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Gustavo Arroyo-Figueroa
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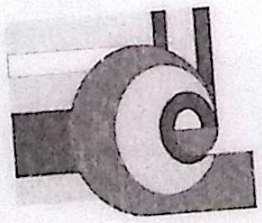

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Gustavo Arroyo Figueroa

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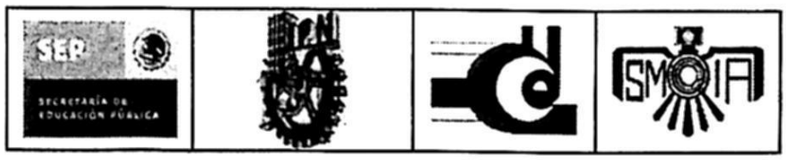

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Investigación en Computación (CIC) Av. Juan de Dios
Bátiz s/n esq. M. Othón de Mendizábal Unidad
Profesional "Adolfo López Mateos", Zacatenco 07738,
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Preface

Artificial Intelligence is a branch of Science which deals with helping machines find solutions to real complex problems in a more human-like fashion. This generally involves borrowing characteristics from human intelligence, and applying them as algorithms in a computer friendly way. Over the past five decades, AI research has mostly been focusing on solving real problems. Numerous solutions for real applications have been devised and improved to do so efficiently and reliably.

This volume presents 23 original research papers selected alter careful review process by the Editorial Board and comprehends a sample of the Artificial Intelligence applications conducted in Mexico.

The volume is divided into four areas of application of artificial intelligence that have recently attracted the attention of the research community and are characterized as areas where artificial intelligence can potentially have a major contribution.

Industrial applications
Social applications
Educational applications
Computer security applications

The academic and editorial effort resulting in this volume was carried out in collaboration with, and was supported by, the Mexican Society of Artificial Intelligence (SMIA). We cordially thank all people involved in its preparation. In the first place these are the authors of the papers constituting it: it is the excellence of their research work that gives sense to the work of all other people involved. We thank the members of the Board of Directors of SMIA, especially to Carlos Alberto Reyes, Raúl Monroy, Grigori Sidorov, Arturo Hernández Aguirre and Alexander Gelbukh. Our very special thanks go to Chairs of MICAI Workshops: Alberto Ochoa, Fernando Montes, Claudia Gómez, Lucía Morales, Raúl Monroy, Erika Sánchez, Carlos Max, Ramón Zantarain, Lucía Barrón, Yasmín Hernández, and also to the members of program committee and additional referees. We express our gratitude to Humberto Sossa Azuela for their significant contribution at various stages of preparation of the volume. We would like to express our sincere gratitude to the Universidad Autónoma del Estado de Hidalgo, in special to the Local Chairs Felix Castro and Joel Suárez for their valuable collaboration. Special thanks to Blanca Miranda, Luis Arturo Domínguez, Jonathan Espinoza and all other people involved in the preparation of the volume. The submission, reviewing, and selection process was supported for free by the EasyChair system, www.EasyChair.org.

Gustavo Arroyo-Figueroa

November 2010

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Artificial Intelligence Industrial Applications I

Evolving a heterogeneous foraging robot task

Fernando M. Montes González, Fernando Aldana Franco, Luis Felipe Marín Urías, and Homero Vladimir Ríos Figueroa.

Facultad de Física e Inteligencia Artificial, Universidad Veracruzana
Sebastián Camacho No. 5, Centro, Xalapa, Ver., México
fmontes@uv.mx, fernando_aldana_franco@hotmail.com
(Paper received on August 30, 2010, accepted on October 20, 2010)

Abstract. In this paper we develop an environmental setup for experimenting with both the e-puck and the Khepera robot platforms. We have used the evolutionary robotics approach to develop a foraging task where the robot approaches food and avoids poisonous food. The use of the EvoRobot* simulator facilitates the implementation of lights as poisonous food and cylinders as healthy food. Later on, the robustness of the Neural Network is tested using the evolved controller in the Khepera robot.

Keywords: Mobile Robots, Evolutionary Robotics, Genetic Algorithms.

