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EXPERT SYSTEM FOR THE CHARACTERIZATION OF THE DESIGN OF A PHOTO-VOLTAIC AND WIND ENERGY GENERATION SYSTEM

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ABSTRACT

Taking as an initiative the energy needs that are presented in Colombia due to population growth and the possible solutions that higher education institution can provide, the idea of creating a tool to characterize or validate designs of alternative energy obtaining systems is born. This work presents the realization of an expert system with which the characterization of the design of photo-voltaic and wind power generation systems is achieved. This expert system evaluates the feasibility of implementing a photo-voltaic or wind system to obtain energy at certain sites in the national territory based on specific data such as the location of the future project and the amount of energy that needs to be generated. Once the viability of the project is determined, the expert system delivers the design of the necessary implements, features and a final project price. Motivated by the boom presented by mobile applications today and the versatility that these can provide the realization of this project is based on the integrated development environment of Android Studio to achieve the visualization of the expert system from a mobile application. The expert system will be divided into two parts, one will be the consultation environment, in this we will find the interface designed for interaction with the user and a second development part where the knowledge base consisting of two main algorithms will be stored which is made the decision making for each of the systems of obtaining energy.

Keywords: expert system, photo-voltaic system, wind system, mobile application, calculate, framework, database.

1. INTRODUCTION

At present, the energy demand that is presented in the world due to population growth and the increase in economic activities has led to a possible energy deficiency. According to the study carried out by the Inter-American Development Bank, it is projected that by 2040 the country's energy needs will increase by 110.3% due to greater economic growth and per capita income (Serebrisky, 2016). Given this future energy deficit, it is necessary to look for alternatives such as alternative energies, especially photo-voltaic and wind energy.

The implementations of these power generation systems are the alternative to the traditional methods that we have used for hundreds of years. Performing a detailed study of the production of photo-voltaic and wind energy can be synthesized the necessary requirements for the implementation of the hardware based on the requirements of the consumer or customer. When addressing artificial intelligence, in search of responses to a series of electrical energy needs, we think of the use of expert systems.

These expert systems are made up of two fundamental parts with which communication between end users and expert knowledge can be established; the first part is the development environment, used by the builder to create the components and introduce knowledge into the knowledge base. The second fundamental part is the consultation environment, used by non-experts to obtain expert knowledge and advice (Turban, 1995).

Taking into account the above, an expert system was implemented for the characterization of a photo-voltaic or wind power generation system, as well as being portable from the Yba app, which seeks to provide a solution to the problems that arise in the design processes of said systems and reliability of the results obtained through the expert system.

In this process of implementation, the search for an expert who can provide all the information he has is carried out due to his vast experience so that he can feed the knowledge base that will be the central engine of the expert system (Luger, 1989).

To begin the design of the expert system, it is decided that this will be an application with client-server architecture. The expert system will be divided into two large parts, the first one will be the one that stores the database and called a server, this database is loaded by a web server located in the cloud, created through the Django web development framework and coded in Python programming language which will facilitate the design of the website making it faster and more pragmatic.

The second part called client will be the mobile application in which all the calculations of the wind and photo-voltaic energy obtaining systems will be carried out, coded in Java programming language and designed from the Android Studio development environment so you can have the control over certain elements that will generate a more pleasant experience for the user.

2. METHODOLOGY

The version used for the development of the expert system software is Django 2.2.6 as framework and codified in Python 3.7.4 programming language, which have their use and licenses for free.

There are several who have written about the steps to follow to design and implement an expert system, among them it is possible to find the doctor (Luger, 1989) who suggests the stages shown in Figure-1, each of these stages meet a specific objective which can be implemented for the development of the expert system and are explained below.

