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Dunas Intelligent System for Evaluation of Vulnerability and Management of the Coastal Dunes Systems

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ABSTRACT

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This paper presents the development of an intelligent system for the process of evaluation of the vulnerability and susceptibility levels of the frontal dune systems, as well as of its management. This system consists of a database, an expert system that makes the inferences about the database and a matching table where the inferences results are presented. The database was built for storing the parameters of five categories: dune morphology and location, beach conditions, features of 200 meters contiguous to the sea, pressure of use and recent protection precautions. The expert system interacts with the database to take a decision, and this decision is based on a proposal that uses the fuzzy logic and it needs to be tested and to be validated. Based on the results of the evaluation, the matching table was built, where the resultant indices of one determined beach can be compared with the results previously gotten by the system. Besides developing this system using concepts of the classic logic, a system in parallel was built using concepts of the fuzzy logic to try to justify better the results to the specialist's thought.

ADDITIONAL INDEX WORDS: *Artificial intelligence.*

INTRODUCTION

In the majority of the countries the coastal zone is being intensely occupied, mainly in the last decades. The uses and conflicts verified in this region are multiple, which only increase the environmental degradation of these sensitive areas of the planet. In world-wide level, the coastal regions shelter more than half of the populous contingent, this because they present enormous social and economic attractive, besides landscape and climatic This populous concentration in the fragile ecosystems that understand the littoral zone is compromising their natural features.

To not accelerate this process of shorelines occupation and its consequent environmental degradation, it is important to adopt strategies that aim to manage these important areas of the planet. The Environment Department, through the Territorial Environmental Management Program, is trying to define strategies to establish a management plan of the Brazilian maritime edge, called Edge Project. This project has as objective to promote the integrated management of the maritime edge, aiming at the bearing of its occupation and of the use of its environmental resources, considering the articulation among the sectors to the government level and these with the society. (BRASIL, 2000).

The important ecosystems found in the littoral regions can be preserved through some measures, however, are almost inexistent the forms of evaluating the levels of environmental compromise and/or vulnerability of these coastal ecosystems. BODÉRÉ *et al.* (1991) and WILLIAMS *et al.* (1993) defined an evaluation methodology of vulnerability levels of the dune fields for northwestern beaches of Europe, more specifically the United Kingdom and France. Later, this model was tested with positive results in Spain and Portugal. (ALVEIRINHO DIAS *et al.*, 1994).

In order to aid the vulnerability and management evaluation process of the dune fields in Santa Catarina coast, this paper proposes the development of an intelligent system based on experts systems from the vulnerability model proposed by BODÉRÉ *et al.* (1991) and WILLIAMS *et al.* (1993), where the definite parameters are classified in five categories: location and dune morphology; beach conditions; features of 200 meters contiguous to the sea; pressure of use and recent protection precautions. After the evaluation of each parameter that composes the checklist, the vulnerability index is calculated, which supplies the evaluation of the vulnerability and management of a specific dune field, intimately related to the fragility of the beach systems.

This intelligent system was developed using the Delphi tool, used in the database management, in the development of the expert system and the matching table. The database contains the general information of the area in study, as well as the data about each evaluation, with supplied scores and the indexes, besides the resultant evaluation. This secular accompaniment allows that the "decision makers" verify the evolution of the vulnerability and the management of the area in question.

The expert system has the function to cross the results of the scores and the vulnerability index in order to supply the evaluation of the area.

The final product of the present paper is the definition of an agile and simplified method for the evaluation of the susceptibility and fragility levels of the beach systems, that constitutes in a fundamental tool to the "decision makers" for the accomplishment of diagnostics about the coastal zones.

METHODS

The methodology followed for the development of the present project is based on the following aspects:

- Bibliographical Survey - study of the concepts of Artificial Intelligence, more specifically of Specialists Systems and what this technique involves, the Knowledge Acquisition and the Representation of the same thing. Moreover, study of the concepts related to the vulnerability and management of the coastal dune systems;
- Study of the problem to be investigated for the problem resolution of adequate form;
- Study of the Delphi tool for the creation of the database, the expert system and the comparison table;
- Study of the ergonomic criteria to generate a friendly interface, moreover, meetings with the person who orientates and the-person who co-orientates the project had been made so that this objective was reached by complete;
- Knowledge acquisition - this was made through interviews with the person who orientates the project for the construction of the knowledge base, being this the base that

"feeds" the expert system;Specification and implementation of the system:

- Database: after the study of the Delphi tool the database was constructed, being that the data to be stored had been acquired through the person who co-orientates;
- Expert System (ES): from the data stored in the database the expert system was made, that consisted in a proposal where ES uses the diffuse logic to present a solution. For this, aleatory rules had been chosen in order to generate the results that supply the dunes evaluation;
- Comparison Table: composed of an aerial photo of the beach (if available) and for one table that shows the segment name, the date of evaluation, IV/MP index and if the segment is in balance or not, allowing to the user a comparison with the gotten results previously;
- Validation and system test - the intelligent system of this project was tested and validated through the person who co-orientates, but the expert system is a proposal that must be validated and be tested.

