to treatment delays [9].

In the study of algorithm efficiency and challenges in evaluating technological solutions due to the possible inclusion of closed source code and the need for laborious research, a basic model of a virtual environment used for decision making is proposed for specific experimental studies. In evaluating technological solutions, the importance of classifying resource consumption into qualitative categories such as "high", "medium" or "low" is highlighted instead of focusing on specific metrics such as bytes or microseconds. This significantly simplifies the evaluation by grouping technological solutions into a reduced number of classes based on resource consumption. In addition, various methodologies and formal models for software component optimization and selection are mentioned, underlining the relevance of multi-objective approaches and evolutionary optimization in cloud service composition [10]
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The study discusses smart grids (SG) and their associated technologies, including distributed energy resources (DER), power electronics components, electric vehicles (EV), and communication and cybersecurity issues. Artificial intelligence (AI) techniques such as fuzzy logic, knowledge-based systems, and artificial neural networks, as well as Internet of Things (IoT) architecture for applications in SG, are highlighted. Furthermore, IoT and blockchain (BC)-enabled services, such as secure and traceable digital transactions, and the improvement of SG services through AI-based analytics, are discussed. The importance of promoting local DERs, especially renewable energy resources (RER), to achieve stable, reliable, sustainable, and affordable electricity is proposed. The progress of DERs in the global SG context and the support for emerging EV technology to reduce the transportation sector's dependence on oil are discussed. With digital advancements, SG services have been significantly enhanced, especially through the use of AI, IoT and BC, enabling automated services and real-time monitoring of the power grid in terms of reliability, availability, resilience, stability, security and sustainability [11].

In software requirements risk assessment, the goal is to minimize maintenance time and promote customer value. The novelty of the work lies in improving requirements risk assessment and handling developers' subjective judgments on multiple conflicting criteria to provide robust solutions within the cloud computing framework that includes information about responsible persons, their rationale, their assumptions, and their initial and final decision values, to support software requirements reuse in distributed/global development [12].

In the transformation of maintenance strategies in recent decades, moving from a corrective approach to a proactive or predictive one. This evolution is crucial due to the increasing complexity of industrial systems and their impact on the competitiveness and productivity of companies. The research proposes the inclusion of fuzzy logic in the mining industry. In addition, a new approach to risk-based maintenance is presented, detailing an algorithm for risk assessment and estimation, exploring various implementation possibilities of the developed method and discussing the results obtained and their implications [13].

In the evaluation of waste sorting systems, a multi-criteria model based on fuzzy logic is identified for evaluating municipal waste treatment systems, defining parameters such as membership functions, inference rules and fine-tuning functions, based on expert opinion. An evaluation model is implemented in a case study of the Wrocław sorting facility for selectively collected waste (metal and plastic), analyzing the evaluation of the sorting line in seven selected cases. The system evaluation level and sorting efficiency are presented as results, a two-step evaluation method based on fuzzy theory is developed for evaluating the efficiency of the waste sorting system and its impact on the energy quality of the RDF and sorting efficiency is analyzed [14].

Decision support systems for assessing agricultural vulnerability and risk of sugarcane to climate change using a multi-agent model. The proposal involves a dynamic model of industrial systems and the digitalization of the sugarcane field in Mexico to achieve precision agriculture of sugarcane. The implementation applies fuzzy logic and its implementation in MATLAB, highlighting the importance of these tools in the research and development of agricultural models [15].

In assessing the risk in power transformer fleets, the technical condition is considered as the strategic importance of the units, the analysis was performed on a fleet of 19 units and the results demonstrated the viability of the proposed approach. In addition, a new method based on fuzzy logic was developed to improve the accuracy and consistency in the estimation of transformer insulation, the approach based on fuzzy logic showed an accurate assessment of the state of the insulating paper, although it presented some inelasticity that can be reduced by using a larger number of membership functions or replacing the trapezoidal distributions with triangular or Gaussian ones [16].