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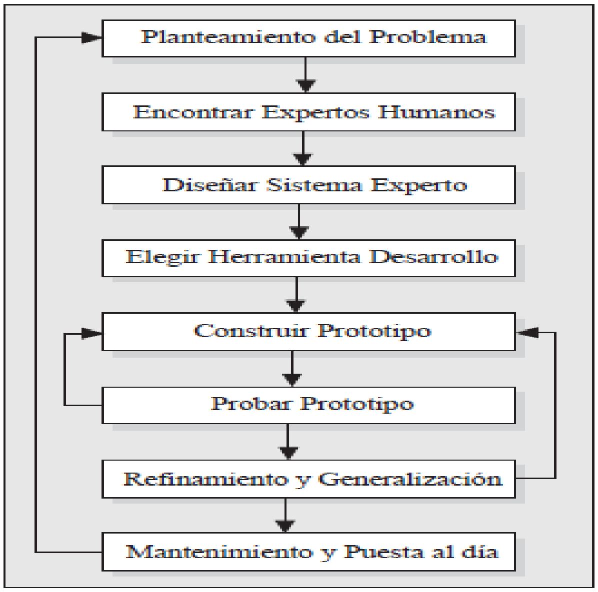

Figure-1. Stages in the development of an expert system.

2.1 Problem Statement

At this stage it is sought to provide a tool that characterizes the designs of photo-voltaic and wind power generation systems, to provide a solution to the problems that arise in the design processes of generation systems and reliability in the results that are obtained through the expert system.

2.2 Finding Human Experts

At this stage of the development of an expert system, the engineer Santiago González Castaño, an instructor of the National Learning Service (SENA), participated as an expert, who, with his experience and through the course of installing photo-voltaic systems, taught us how to design systems obtaining photo-voltaic and wind energy to carry out the expert system.

2.3 Expert System Design

At this stage for the design of the expert system it is decided that it will be an application with client-server architecture. The expert system will be divided into two large parts, the first one will be the database or knowledge base, in this case called server, this database is loaded by a cloud-based web server created through a web development framework and encoded in a free software programming language; The second part called the client will be the mobile application, which will perform all the calculations of the systems for obtaining photo-voltaic and wind energy, designed from the free software development environment.

2.4 Choice of Development Tool

At this stage the tool for client and server development is chosen, for the client development, the use of smartphones was used as a base and a mobile application is developed as an expert system using the Android Studio development environment, coded in language JAVA programming. A cloud-loaded VPS (private virtual server) was used for the server, created using the Django web development framework as a database, encoded in Python programming language.

2.5 Building and Testing Prototype

For this stage a base prototype has been developed in order to test the ease that the user has with the interface when entering the application the design requirements and the response that the application delivers. Simultaneously, the results delivered by the application are reviewed and compared based on a design previously made and verified in order to verify the characteristics delivered by the expert system are reliable and correct. This process is done until you find the prototype that works correctly to move to the refinement of the mobile application.

2.6 Refinement and Generalization

This process is carried out synchronously with the previous stage in order to find the prototype that works correctly and improve the initial designs of the mobile application.

2.7 Maintenance and Updating

At this stage, the mobile application is delivered with the expert system to the project manager, this being the end user who verifies that it meets all the requirements proposed in the problem statement and shows the final product updated.

3. ANALYSIS

This project is developed based on the need to provide a tool that achieves the characterization and validation of the designs of photo-voltaic and wind power generation systems, taking advantage of current technological and computer advances such as mobile applications and expert systems.

At present it is evident that, for the development and implementation of photo-voltaic and wind systems, there is a need to go to an expert on the subject, which this expert through a design process provides a description of everything necessary for the implementation of power generation systems, either photo-voltaic or wind.

With the technological advance that is now at hand such as mobile devices, it is sought to generate an additional option of having an expert in photo-voltaic and wind generation systems through a mobile application, which can provide information from any site with Internet connection and obtain the design for the implementation of photo-voltaic and wind power generation systems at no cost.

3.1 System Modelling

Figure-2 shows the navigation scheme between screens of the application represented by a flowchart.

