Expert System for appropriate actions to be taken before, during and after a Seismic event in Venezuela

Francklin Rivas-Pérez, Astrid Dos Santos, Víctor Pardo, Francklin Rivas-Echeverría

Abstract— In this paper it is presented a methodological framework created for Expert systems design and development for selecting the appropriate actions to be taken before, during and after a seismic event or earthquake. This expert system is implemented in a web site in order to let the users to present their own personal and familiar situation to the system and find accurate information about the consideration and safety actions that the users and their families should take. For building the system it was used a set of experts with more than 25 years of experience in diverse areas including engineering, safety, security, geophysics, medical, among others.

Keywords—Artificial Intelligence, Expert Systems, Seismic events, prevention and risk management

I. INTRODUCTION

Planet Earth is a dynamic planet, i.e. is continuously moving. Scientists have been interested in studying not only the rotational and translational motions of the earth, but also has been concerned in studying volcanic eruptions and earthquakes that have resulted in large geographical changes, and the need has arisen to develop jointly equipment and tools that help on the detection or explain the causes of these phenomena [11, 12].

The Earth is made up of a series of plates called "tectonic plates", which over millions of years have moved relative to each other, adjusting in such a way that the planet has taken the current form and has promote the rising of continents and existing geographic reliefs. The American continent is composed of two continental plates: the North American and South American. Venezuela is located within the boundaries of South American plate, Pacific plate and Caribbean sub plate [14], so the territory is crossed by a system of faults that are longitudinally extended by hundreds of miles away and that correspond to Boconó fault system, Oca-Ancon fault, San Sebastian fault and El Pilar fault mainly, which divide the mountains near the Caribbean Sea and cut the Venezuelan Andes cordillera.

One of the most important active faults of the Andean Cordillera is Boconó Fault [13], which is located in western Venezuela, through the states of Táchira, Mérida, Trujillo and Lara, ending at the coast of the town of Moron, with an approximate length of 420 kilometers in Venezuela. In figure 1 it can be seen the seismic zones in Venezuela. This Boconó fault system covers a great part of Chama's River trajectory in Mérida State.

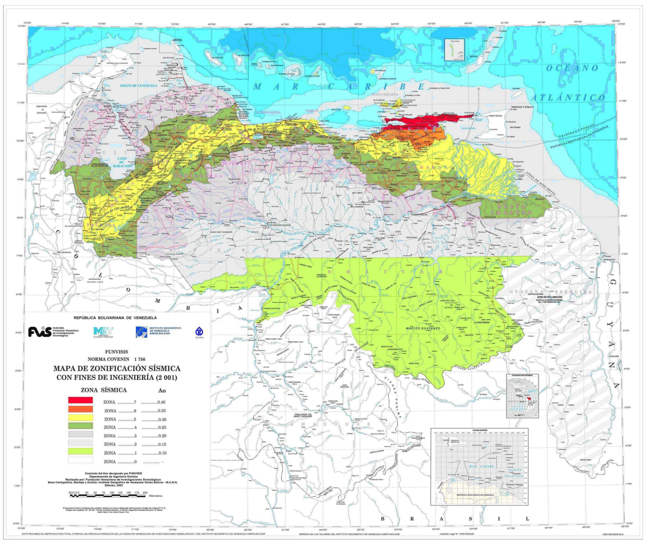

Fig 1. Map of seismic zones in Venezuela
Source: FUNVISIS

Whereas the city of Merida is located in a constantly

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active seismically area, is of great importance to people, be aware of the actions to be taken under the possible occurrence of seismic events of diverse magnitudes, it is proposed to develop an intelligent system [2] based on the knowledge of experts [7] in the seismic area, infrastructure and disaster prevention to train people in basic actions to be taken. In figure 2 can be seen the areas with worst earthquakes in Venezuela during the last century.

This proposal is based on the application of an expert systems, widely used in various scientific disciplines, and are reported to be excellent tools in the dissemination of information and training staff to act in certain situations [3, 4, 5, 6, 15, 16].