Integrating COVID-19 pandemic-inspired behaviors into agent-based modeling (ABM) to respond to pollution in water distribution systems. The study uses a modeling framework developed in MATLAB, which is coupled in real-time with the EPANET hydraulic simulation software, allowing instant synchronization and optimization problem solving during simulation. The research focuses on a medium-sized water network model, Net3, to demonstrate the capture of emergent phenomena and the effectiveness of the proposed approach. It details how consumer behaviors, influenced by the pandemic, can be modeled deterministically, eliminating the need for uncertainty analysis. The results show the actions taken by different types of societies over 24 hours, evenly distributed due to the lack of geographic information on pollution [17].

In this work, we developed a method to evaluate pre-professional internship reports in a public university in Peru, where evaluations are often carried out in a qualitative manner, such as good, average or low, which makes it difficult to determine whether the report is approved. We developed the traditional evaluation method through a web system and how this can also be complemented with the use of the Fuzzi Logic model, which allows us to evaluate whether the student passed their pre-professional internship report.

2. Methodology

Pre-professional internships are an essential component of the training of students at public universities in Peru, who begin their insertion into the labor market for a specific period of time, thus building a bridge between theory and practice, between the training stage and entry into the labor market. In this sense, pre-professional internships are a critical aspect for students at public universities, since they allow them to acquire work experience in their area of study and establish important contacts in the working world. In the public university, where there are a large number of students and companies involved in this process, the management of pre-professional internships can be complex. When implementing a web-based system to manage the pre-professional internship process, a series of challenges and problems arise that hinder its effective implementation and proper use.

Consequently, if we consider that public universities in the Lima region have a varied student population between the ten semesters of study, it is estimated that everyone at some point will take the pre-professional internship course, since this course is included between the ninth and tenth cycle of the study plan and the school management must be prepared to be able to generate a process in the most perfect way possible. In this sense, we should mention that for different reasons the professional schools do not have a system that automates the management process of pre-professional practices, which is why it becomes an object of study in this thesis.

The materials and methods are described by the presentation of the processes necessary to be able to replicate the methodology.

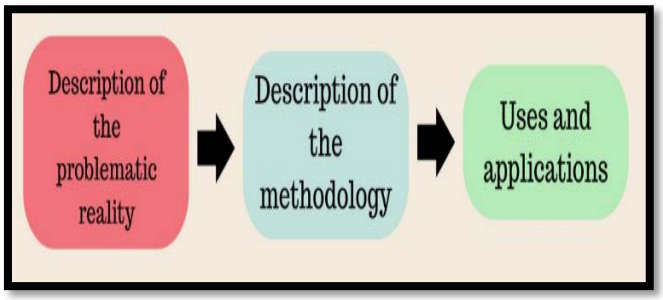

Figure 1: Block diagram of the proposal.

Figure 1, presents the block diagram that represents the method of the proposal, starting with the description of the problem, followed by the description of the methodology and ending with the uses and applications.

2.1. Description of the problematic reality

The description of the problematic reality is described in the conditions that are needed to be able to start and to be able to conclude the pre-professional practices processes. We begin by indicating that the pre-professional practices are an indispensable requirement to be able to obtain the bachelor's degree for the students, which is why there is a need for the students to be able to pass

this evaluation, which consists of the review of the practice report that the student made and that must be approved.

The mechanism of review and approval of the practice report consists of the detailed review of the report by three teachers, each of them evaluates the report and according to their recommendations, the report is approved or disapproved. The report is sent to 3 teachers, after the student registers in the Web System for the exclusive use of students and the degree and title office.

Below we present the main processes of the pre-professional internship system:

1. **Management of pre-professional internships**
   The management of pre-professional practices encompasses the development, programming, coordination, control and assessment of internship plans, with the purpose of ensuring an adequate education for students and an effective connection with the work environment.
   Pre-professional internship management involves the planning, coordination and evaluation of practical learning opportunities for students, in order to combine theory and practice, boost the development of skills and competencies, and facilitate the transition to employment.