The system is modeled by implementing the UML unified modeling language, which visually and easily expresses the operation of the system, UML allows a modeling of the static components of a system (use case

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diagrams, class diagrams), as well as the dynamic behavior of its main elements during its operation, including state diagrams and sequence diagrams (Vidal, 2012).

It begins with the diagram of uses represented in Figure-3, which allows a description of the actions of the system through the way in which an actor interacts with the system through operations or use cases.

First, the elements that make up a use case diagram are identified in order to describe how these interact.

Below are the actors and use cases of the system:

Actor 1: Client-user. Actor who is linked to the mobile application, and through which he accesses the services offered by the application.

Actor 2: Server - expert. Actor responsible for the proper functioning of the mobile application, managing the database and process control software.

With the actors and each of their functions identified, we proceed to determine the use cases that interact in the system in order to make the respective design.

The identified use cases are the following: Wind system, Photo-voltaic system, Photo-voltaic system with batteries, Photo-voltaic system interconnected to the network, Calculate.

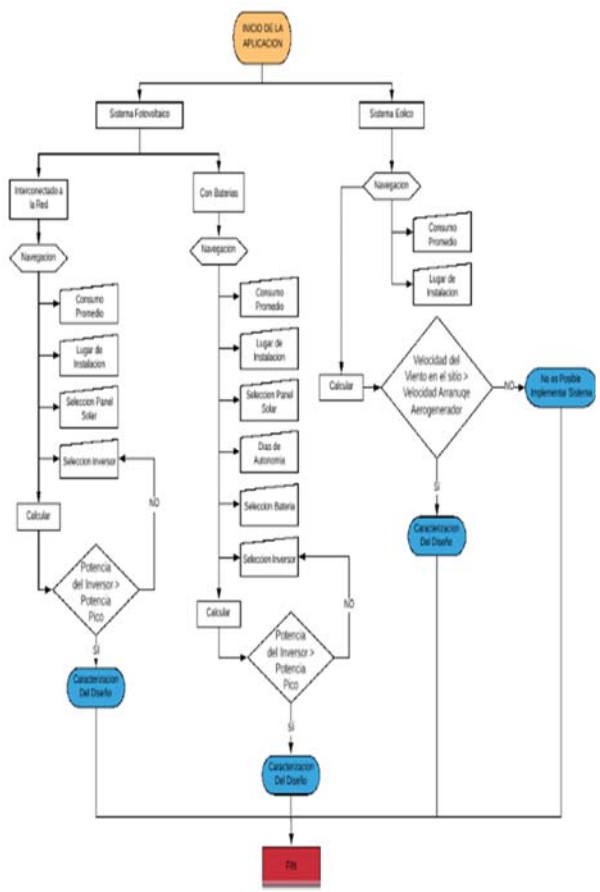

Figure-2. Flowchart of the expert system.

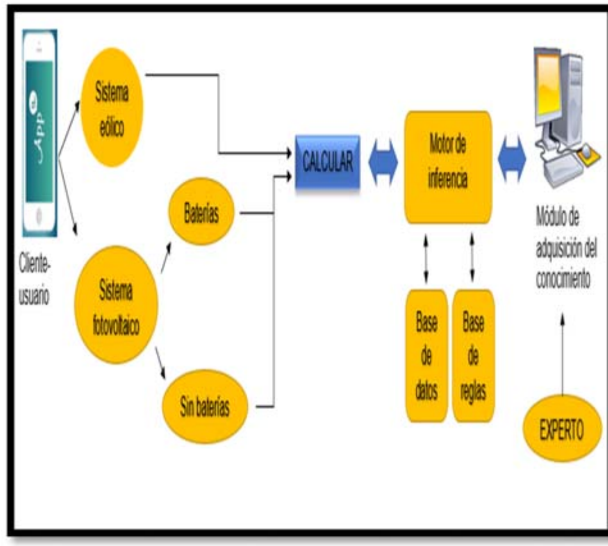

Figure-3. Use case diagram.