1 Introduction

The Evolutionary Robotics (ER) approach commonly relies on the implementation of an evolvable robot controller which produces the fittest individuals after several simulator interactions. In general an average population to be evaluated forms the elementary building blocks [1] that will serve as the necessary leverage to increment the overall fitness population. Parameter interactions in the implementation of a robot controller epistatically increment the chances to find near-optimal solutions. Most of the times a single objective evaluation function is employed in ER due to the fact that the resultant robot behavior comes from a dynamic system made with the robot and its environment [2]. However, in evolutionary computation is possible to simultaneously optimize several objectives without aggregating them as a single monolithic fitness function [3]. Recent research relies on the concept of domination and generates the so-called Pareto front to bootstrapping a light-seeking robot behavior [4]. Here we use a single objective function to reward the performance of global behavior; thus we start by designing a foraging robot task. Section 2 introduces some necessary background on genetic algorithms for the development of the experiments below described. In Section 3 we present the evorobot simulator used for our experiments. Then, in section 4 we explain the implementation of the foraging task for the e-puck and the Khepera robots. Next, section 5 presents the results of setting up a robot in a foraging task with non-homogenous food. Finally, in section 6 we provide a general discussion highlighting the importance of our work.

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2 The use of Evolution in Robotics

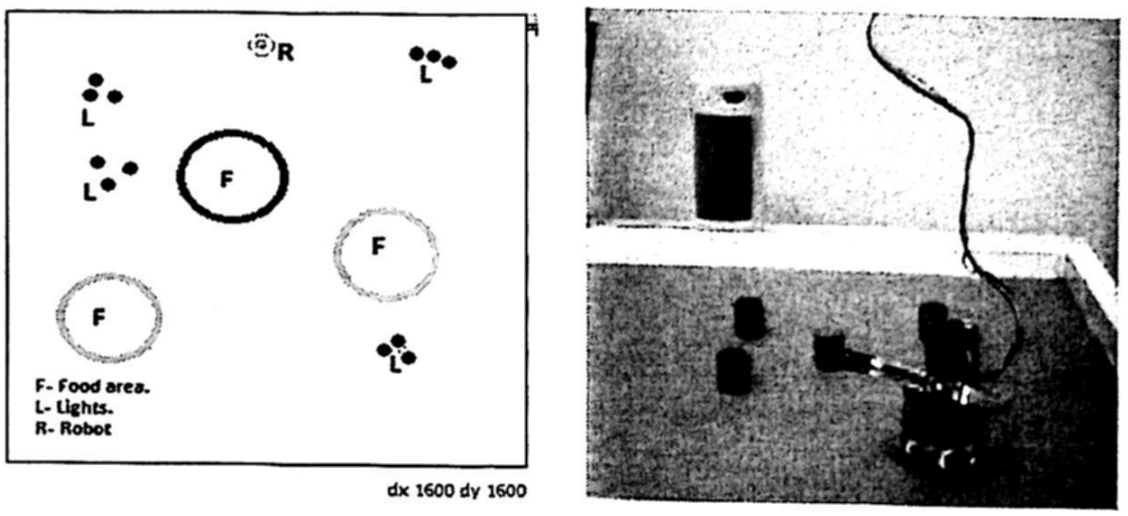
The use of evolutionary techniques for the development of robot control systems commonly relies on the use of neural networks [5]. Therefore, a population of robot controllers is encoded into phenotypic representations, and then three operators known as reproduction, crossover and mutation, are applied to the population in order to produce a new offspring. The decoding of every genotype into individual phenotypes aids the evaluation of a new offspring by allowing each individual to live for a limited period of time. This process is repeated until a satisfactory evaluation level is obtained. In robotics we can shape behavior with high-quality results using a gradient descent computational method known as Genetic Algorithms (GAs) [6]. In order to find a solution within a search space a set of biologically inspired operators are applied to move across a convoluted landscape. This surface is the result of measuring over an evolutionary timescale an entire population of all possible individual fitness. Hence, search in the fitness landscape is guided by the definition of ecosystems where the species in evolution will interact, in particular by the definition of their own fitness [7]. Therefore the set of points in the landscape is the result of applying an evaluation function to each possible member on the entire population during simulated evolution; as a consequence individuals are rewarded according to their own performance when resolving a specific task.

The fitness of an individual together with the operator's reproduction, crossover and mutation spawn a new generation which corresponds to a specific point in the landscape. Whether this point is closer to the optimal fitness depends on the degree of fitness of the individual. The more fitted is the individual the closer the search is to find an optimal solution. In order to acknowledge the fitness of a population, each individual has to be evaluated during its own lifespan while developing the abilities to solve a particular task. Next, a specialized representation of the robot controller, to be tested, is coded into chromosomes where each locus (or position) takes a finite possible value (allele). This representation is the genotype from where the phenotype will be derived. Often the genotype directly codes into the phenotype; however sometimes an elaborated translation is needed. Initially, a population of random controllers is spawned, and then three GA operators are applied.