2. **Selection process**
   The selection process comprises a series of organized and consecutive stages that are carried out for the purpose of collecting data on candidates, analyzing their capabilities and competencies, and making informed decisions about their suitability for a given position. The selection process encompasses a set of methods and tools used to recognize and assess suitable candidates, with the goal of determining who will be hired to fill a position, thereby ensuring a fair and unbiased selection.

3. **Number of students practicing**
   Refers to the number of students who are carrying out internships in an organization or company as part of their academic or pre-professional training. These numbers may vary depending on the context and policies of the university and the organization receiving the internship.

4. **Percentage of students practicing**
   Refers to the percentage of students who are carrying out internships in an organization or company as part of their academic or pre-professional training. These percentages may vary depending on the context and policies of the university and the organization receiving the internship.

5. **Supervision**
   Supervision encompasses the act of observing, guiding, and leading the work of subordinates for the purpose of ensuring that established objectives are achieved and required performance standards are met.

6. **Number of supervisory visits**
   Refers to the number of times a supervisor visits or inspects the internship center to monitor and evaluate its performance. These supervisory visits are part of a monitoring and follow-up process designed to ensure that quality standards, established objectives, and university policies and procedures are being met.

7. **Communication**
   Communication refers to the process by which information and meaning are transferred and exchanged between two or more individuals, for the purpose of sharing knowledge, ideas, feelings, and coordinating actions effectively. Communication involves conveying information, ideas, emotions, and meanings using both verbal and nonverbal symbols for the purpose of exerting influence on other people's thinking and behavior.

8. **Number of students who recommend taking the pre-professional internships**
   Refers to the number of students who recommend to other students to carry out an internship in an organization or company as part of their academic or pre-professional training. These numbers may vary depending on the context and policies of the university and the organization receiving the internship.

2.2. Description of the methodology

The description of the methodology is related to the description of the tools used to implement the web system and the intelligent part, which consists of working through fuzzy logic, for which the Matlab tool has been used. Below we describe the architecture of the application.

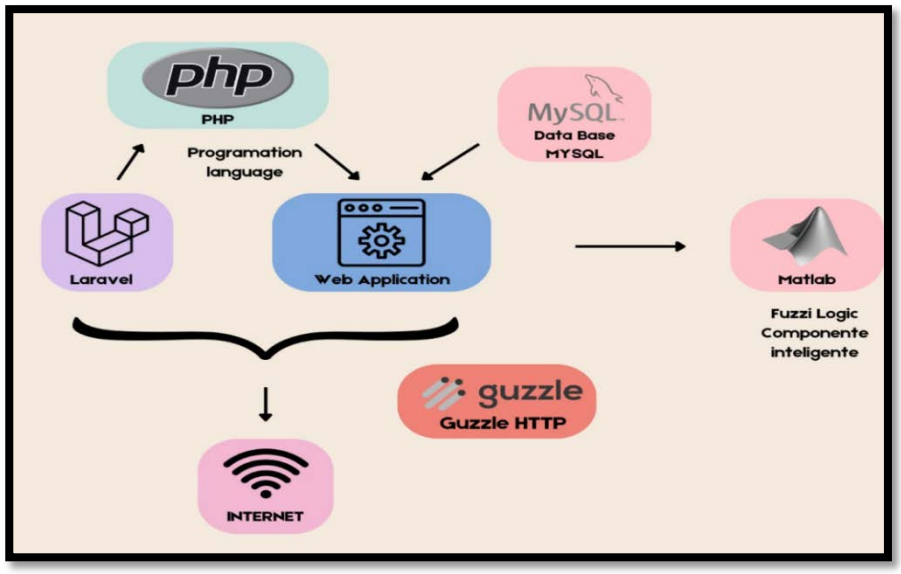

Figure 2: Description of the architecture of the development proposal.

Figure 2 presents the architecture of the implemented solution; for the implementation of the web system, where the use of the PHP programming language in version 8 with Laravel in version 9.19 is used, the chosen database is MySQL and as the HTTP client Guzzle for PHP, the intelligent component is developed in Matlab using the Fuzzi Logic tool.