Possible cases are described below:

Use case 1. Wind system: Process where the user can perform the calculation of wind power generation system, the expert system asks a series of questions and selecting a series of elements, gives the final result of everything necessary for implementation of a wind system.

Use case 2. Photo-voltaic system: Process where the user wishes to obtain the calculation of the photo-voltaic power generation system, there are two use cases, which the user can choose if he wishes to calculate the photo-voltaic system interconnected to the network or system Photo-voltaic implementing batteries.

Use case 3. Photo-voltaic system interconnected to the network: Process in which the user interacts with the application through a series of questions and selection of elements (solar panels, inverters), where finally using the calculate button, the expert system throws the result of everything necessary for the implementation of a photo-voltaic system interconnected to the network.

Use case 4. Photo-voltaic system with batteries: Process in which the user interacts with the expert system through a series of questions and selection of elements (solar panels, inverters, batteries), where finally using the calculate button, the expert system throws the result of everything necessary for the implementation of a photo-voltaic system with batteries or also called isolated photo-voltaic system.

Use case 5. Calculate: In this process the user accesses a form where he delivers a quote with all the necessary elements for the implementation of a photo-voltaic or wind generation system, this form shows the elements for the implementation of the system, quantity,

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price, total value and finally, some additional items of how the connection to the inverter should be made if it is a photo-voltaic system, the minimum area necessary for the implementation of the system and the monthly savings if the system is implemented or the estimated recovery time from the investment.

3.2 Interface

The mobile interface or application is the means by which the client connects to the expert system through an Api Rest with the web server (Mgbemena, 2016), with the aim of making use of the necessary elements for the implementation of the system calculation. Photo-voltaic and wind generation, in addition to obtaining a quote or total value of all the elements, there are some monthly savings items in pesos and minimum area necessary to perform the installation.

The application view is shown in Figure-4, which shows us the step by step to reach the most optimal infrastructure solution of Expert System.

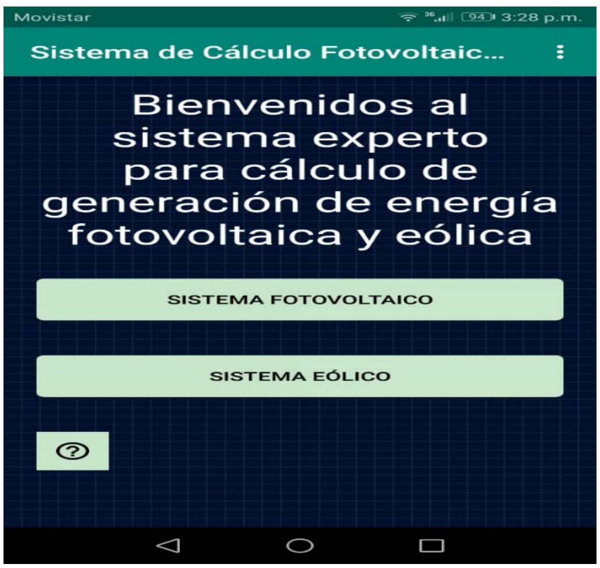

Figure-4. Expert system interface.

3.2.1 Photo-voltaic generation system

The customer when choosing the photo-voltaic system may choose interconnected to the network or with backup batteries as shown in Figure-5.

Figure-5. Generation photo-voltaic interface.

Figure-6 shows the sequence when choosing the photo-voltaic generation backed by the national interconnection network.

a) b)

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c) d)

Figure-6. Generation photo-voltaic interface interconnected to the network.

In the process of calculating a photo-voltaic system interconnected to the network, the average value of energy consumption required by the customer is entered; the location of the location where the system will be installed is chosen; choose a type of solar panel with its characteristics and price (b), likewise choose the inverter with its characteristics and price (d). It ends with the calculate button, giving a result of a quote with the necessary elements for the installation of the chosen power generation system (e).

3.2.2 Photo-voltaic generation system

Figure-7. Generation photo-voltaic interface with batteries.