3 The Evorobot Simulator

EvoRobot* is a software simulator [8] developed by Stefano Nolfi and Onofrio Gigliotta at the Laboratory of Artificial Life and Robotics (ISTC-CNR) in Rome Italy. This robot simulator is a powerful tool for experimenting with the e-puck and the Khepera robots. Additionally, it allows the simulation of individual and collective tasks. This software employs neuronal networks for robot control and genetic algorithms for the optimization of proposed behavior. In order to run the experiments is necessary to configure parameters related to the definition of the simulated world where the robot is to be set. Some of these parameters define: the number, size and position of surrounding walls; number, position and size of food-zones; position and

number of lights; and also the number and position of related landmarks. On the other hand, the characteristics of the simulated robot are defined with parameters for various sensors, topology of the neuronal controller, lifetime of the robot, the fitness function and also parameters for the genetic algorithm. Once these parameters are set evorobot tests several robo-controllers using evolution. The weights of the neuronal network on each individual are modified according to an already defined fitness function. Therefore, evolution shapes behavior by analyzing the fitness of both the best individuals and the average of all the individuals on the currently generated population. The final fitness was defined using an incremental approach; thus the simulator had to be recompiled every time the fitness function was modified. Finally, is possible to add new sensors by modifying the open source code of evorobot.



a) b)

Fig. 1. *a) The setup of the simulated e-puck robot: 3 healthy food zones (F circles), poisonous food as 4 sets of lights (L circles) and 4 walls (squared environment); b) The Khepera setup scenario with poisonous food represented as colored wooden cylinders and a recharging station as healthy food.*

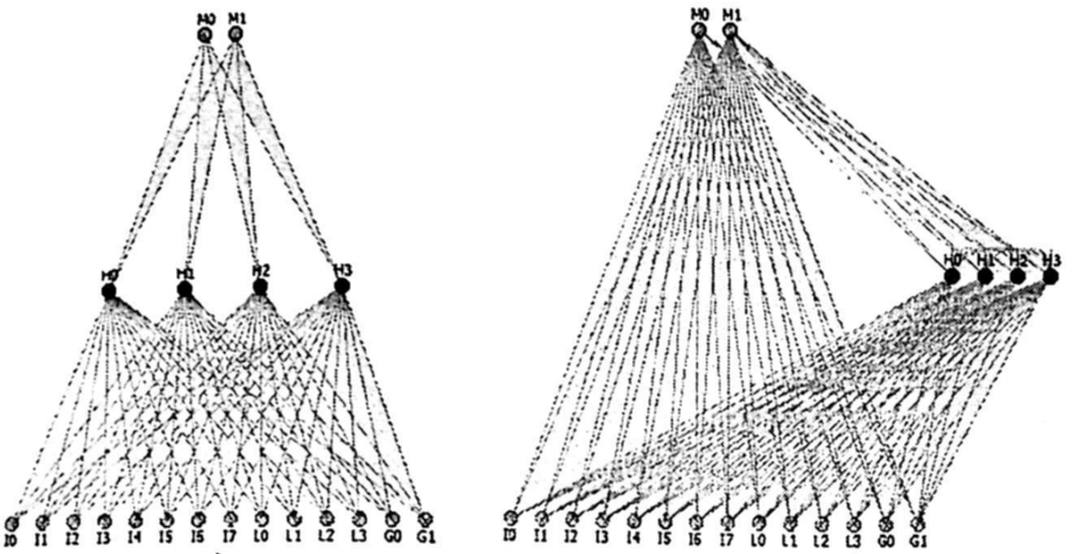
4 Robotics Experimental Setup

We have defined a general scenario for our experiments with small variations for testing evolved neuro-controllers in either simulated or real robots. In both cases the testing arena is defined as a squared area. As for the environmental setup in the simulator, available in the world area there are four sets of three lights (poisonous food) and three zones of healthy food (see figure 1-a). On the other hand, in the real world scenario healthy food is recognized using colored tags adhered onto different objects. Poisonous food is implemented as paper colored wooden-cylinders and red leds (light emisor diodes) attached on top of non-colored cylinders; all them scattered around the arena (see figure 1-b). Thus, we use two different kinds of unhealthy food to test the Khepera under different color variations. Next, fitness was implemented

rewarding those individuals that avoid cylinders and lights approaching nearby food zones.