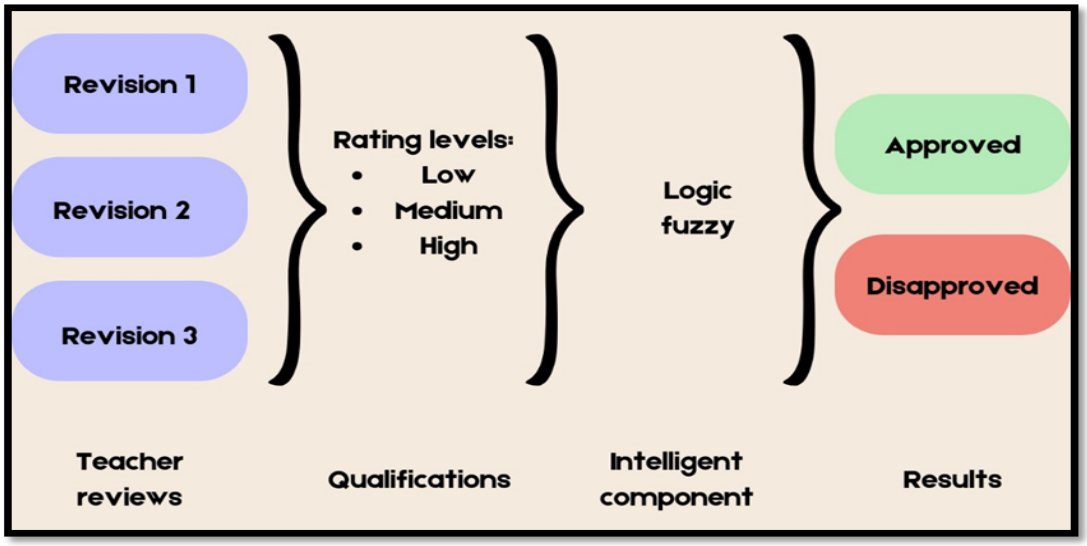

Figure 3: Description of the evaluation method for pre-professional practice reports.

In Figure 3, the evaluation mode of the practice reports is presented, the process begins with the sending of the report to three teachers, each one evaluates according to their perception and experience, the result of the evaluation is a grade that in many cases is a qualitative grade, which can have the values of "High", "medium" or "Low", which makes it difficult to obtain the final result of the evaluation that is approved or failed; For this task, we resort to the use of the intelligent component that is the use of fuzzy logic, for which the values of the teachers' grades are evaluated, and the final evaluation value is returned.

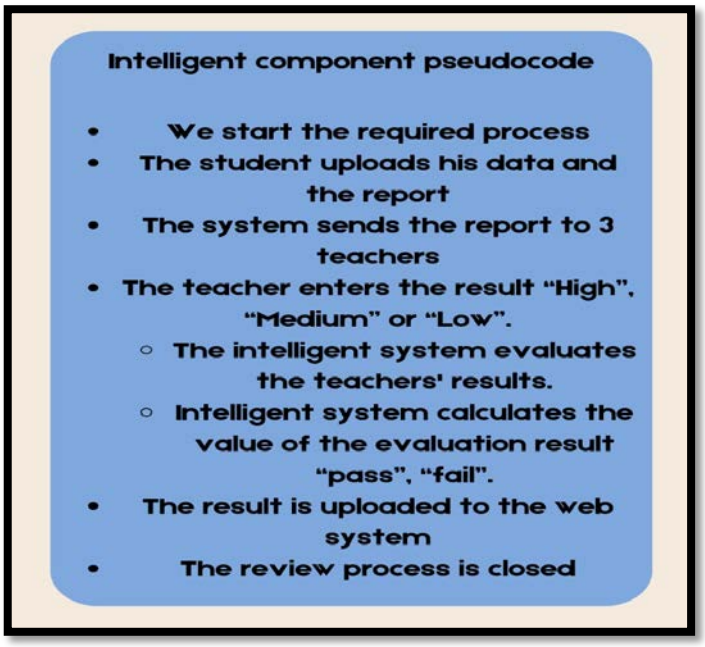

Figure 4: Pseudocode of the we system.