RESULTS

This intelligent system presented to be simple and agile in the evaluation of the fragility and susceptibility levels of the beach systems, becoming a basic tool to the decision makers to verify the evolution of the vulnerability and management of the coastal dune systems.

The user makes use of a results screen that contains the punctuations gotten in each category, the calculated indexes that demonstrate if the dune system is in balance or not and two graphs that help it to understand better these results. These information are available quickly by the system. If they were gotten manually this would take much time, as well as all manual work. Soon, the developed system allows that the user takes his/her decisions with bigger rapidity, acting with more efficiency in the management of the Santa Catarina coast. Moreover, there is the comparison table and the comparative analysis (in graph form), important so that the user follows the evolution of these coastal systems.

Another important gotten result was the development of a friendly interface, through the study about ergonomics, several meetings and the changes of e-mails with the person who co-orientates and the person who orientates this project. This interface is presented of clear form, therefore being inexperienced, the user has the capacity to interact easily with the system.

DISCUSSION

The DUNAS, Intelligent System for Evaluation of the Vulnerability and Management of the Coastal Dune Systems, is an intelligent system based on specialists systems that has as objective aid in the evaluation procedures of the vulnerability and susceptibility of the coastal dune systems.

This system was developed using the Delphi tool, that was used in the construction of the database, the expert system and the comparison table. Therefore, no shell was used for the development of the Expert System

After this, an opening screen is presented an introductory screen of the system, describing the use of the same thing. Then, in the menu screen, the user makes use of options to interact with the system, a the Figure 1 shows.

The register of beaches features stores the general information of the same one, for example, location, climate, average width, length, type of wave, among others.

In this register, and in other register screens, the user has the possibility to consult definitive information, for example, to look for registered beaches in the system. Moreover, in the majority of the screens is possible to return to the beginning, so that the user can be situated when it is necessary. And still, in the majority of the screens is allowed their impression for better observation or comparison of results.

From this register screen there is still the option of report through a button. Pressuring this button, the screen of

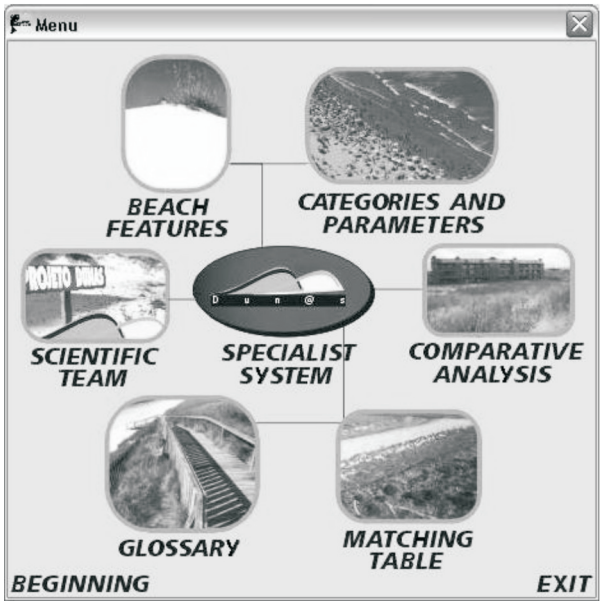

Figure 1. Menu Screen .

Beach Report will appear with all the information registered in relation to the same thing. Another report found in the system is the Results Report generated from the Results screen, that contains the calculated indexes.

After registering the segment of a beach, categories register is necessary in order to get the resultant evaluation. This can be done through the register screen of the segments and categories. These categories are divided in five and they understand the dune morphology and location, beach conditions, features of 200 meters contiguous to the sea, pressure of use and recent protection precautions.