$$f = \sum_{i=0}^{1000}(\text{abs}(m_l + m_r)(1 - \sqrt{m_l + m_r})(1 - maxir_i)) - 0.5 \cdot maxls_i + 0.25 \cdot food\_zone\_on_i \quad (1)$$

where for iteration i: m_l and m_r respectively are left and right motor speeds, $maxir_i$ is the highest infrared value. The highest light sensor value is $maxls_i$ and $food\_zone\_on$ takes a binary value depending on the detection of available food.



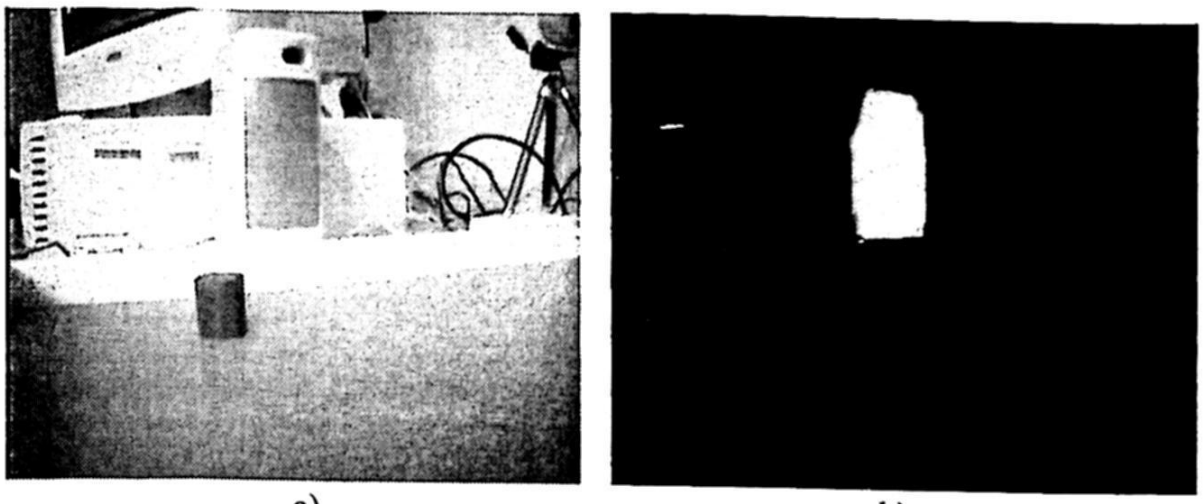
a) b)

Fig. 2. a) Neuronal network for controlling the robot with 8 infrared sensors, 4 light sensors and 2 ground sensors; one hidden layer with 4 neurons and 2 neurons in the output layer (corresponding to the motors of the robot); b) Neuronal network with 8 infrared sensors, 4 light sensors, 2 ground sensors; a hidden layer with 4 neurons; 2 neurons in output layer. Also we added recurrent connections in the middle layer and direct connections between the input and output layers.

The configuration of the neuronal network is as follows. In total the input layer has twelve neurons that correspond to each of the employed sensors (eight infrared sensors, two ground sensors for finding different available food and four light sensors). The hidden layer has four neurons while the output layer has two neurons that represent the robot motors (see figure 2-a). In addition to the above described controller, we evolved a different neuronal network with the same number of neurons for all the layers, but in this case using recurrent connection at the hidden layer and connections between the input and output layers (see figure 2-b). In order to test the non-recurrent neuro-controller on the real robot platform, we export the evolved neural network with its weights into a text format. Thus, in Matlab we re-implemented the neural network to control and process in the Khepera the available infrared, led, and visual information. Next, a standard RS232 interface was used to connect the robot to the computer host. The foraging task for the Khepera robot was

set in an arena for running the experiments in a similar fashion to that of Montes-González, et al. [10].