In Figure 4, the pseudocode of the intelligent component is presented, where it is described how the web system and the Matlab tool work, in order to have the final result of the evaluation, this process is carried out manually, as a demonstration mode, where the evaluation value of each teacher is taken, loading it into the Matlab application and the result is loaded into the web system, with which the process is closed, with the final evaluation values which are "Passed" or "Failed".

2.3. Uses and applications

The uses and applications are related to the way of using the implemented web system, where the intelligent component that performs the calculation of the evaluation of the partial results stands out; in the implemented test model the process is carried out manually, with the intention of being able to carry it out automatically by presenting a function that converses the Matlab function with PHP.

3. Results

The results we describe are related to being able to describe how the web system and the intelligent component work, analyzing the main processes of the system, such as the student registration process and the evaluation with the Matlab tool.

Figure 5: Implementation design.

In Figure 5, the registration screen of the proposed system is presented, where the entry is evidenced through a user registration, having to enter with its corresponding password.

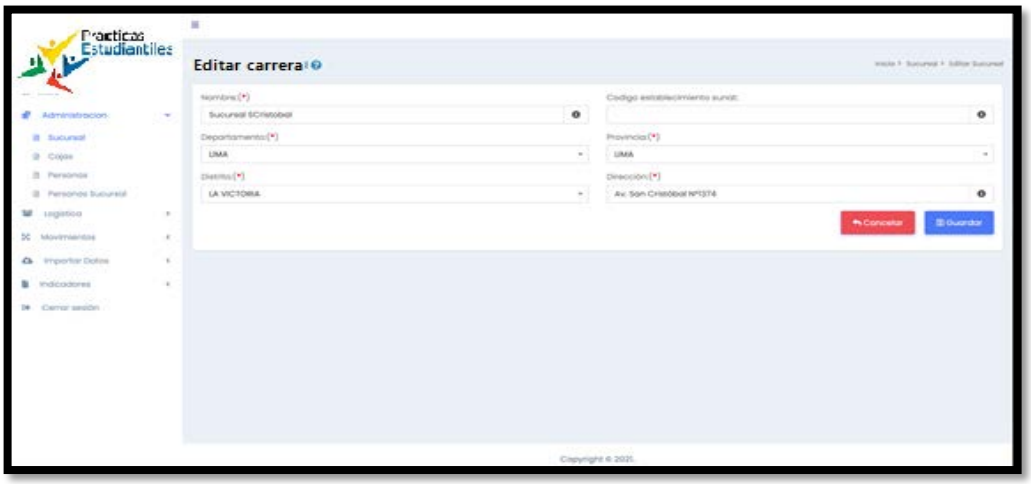

Figure 6: Data entry form.

Figure 6 shows the main form for data entry by students. The data entered includes the specialty that the student is studying, the place where he/she did his/her internship, and most importantly, the entry of the report made, where the information on the internship process is found.

3.1.1. Smart component

When quantitative results are obtained, evaluation is carried out using Fuzzi Logic techniques, with which a report is evaluated by 3 teachers, so its result must be approved and disapproved, the evaluators' review values are "good", "regular", and "bad". Below we present the generated model, considering an output with "approved" and "failed" values.