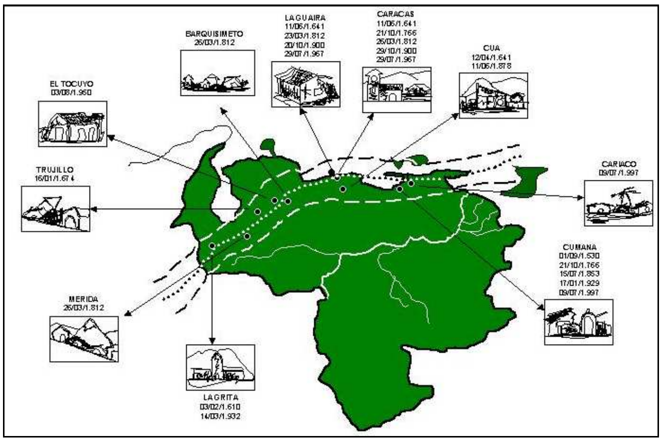

Fig 2. Historic seismic map of Venezuela
Source: http://victorgarciaprofe/blogspot.com

This paper is structured as follows: In section 2 it's presented the approach for studying the problem, the objectives and needs for the research. Section 3 presents the methodological framework for the development of expert systems. Section 4 describes the developed expert system design and section 5 contains the conclusions, recommendations and future work.

II. Problem Formulation

The implementation of an expert system as a tool for training and dissemination in disaster prevention, as in the case of the occurrence of a seismic event, is necessary, because it would provide an important aid to the population in general, directing how to respond or act upon the occurrence of a seismic event [7, 8, 9]. It may be noted also, that this system is relevant since its installation is based on web technology and the collected knowledge comes from experts in the field of earth movements, disaster prevention, medical and infrastructure aspects [10], among others.

With the implementation of this system it is expected to impact and sensitize society to the problems mentioned above, and expectations in the medium to long term point to the consolidation of a prevention system used by regional institutions for disaster prevention and citizenship care. On the other hand, expert systems as a computational tool, its knowledge can be updated over time and can be easily handled the system maintenance.

The scope of this system is large, because it's based on a web implementation that can be accessed by anyone with internet access, letting to construct a reference tool for people living in areas of high or lower seismic risk as a preventive tool.

It has been defined as general objective to create an Expert System for community support in situations related to seismic events (before, during and after) in Venezuela.

As specific objectives it has been defined:

- Collect the knowledge handled by experts in various areas related to prevention and emergency management at the occurrence of seismic events.
- Implement a web-based system to alert the population.
- Disseminate in the population the right steps to be taken in case of seismic events, creating customized plans for each user cases.

III. Expert System Methodology description

An Expert system (ES) is an Artificial Intelligence technique that uses the knowledge compiled in its program for solving complex or difficult problems that normally require human expertise [20]. They concentrate information given by a human expert for replacing him/her when is not available or when this knowledge is needed in diverse places simultaneously. ES imitates the reasoning process that experts use for solving specific problems, and can be used by non-experts in order to improve their problem-solving capabilities and by experts as a knowledgeable assistant [20].

Knowledge-Based systems are one of the most known artificial intelligence areas, which compile information about a particular subject and, if that information is given by a human expert, it is called Expert System. The process of knowledge acquisition and its suitable structuring is known as Knowledge Engineering.

The capabilities that ES have related to compiling information that human experts have concerning a particular field and since they could be able to replace this experts in case of absence, brought them to great interest for diverse areas including industrial environments where highly qualified knowledge can be required at any time.

The methodology used for developing the expert system arises from the integration of some others well-known methodologies of areas as Software Engineering and Knowledge-based Systems and is presented in [1]. It considers the computational nature of expert systems and is easy to follow because of it structure based on stages, steps and phases. The methodology description is presented next:

A. *Stage 1: Analysis and description of the problem:*

Step 1.1.- General description of the problem:

1.1.1.- Familiarization with the process selected for using an Expert System.

1.1.2.- Familiarization with the computational environment where are located the data that will be used by the expert system.

1.1.3.- Detailed definition of the problem to be solved using Expert Systems.

Step 1.2.- Feasibility analysis for developing the Expert System: In this step the conditions for developing the Expert Systems are verified considering:

1.2.1.- The problem to be solved requires of knowledge handle by an expert.

1.2.2.- Expert or team of experts availability

1.2.3.- The expertise is required in many places at the same time.

1.2.4.- The system requires uncertainty manipulation and personal criteria.

1.2.5.- There exist a potential users group.

1.2.6.- There is time for developing the expert system.

Step 1.3.- Data Analysis: Search for data location and representation format, considering database type and computational platform.

Step 1.4.- Knowledge source election: It is necessary that an expert or a team of expert want to help with the project. The users should consider as an expert the person to be used in the knowledge engineering process.

B. *Stage 2: Requirements specification:*

Step 2.1.- Information requirements: It is specified the kind of information that must give the Expert System as presentation format, direct users and interconnection with other programs.

Step 2.2.- Functional requirements: There are specified the general functions that the Expert System must satisfy.