Next, poisonous 'food' was set using wooden cylinders, which were set around the arena. The infrared inputs of the neural networks were taken directly from the Khepera robot. Additionally, red lights simulated poisonous food and the infrared sensors were used for detecting this kind of food. Though, different nodes at the input layer of the neural network were used. Therefore, the infrared sensors, in the ring around the robot body, were used to avoid both kinds of poisonous food. Food areas were simulated as three recharging stations using green or blue colored paper glued in front of external computer speakers. The different inputs of the ground sensors of the neural network were used to determine that a specific colored recharging battery is either located in the image taken from the Khepera robot. Therefore, cylinders of food were treated as obstacles sensed by the infrared sensors, lights as poisonous food that had to be avoided, and healthy food were the recharging stations detected using color segmentation.



a) b)

Fig. 3. *a) A real image acquired from the Khepera robot camera. Healthy food isidentified by the green tag glued onto the speaker; b) Object recognition using color segmentation is shown in green.*

The use of visual information from the camera is extremely rich, and needs to be extracted from images taken on-the-fly. A major problem in dealing with visual information is related to illumination changing conditions. A simple way to achieve chromaticity invariance [11], with respect to illumination changes, relies on the conversion of the RGB space into a normalized color space (rgb).

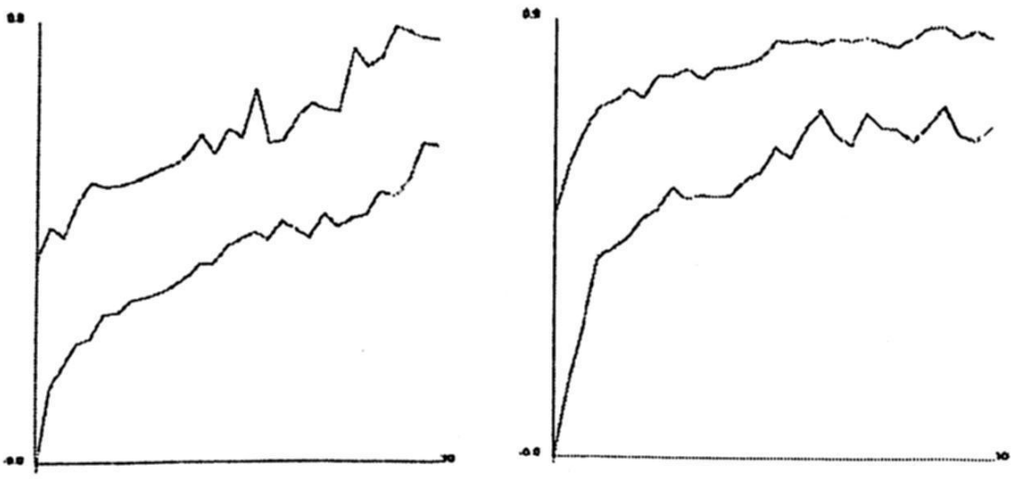
$$r = R/(R+G+B)\ ,\ g = G/(R+G+B)\ ,b = B/(R+G+B) \qquad (2)$$

As suggested in [12], this approach can be interpreted as obtaining a simple form of color constancy under various illuminating conditions while preserving directional information of the color vector. The colored object of interest is characterized by its chromaticity, in the normalized color space, using a statistical color distribution. We assume that previously similar objects have already been learned, and that the

distributions are Gaussians. Then, we use a statistical band-pass filter for the colored object. Figure 3 shows color segmentation for nutritious food.

5 Results

The evolution of two kinds of neuro-controllers was carried out. Evolution was stopped after 30 generations (figure 4). The evaluation of evolved individuals in each generation was carried out after five trials of the best individuals and five trials of random individuals. As a consequence various different aspects were evaluated for the experiments: type of movement, avoiding collisions, finding food zones and the avoidance of lights (see tables 1 and 2).



a) b)

Fig. 4. a) Evolution after 30 generations of a non-recurrent neuro-controller. The upper curve shows the best individual in each generation and the lower curve shows the average individual fitness; b) The fitness for the evolution of a retro-connected neural network after 30 generations. The upper curve shows the best individual and the lower curve shows average individuals in the population.

Summarizing, we observe that after the evolution has been stopped a neuro-controller without recurrent connections is able to complete its main goal slower than a neuro-controller with recurrent connections. The evolution of non-recurrent neuro-controllers presents variations in the fitness affecting detection and hence avoidance of lights. On the other hand, recurrent neuro-controllers evolve at a regular pace during initial generations presenting a non-decreasing fitness functions (see figure 4). In general, the more stable reactive non-recurrent controller takes more generations to find a better solution. On the contrary, the recurrent controller finds a solution after few generations and is less reactive to locate objects [9].