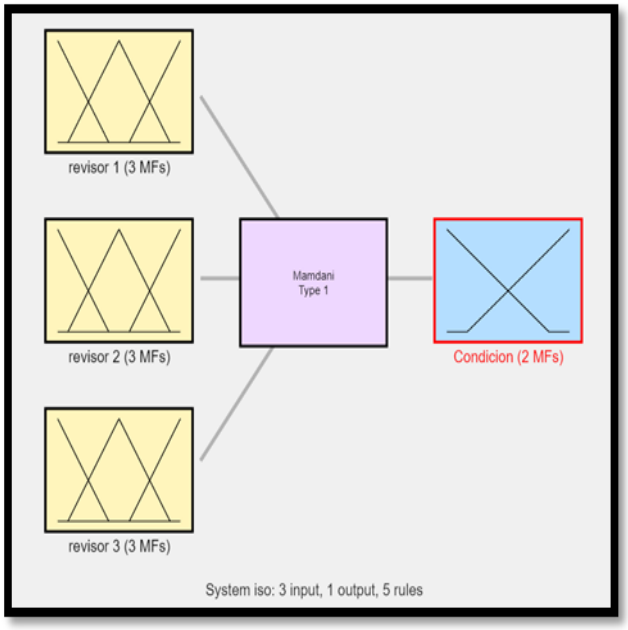

Figure 7: Fuzzi Logic Model.

In Figure 7, the fuzzy logic model is presented where there are 3 inputs that correspond to the evaluators and an output that corresponds to the result of the evaluation.

System: iso

Add All Possible Rules | Clear All Rules

	Rule	Weight	Name
1	If revisor 1 is malo then Condicion is desaprobado	1	rule1
2	If revisor 2 is malo then Condicion is desaprobado	1	rule2
3	If revisor 3 is malo then Condicion is desaprobado	1	rule3
4	If revisor 1 is regular and revisor 2 is regular and revisor 3 is regular then Condicion is aprobado	1	rule4
5	If revisor 1 is bueno and revisor 2 is bueno and revisor 3 is bueno then Condicion is aprobado	1	rule5

Figure 8: Interpretation of the rules.

Figure 8 presents the roles considered in the evaluation, where there is a general condition, the student is approved if at least the reviewers' evaluations correspond to the regular value, higher values guarantee approval and a bad value ensures failure.

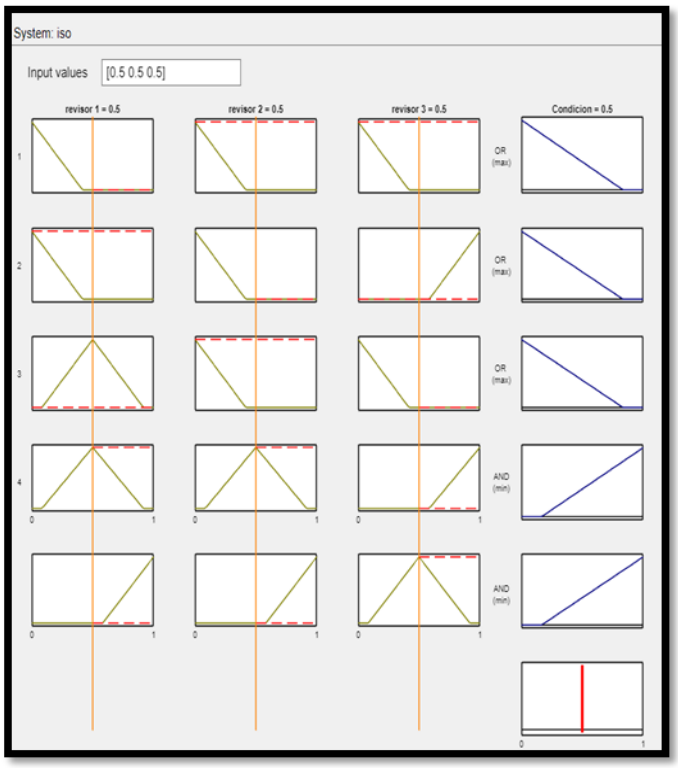

Figure 9: Analysis of results.

In Figure 9, the interpretation of the rules is presented, considering a value of bad ensures disapproval, and a minimum approval value is when the 3 evaluators consider it as regular, higher combinations ensure approval of the report.