Step 2.3.- Input data requirements:

2.3.1.- Selection of the possible inputs to be given to the Expert System.

2.3.2.- Data source identification.

2.3.3.- Specifications for Data acquisition process.

2.3.4.- Specification for Parameters generation processes.

2.3.5.- Databases interconnection required for implantation Stage.

Step 2.4.- Hardware and Software requirements for implanting the Expert System:

2.4.1.- Specification of the Hardware platform to be used for building and operating the Expert System.

2.4.2.- Software Analysis and selection: Verification of available computational tools for building Expert Systems.

Step 2.5.- Definitions of the final users for the Expert System.

Step 2.6.- Requirements verification with the users.

C. *Stage 3: Cost, time and resources analysis.*

Step 3.1.- Construction of development and implantation activities plan.

Step 3.2.- Estimation of the required time for building the Expert System.

Step 3.3.- Estimation of the hardware-software requirements for building the Expert System.

Step 3.4.- Cost estimation for building the Expert System.

D. *Stage 4: Knowledge Engineering*

Step 4.1.- Knowledge Acquisition: Is the most important part of an Expert System. It is when the Knowledge Engineer interacts with the expert(s) in order to obtain the information about the appropriate way for solving the problems. Also evaluates the strategies used for obtaining that solution.

Step 4.2.- Knowledge structuring: In this step, the knowledge engineer must organize in a Knowledge base the information given by the expert(s). The knowledge can be of superficial or deep nature depending of the intern structure and the interaction between its components.

E. Stage 5: Preliminary design of the Expert System

Step 5.1.- Preliminary design of the architecture for the Expert System.

Step 5.2.- Computational tool selection according to requirements that have appear in Knowledge Engineering Stage.

Step 5.3.- Preliminary design for data acquisition and storage processes.

Step 5.4.- Preliminary design for interconnection processes

5.4.1.- Intern Integration

5.4.2.- Extern Integration

5.4.3.- Auxiliary software selection

Step 5.5.- Verification of the Expert System preliminary design.

F. Stage 6: Expert System building and implantation

Step 6.1.- Prototype construction

Step 6.2.- Prototype validation

Step 6.3.- Operational model construction

Step 6.4.- Test and refinement: In this step, there are given some situations to the human expert and to the Expert System and it is verified if both give the same solution using the same strategies. If there exist any discordance between the human and the Expert System, it is review or modified the knowledge base.

Step 6.5.- Maintenance and actualization

IV. EXPERT SYSTEM FOR CUSTOMIZED ACTIONS TO BE TAKEN BEFORE, DURING AND AFTER A SEISMIC EVENT IN VENEZUELA

The developed system is a web-based application that allows its use by anyone who wants to know the actions to be taken at different stages associated with occurrences of seismic events (before, during and after).

The system is organized in three parts (see Fig. 3):

1. General Information: This part provides information on key definitions associated with earthquakes: Features, measuring scales, major seismic events, photo galleries, among others. It can be seen in Fig, 4, Fig. 5 and Fig. 6.
2. Advisory Panel: Provides a brief curricular description of the experts consulted by area. It is depicted in Fig. 7.
3. Determination of actions for seismic events. This is the main expert system developed. The idea is that given a particular situation presented by the user, the system provides the actions that should be taken before, during and after the seismic event according to those situations selected by the user. This part for being the most important of the system will be presented in detail next.