Table 1. The behavior of the no-recurrent neuro-controller is decomposed into elementary actions. After generation 10^{th} the overall behavior of the robot is irregular when avoiding obstacles; but is able to finding food areas, avoiding lights, and moving forward.

Generation	Movement	Avoiding collisions	Finding food areas	Avoiding lights	Generation	Movement	Avoiding collisions	Finding food areas	Avoiding lights
0	Backward	No	Yes	No	15	Forward	Yes	Yes	Yes
1	Circular	No	Yes	No	16	Forward	Yes	Yes	Yes
2	Elliptical	No	Yes	No	17	Forward	Yes	Yes	Yes
3	Elliptical	Sometimes	Yes	No	18	Forward	No	Yes	Yes
4	Circular	Yes	Yes	No	19	Forward	Yes	Yes	Yes
5	Spiral	Yes	Yes	No	20	Forward	Yes	Yes	Yes
6	Spiral	Yes	Yes	No	21	Forward	No	Yes	Yes
7	Forward	Yes	Yes	Sometimes	22	Forward	Yes	Yes	Yes
8	Forward	Yes	Yes	Sometimes	23	Forward	Yes	Yes	Yes
9	Forward	No	Yes	Sometimes	24	Forward	Yes	Yes	Yes
10	Forward	Yes	Yes	Yes	25	Forward	Yes	Yes	Yes
11	Forward	Yes	Yes	Yes	26	Forward	No	Yes	Yes
12	Forward	Yes	Yes	Yes	27	Forward	Yes	Yes	Yes
13	Forward	Yes	Yes	Sometimes	28	Forward	Yes	Yes	Yes
14	Circular	Yes	Yes	Yes	29	Forward	Yes	Yes	Yes

Table 2. *The table summarizes the elementary actions on robot behavior during the evolution of a recurrent neuro-controller. After third generation, individuals complete the foraging task: avoiding obstacles and lights, finding food areas, and moving forward.*

Generation	Movement	Avoiding collisions	Finding food areas	Avoiding lights	Generation	Movement	Avoiding collisions	Finding food areas	Avoiding lights
0	Backward	No	Yes	No	15	Forward	Yes	Yes	Yes
1	Circular	Yes	Yes	No	16	Forward	Yes	Yes	Yes
2	Spiral	Yes	Yes	No	17	Forward	Yes	Yes	Yes
3	Forward	Yes	Yes	Yes	18	Forward	Yes	Yes	Yes
4	Forward	Yes	Yes	Yes	19	Forward	Yes	Yes	Yes
5	Forward	Yes	Yes	Yes	20	Forward	Yes	Yes	Yes
6	Forward	Yes	Yes	Yes	21	Forward	Yes	Yes	Yes
7	Forward	Yes	Yes	Yes	22	Forward	Yes	Yes	Yes
8	Forward	Yes	Yes	Yes	23	Forward	Yes	Yes	Yes
9	Forward	Yes	Yes	Yes	24	Forward	Yes	Yes	Yes
10	Forward	Yes	Yes	Yes	25	Forward	Yes	Yes	Yes
11	Forward	Yes	Yes	Yes	26	Forward	Yes	Yes	Yes
12	Forward	Yes	Yes	Yes	27	Forward	Yes	Yes	Yes
13	Circular	Yes	Yes	Yes	28	Forward	Yes	Yes	Yes
14	Forward	Yes	Yes	Yes	29	Forward	Yes	Yes	Yes

6 Discussion

In this paper we have shown a foraging robot task with non-homogenous food optimized by the use of genetic algorithms. The same evolved neural network was used to control both a simulated e-puck and a real Khepera robot. At the two different robot scenarios robots complete the task of approaching healthy food and avoiding poisonous food. In future experiments we intend to allow a predator co-exist with the foraging robot. Therefore, we expect to combine the use of the real e-puck and Khepera robots. Finally, we plan to further extend the "copy-lefted" evorobot simulator.

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Graphic representation of the competitiveness model developed under a fuzzy characterization.