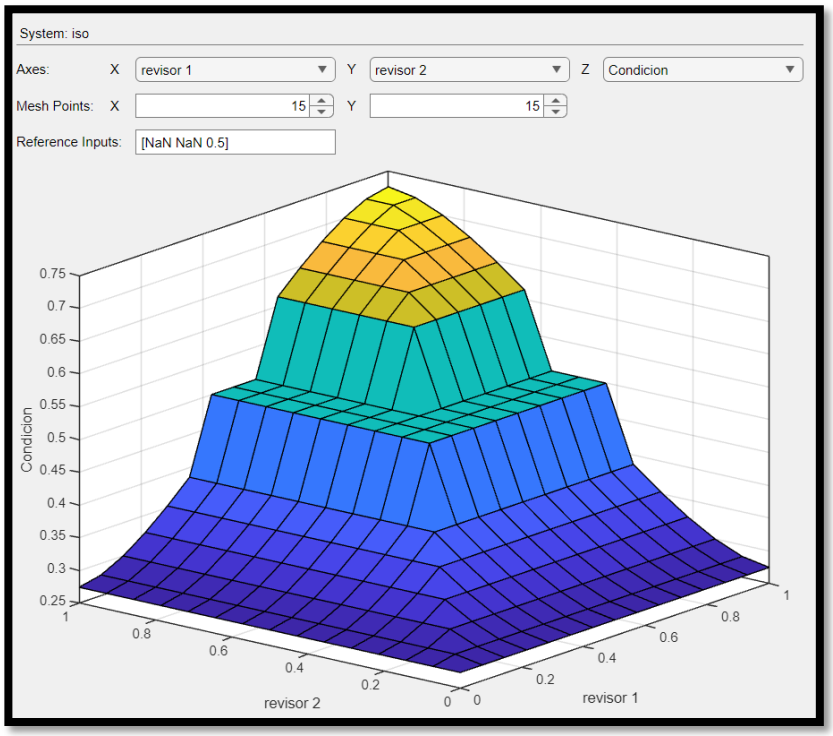

Figure 10: Fuzzi logic model 3D.

Figure 10 shows the 3D model, where the minimum approval values are evident; values greater than 0.5, which corresponds to the "regular" value of the evaluation, ensure approval and lower values are considered as failure.

4. Conclusions

In conclusion, with the use of fuzzy logic, embedded in a web application, an increase from 40.52% to 82.76% was achieved, which allowed validating that the use of fuzzy logic, implemented in a web system, is favorable for the indicator number of practicing students.

It is concluded that for the indicator number of supervised visits to the pre-professional internship center there was an increase of visits to the pre-professional internship centers by the pre-professional internship supervisors quite considerable equivalent to 42.24% since at the beginning the supervised visits were on average 40.52% per semester and after the implementation of the software the sales were on average 82.76%.

It is concluded that the indicators number of students practicing and the number of supervised visits to the center of pre-professional practices allow a favorable measurement for the management of pre-professional practices validating that these are concluded in a correct way and that they increase in quantity and therefore there will be more graduates for the university.

It is recommended to optimize the internship computer system by developing a new project solution following the MVC (Model View Controller View) software architecture pattern that will help to separate the data and business logic of the internship system, thus facilitating maintenance, component reuse and scalability of the application.

It is also recommended to improve the organization of the employability workshops to be more precise the workshop of Induction of pre-professional practices, it could be considered the use of the google calendar for the scheduling of the workshops mentioned on the website and other media that the Communications office uses for the dissemination of our event thus informing students the schedule of the workshops in a timely manner for their registration and participation.

It is recommended to continue conducting periodic studies on the satisfaction of students who are doing internships, since in many surveys the suggestions presented by the students show which changes or problems are the most critical in order to address them in a timely manner, even more so if they are related to the internship computer system.

Finally, it is also recommended to make an evaluation about the programming language to be used in a future new version of the internship computer system, since the public universities can use the reculate framework for the projects that are developed in the corporation can also adopt the Python programming language that has additional advantages to the language used in the present pre-professional internship system (PHP) since most of the web applications used in the corporation and also in the development industries that use Python with R.

When evaluators provide qualitative values, we resort to the use of evaluation tools using the fuzzy logic technique, resulting in a result that can be worked on, as is the case with the evaluation of reports, where a report result is required, for which the fuzzy logic technique is very helpful.

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