For this first section, the user must enter the average energy consumption that he wishes to generate in one day. Then the user will choose the city in which he intends to implement the power generation system. The expert system will provide the specific peak solar hour (HSP) that each location has. Once the previous step has been completed, the user will select from the options that the expert system provides the panel with which he wishes to implement his photo-voltaic power generation system. Depending on the choice made by the user, specific electrical characteristics available to each solar panel may be known. The user must also enter the days of the week that the system will have total autonomy from the public electricity grid. With this selection you must choose the type of battery with which the energy storage bank will be designed.

The electrical characteristics of each battery will be charged automatically by the expert system. Finally, the user must choose the inverter that he will implement with his power generation system within the options offered by the expert system. The electrical characteristics contained in each inverter will be automatically charged by the expert system. Finally, the "CALCULATE" button will be pressed and the characterization of the photo-voltaic system will be obtained.

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Figure-8. Results Generation photo-voltaic with batteries.

In this view you can see the results of the design of a photo-voltaic system with batteries. Among the results are items such as quantities, individual prices and totals as well as some specific specifications for each design.

3.2.3 Wind generation system

The user inserts the boot data so that the expert system starts the characterization of the wind system design.

Among the data that the user can provide we find the power (W) that he intends to generate and the location of the future project. By entering this data, the system generates the wind speed (m / s) and the wind rose. Finally, the "CALCULATE" button will be pressed and the characterization of the wind system will be obtained.

Something has failed: It is an alert message that will be displayed in case where you want to implement a wind system the wind speed is low and it is not recommended to carry it out in that location.

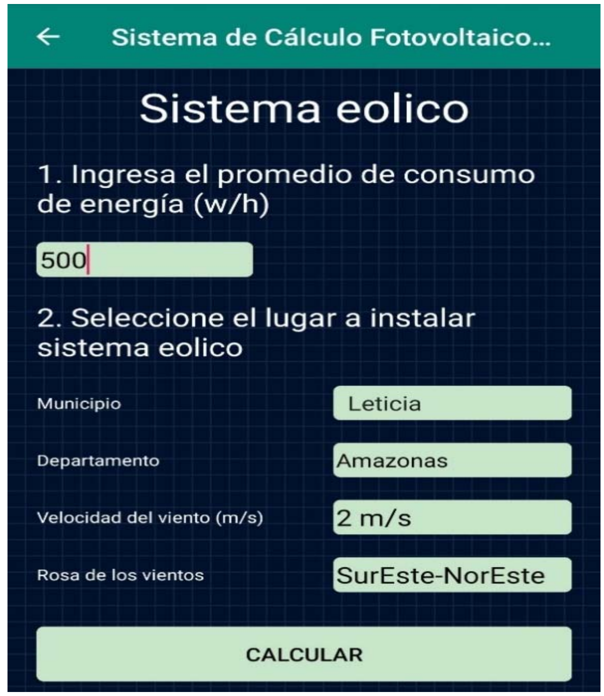

Figure-9. Wind generation interface.

In Figure-10, the user can appreciate everything necessary to implement a wind system according to the energy value entered and the location of their choice. In this you will find the pertinent elements for the assembly of the wind system together with its prices and characteristics.

Figure-10. Wind generation results.

4. CONCLUSIONS

With the use of expert systems, it is sought that people with little experience can successfully carry out problems that require specialized formal knowledge in a practical and quick way.

This project demonstrates the efficiency, reliability and ease offered by expert systems in problem solving, thus checking that these can be a great application tool in the different branches of knowledge.

By making the entire application with the client-server architecture, where the server is in the cloud, it allows the possibility of having n number of clients which may be on other n platforms, for this case the client is developed on the platform of Android Studio

With the use of a REST API as an intermediary for the communication of data between the web server and the clients, it is possible to make the export of data more secure since these clients do not make direct SQL queries on the database.