Darwin Young[1], Pedro Pérez[1], Alberto Ochoa[2], and Jöns Sanchez[3]

[1]Corporación Mexicana de Investigación en Materiales,
[2]Universidad Autónoma de Ciudad Juárez
[3]Centro de Innovación Aplicada en Tecnologías Competitivas, León
Guanajuato, México
megamax8@hotmail.com, dyoung@comimsa.com, pperez@comimsa.com
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Abstract. Currently it is extremely important for businesses to identify their strengths and weaknesses in the presence of competitors and open global markets; for which, there is interest in determining the level of competitiveness that companies can achieve and how define and prioritize the improvement actions for the sustained growth. This paper presents the development and use of graphical representations for the implementation of competitiveness model that generate the strategic profile of a company that considers qualitative variables under a fuzzy approach with the application of modified triangular membership functions. This is the continuation of a research project involving the development of a competitive model for the diagnosis and prediction, and whose future researches consider evolution strategies for optimization and contrast with the field data.

Keywords: Competitiveness, fuzzy variables, graphic representation, quantitative variables.

1 Introduction

The interest in determining the competitiveness of businesses has generated numerous researches that are focused on different groups of variables. Some variables examine the strategic management of information for acquiring a competitive advantage in order to maintain flexibility and business innovation [1]. Emphasizes the creation and sustenance of knowledge from internal and external business environment, rather than intervening directly to the operational characteristics of the company. Given that information and its management are necessary to provide a competitive advantage, business strategy focuses on knowledge management tools and methods. As suggested in [2], the dynamics and distribution of knowledge and skills can result in a competitive advantage.

During the first part of this investigation, the process to define the variables used to determine the overall indicator of competitiveness is under triangulation of data

obtained from different companies to identify those factors that include the main functions of operation and administration. Qualitative variables are treated under the definition of fuzzy variables that are correlated to a self-assessment system used within a group of participating companies [3].
The model generates a functional analysis that identifies and describes the key variables that are specified on the strengths and weaknesses of the company, developing a strategic operating profile, which has as main objective, assess the potential of the company in each of the key variables, so as to make more clear their activities should be concentrated where the actions and strategies to achieve a sustainable improvement of key aspects of the company to reach a level of world-class company [3].

The problem faced during the implementation of the model is the lack of knowledge or expertise that makes it inoperable the use of graphics fuzzy variables and multivariate analysis graphs by operators or employees of companies, which causes the model's potential is limited for use and decision making. Therefore, the objective of this paper is to show the development process to match the graphics of the model to the understanding of company personnel.

The paper is organized as follows. Section 2 presents the proposed methodology to define the kind of graphics use by the model. Section 3 describes the general outline of the competitiveness model and its overall efficiency index. Section 4 presents the definition of graphical representations. Section 5 shows the results obtained by applying the evaluation model to various companies participating in the study. Section 6 presents conclusions and future work.

2 Methodology

The results and information obtained from any investigation usually must be displayed in graphical form to improve understanding of these results; otherwise, there is the problem of abandoning those models. The best type of graph is one that conveys the message most effectively. It can be a complex or simple graphics, lines, points or segments of a circle, even a combination of various types, and many more types of graphics are observed and tested, you can choose the most appropriate type for your purpose. If you select the most effective type of graph, the data will be clearer, solid and generate support for decision making.

With the use of graphics can identify possible correlations between data, even find hidden relationships between them, which then could be accompanied and tested using statistical techniques. It is important to note that graphical representations are often neglected by its apparent simplicity with other techniques, they take relevance to an audience that does not have knowledge of the subject, and it can support its conclusions to work with appropriate graphics. In fact, there are complex multivariate analysis techniques such as multidimensional scaling or self-organized neural maps, whose final product is a graph or set of them.

A chart can analyze and report information of any kind of process commercial, financial and operational, where understanding of the graph may exceed the use of tables, yet they have not been given much importance to identify which should be the ideal type of graph, to show evidence of an analysis, because the designer usually develops, the graph according to their academic level, but rarely tries to identify if the graph is understood by the target audience.