From the information registered in the register screens of the categories, the IV/MP index is calculated. Through this index the system stability is verified, being that the same thing will be in balance when the index to result between 0,8 and 1,3. If the index is below of this interval, this means a positive inbalance and if the index is above of this interval, the system is in negative inbalance. Figure 2 shows the results screen with the generated graphs, also, from the registered information.

The Comparison Table contains an aerial photo of the beach (if available) and one comparison table, that allows the comparison between the calculated indexes (previously for the system) of the segments of the one determined beach. The Comparative Analysis also allows this comparison, but IV/MP indexes are presented in graph form, where the indexes of the last twenty evaluations of one determined segment are shown.

In the Glossary the user finds the explanation of the words used in this work in Oceanography area.

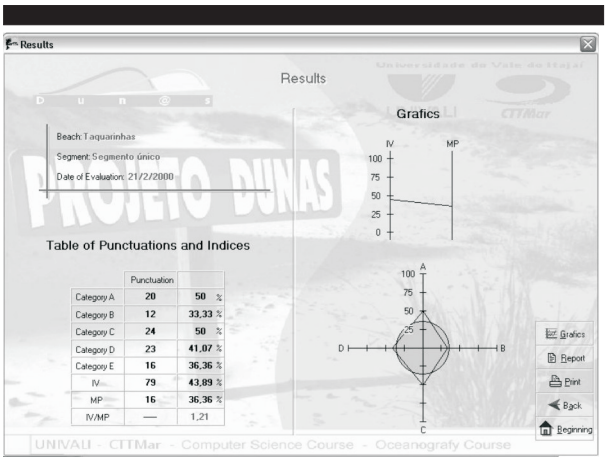

Figure 2. Results Screen .

Table 1. *Relevancy Fundactions.*

Linguistic variable	Relevancy Function
0	$\mu(x) = 1$, se $x = 0$
	$\mu(x) = -1/2x + 1$, se $0 < x < 2$
	$\mu(x) = x \;\; 1$, se $1 < x \;\; 2$
2	$\mu(x) = 1$, se $x = 2$
	$\mu(x) = -x + 3$, se $2 < x \; 3$
	$\mu(x) = 1/2x \; 1$, se $2 < x \;\; 4$
4	$\mu(x) = 1$, se $x = 4$
	$\mu(x) = -x + 5$, se $4 < x < 5$
Not applicable	$\mu(x) = 1$, se $x > 4$

With relation to the expert system, a proposal was done where the same thing would use the diffuse logic "to make a decision". Thus, the modification in the register way of the categories was necessary.

The rules used in the Expert System are about the parameters combination of each category. As this combination would generate many rules, some of them were selected, classifying them in excellent, good, average, bad or very bad. Then, the relevancy functions had been made (Table 1), where the linguistic variable available in this table (0, 2, 4 and not applicable) represent the true linguistic variable of each parameter. For example, the linguistic variables of the parameter called Ortogonal Migration Field are small, average and big; while the parameter called Arenaceous Suppliment Entrance are high, moderate and low. Moreover, all the parameters can be not applicable to the determined beach.

Another important point to be considered, is that the diffuse logic is only used in the not numerical variable.

From this, combinations with the classification of each category had been made. Some rules were chosen again, because they were still many. Of this combination a result considered excellent, good, average, bad or very bad was generated. The chosen rules must be the best ones to represent the current model, but they had not been tested and validated because of the little availability of time presented for the expert.

After the parameters of each category was registered, the user will be able to have access the screen of the Expert System. In this screen the user selects the beach, the segment and the evaluation date, pressures the "Evaluation" button and the system presents the result according to its "decision making".

CONCLUSIONS

The main objective of this project was the development of an intelligent system based on expert systems that aid in the evaluation procedures of the vulnerability and susceptibility of the coastal dune systems.

The referring stage to the intelligent system was concluded successfully, counting on a database that stores the parameters of the five categories, with IV/MPindex that can show the evolution of the dune system through the time and with the graphs that help the user to verify if the system is in balance or not. Moreover, this stage was tested and validated through the person who co-orientates this project.

The matching table is composed of an aerial photo of the beach to be consulted (if available) and one table that possesss the name of the segment, the evaluation date, IV/MP index and a field informing if the segment is in balance or not. This table allows the comparison of the results gotten for the system previously.

With relation to the expert system, a proposal was done where the same thing would use the diffuse logic "to make a decision". This proposal was implemented, but it could not be tested and be validated due to little availability of time presented for the expert to conclude this stage. Therefore, the expert system must be tested and be validated, because it will be of great utility for the coastal administrators.

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