Communication between the web server and the clients is standardized through the REST API so that regardless of the language in which the client is located, a request is made in a single way and thus obtain a single response for the various clients, thus deriving in a total control of the information regardless of the precedence of the information requests.

A pleasant experience in the use of the interface for the end user is achieved by developing the application in the Android Studio platform.

REFERENCES

Abao R. P., Malabanan C. V., Galido A. P. 2018. Design and Development of FoodGo: A Mobile Application using Situated Analytics to Augment Product Information. Procedia Computer Science, 135, 186-193. DOI: https://doi.org/10.1016/j.procs.2018.08.165

Apache Software Foundation. 2015. https://cordova.apache.org/docs/en/latest/guide/overview/index.html. Consultado 17 de octubre de 2019.

Cruz-Ardila J., Cardona-Gómez J., Hernández-Porras D. 2013. Aplicación electrónica para el ahorro de energía eléctrica utilizando una energía alternativa. Entramado. 9(2): 234-248.

Framework 7, 2016. https://framework7.io/docs/introduction.html. Consultado 19 de octubre de 2019.

Mikati M., Santos M., Armenta C. 2012. Modelado y Simulación de un Sistema Conjunto de Energía Solar y Eólica para Analizar su Dependencia de la Red Eléctrica. Revista Iberoamericana de Automática e Informática industrial, 9(3): 267-281. DOI: https://doi.org/10.1016/j.riai.2012.05.010

Ospino Castro, A. 2010. Análisis del potencial energético solar en la Región Caribe para el diseño de un sistema fotovoltaico. INGE Corporación Universitaria de la Costa. 6(1): 95-102.

Rodríguez Murcia H. 2008. Desarrollo de la energía solar en Colombia y sus perspectivas. Revista de Ingeniería Universidad de Los Andes. (28): 83-89.

Barreto L. E. Frameworks. 2009. [3 de febrero de 2019]. Disponible en internet: http://www.maestrosdelweb.com/tienen-lugar-los-frameworks-en-el-futuro-del-desarrollo-web/.

Garibay Cárdenas V. 2016. Consumiendo una Api con Retrofit 2 en Android. [12 de febrero de 2020]. Disponible en internet: https://stories.devacademy.la/mi-primer-app-con-retrofit-y-android-ac61a8954a2c.

Holovaty Adrian, Kaplan Jacob. 2009. Porque usar Django. 2007. [20 de enero de 2020]. Disponible en internet: https://devcode.la/blog/por-que-usar-django/.

Luger G. F., Stubblefield W. A. 1989. Artificial Intelligence and the Design of Expert Systems. Benjamin - Cummings, Redwood City, CA. DOI: http://dx.doi.org/10.1016/j.riai.2013.05.004

Lujan Castillo, Jose Dimas. 2019. Desarrollo de aplicaciones Android con Android Studio: Conoce Android Studio

Mgbemena, C. Retrofit. 2016. [en línea]. https://code.tutsplus.com/es/tutorials/sending-data-with-retrofit-2-http-client-for-android--cms-27845. Consultado 3 de enero de 2020.

Pino Raul. 2001. Introducción a la inteligencia artificial: sistemas expertos, redes neuronales artificiales y computación evolutiva. (Gijón: Servicio de Publicaciones. Universidad de Oviedo, 2001.)

Serebrisky Tomás. 2016. Luces encendidas? Necesidades de energía para América Latina y el Caribe al 2040. Estudio realizado por el Banco Interamericano de Desarrollo.

Turban E. 1995. Decision Support and Expert Systems (4ta edición). EE.UU. Prentice-Hall. DOI: http://dx.doi.org/10.1016/j.procs.1995.07.012

Vidal C., Schmal R., Rivero S., Villarroel R. 2012. Extensión del Diagrama de Secuencias UML (Lenguaje de Modelado Unificado) para el Modelado Orientado a Aspectos. En: Información tecnológica. 23(6): 51-62. DOI: http://dx.doi.org/10.4067/S0718-07642012000600007