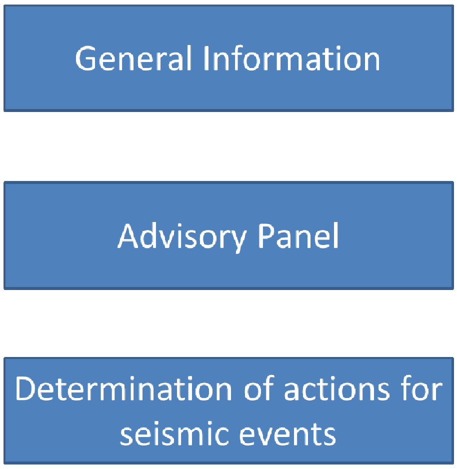

Fig. 3. Organization of the system

Fig. 4. Expert system General Information page

Fig. 5. Expert system General Information page

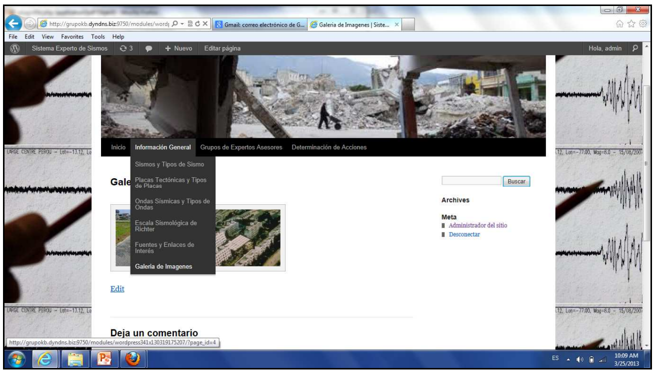

Fig. 6. Expert system General Information page

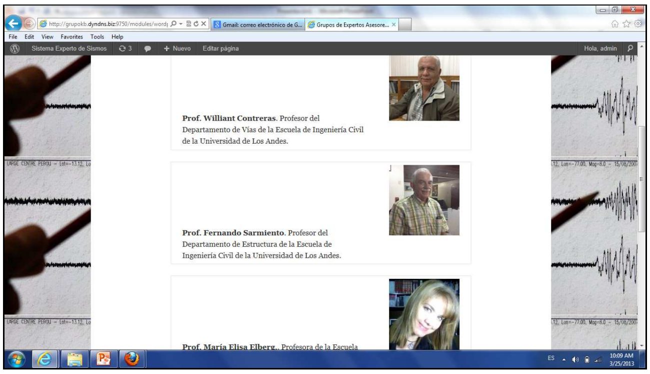

Fig. 7. Expert system Advisory Panel page

According to the information collected from the experts, in the "Determination of actions for seismic events" option, the user must select the place on which he wants to evaluate the actions. These places may be:

1. Home
2. School or Workplace
3. Crowded
4. Car
5. On the street
6. Buildings

The user should select only one of these options in each working session with the system, as can be seen in Fig. 8. Subsequently, if it is selected the options 1,2,3 and 6 (Home, School or Workplace, Crowded Places or Buildings) should be consulted if it is (see Fig. 9):

- A house or location below the second floor of a building.
- Location on an upper floor to the second floor of a building.

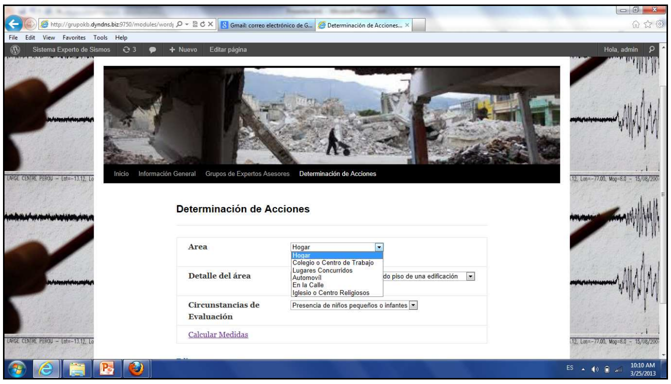

Fig. 8. Expert system place selection page

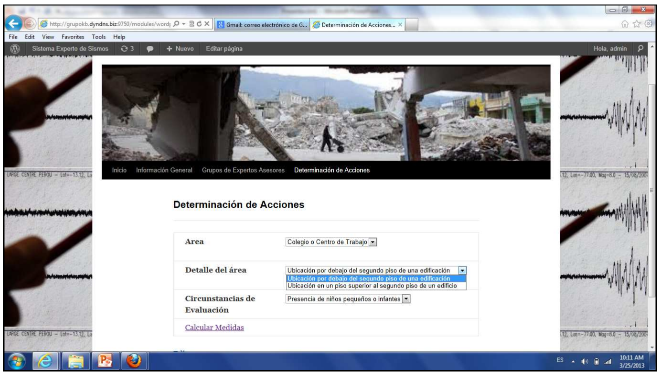

Fig. 9. Expert system details about place selection page

And finally it must be selected which of the following circumstances wish to be assessed:

- Presence of children and infants
- People with disabilities
- Elderly
- People with continuous medication
- Pets

In this case it can be selected one or more of these options (see Fig. 10).

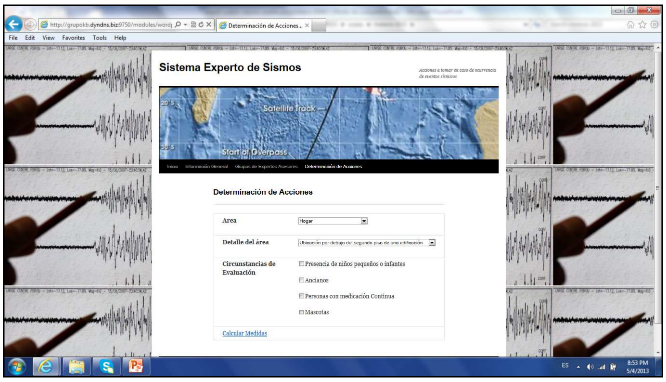

Fig. 10. Expert system particular circumstances page

Once the selection of the elements to be considered in the event of the occurrence of the seismic event is made, the system generates a page displaying the actions to be taken before, during and after seismic events. It can be seen in Fig. 11, Fig. 12 and Fig. 13.

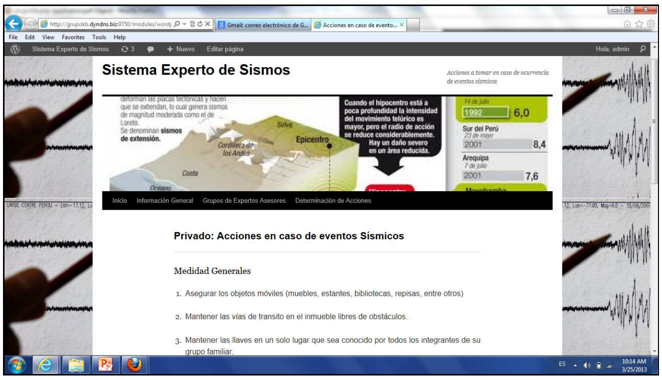

Fig. 11. Expert system particular circumstances page

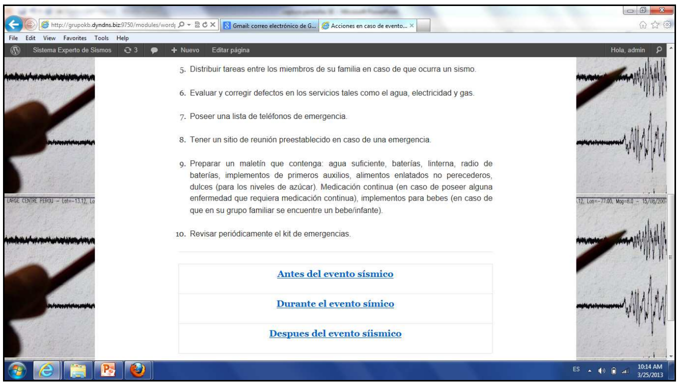

Fig. 12. Expert system particular circumstances page

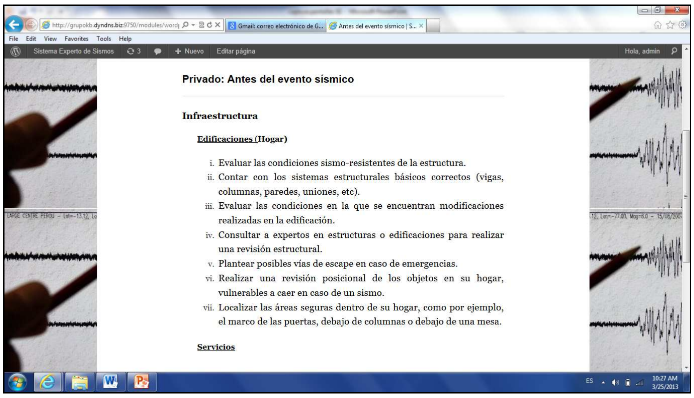

Fig. 13. Expert system particular circumstances page

In each of the stages (before, during and after) provides the following information than was generated with the knowledge obtained from the group of experts:

- General actions
- Infrastructure:
- Buildings
- Services
- Road
- Health
- Security

It includes links to figures, photos, videos, sounds or web pages.

It also features a "Recommended Plan" which indicates the actions implemented by the user to take action in the event of the occurrence of the seismic event. This plan is customized to the particular characteristics of the users and their families.

V. Conclusion

It has been designed and developed an Expert system for giving the actions to be taken before, during and after a seismic event could happen.

The use of experts with high experience (more than 25 years in average) in diverse areas related to seismic events as: geophysics, infrastructure engineers (electrical, structure, services, roads), medical doctors, firemen, rescuers, among others, gives an important knowledge to be disseminated to the community in order they can be aware to the actions that have to be taken in case a seismic event could occur.

The use of a web-based design let any person with internet access to use the system and to evaluate diverse situations that can be involved during a seismic event as the place the person could be located at that moment, the familiar conditions, among others.

This system is currently being evaluated by diverse organizations in order to be completed and to try to develop joint actions between institutions for coordinating plans in the case that a seismic event can occur.

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