On this basis, the process of identification of graphic representations for the competitive model is developed under the following steps:

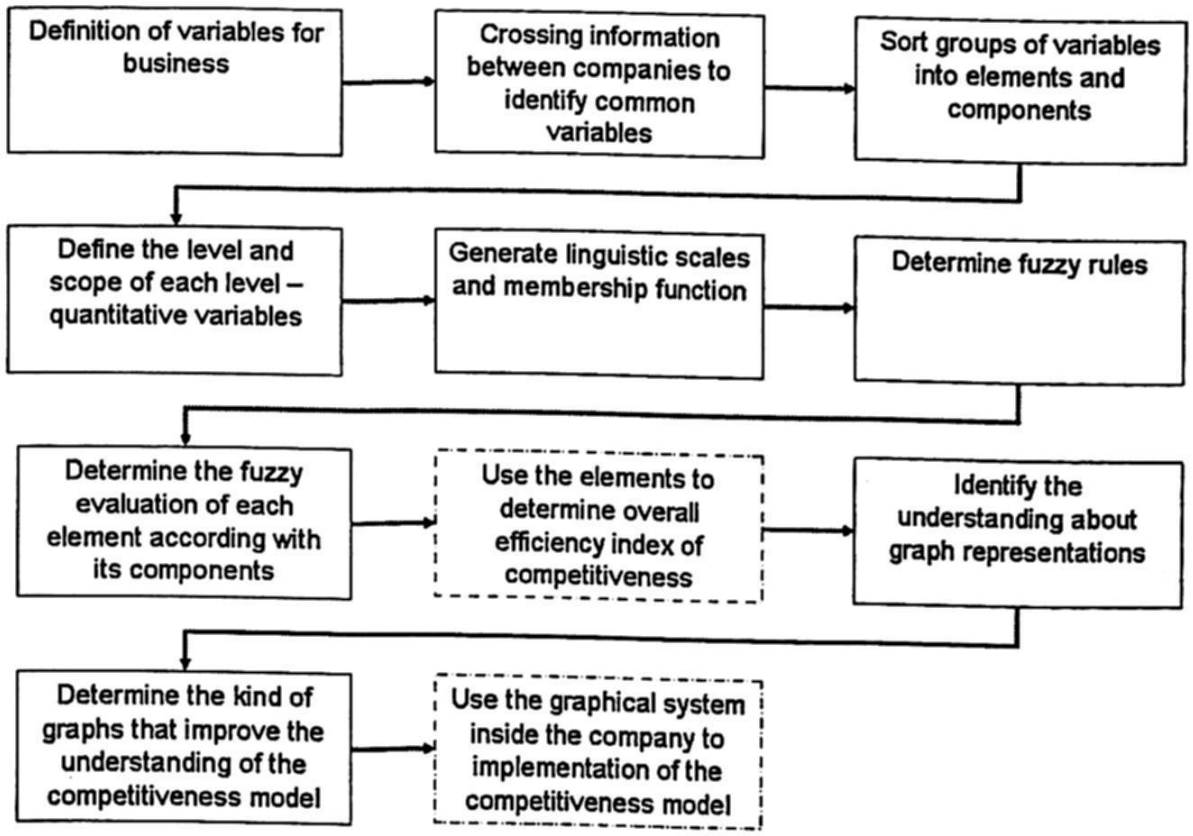


Fig. 1. *Process to determine the graphical system of the competitiveness model (Flow down).*

The importance of this process is to identify the influence of the shape of the graphics on the perception that analysts have on the competitive model information for decision making, planning of activities and strategies.

3 Competitiveness Model

Each element is represented by a fuzzy variable, under a scale of 1 to 10. And that group of components in each element determines the fuzzy set of entries in a scale of 1 to 10, rescale it to a table of values of 5 levels, under the following relationship. In

figure 2, the first component of the element "Leadership and Commitment" is transformed in a set of equivalent membership functions.

1.0 Leadership and Commitment					
	Levels				
Component	1	2	3	4	5
1.1 Deployment of competitive systems	Competitiveness system is known by the management team of the Business. The organization has not conducted its assessment of their position in the competitive model	Self-evaluation of competitive system was conducted but have not communicated the results to all levels of employees. It defines the elements that are the business priorities. The competitive system has been disseminated at the level of managers, supervisors and department heads.	The system has been released to the supervisor level and facilitators. The results of the self-assessment have been communicated to all employees. It has set targets for profitability and targets for all indicators of the business scorecard. (BSC) The staff employee has been informed of the goals to achieve in these indicators. There are specific plans and projects, as defined by the Self Assessment.	It has spread the competitive system to all workers with the use of different media, in simplified form, they know the system and how they participate in their work areas. Employees and operators understand the actions of the system of competitiveness and they are aware of how they participate in achieving the goals of the indicators that they are involved.	There is a clear understanding of how outcomes are linked workspace with the results of the overall efficiency index of competitiveness and Balanced Scorecard indicators (BSC). All employees know the goals to achieve, progress and action plans to address the priorities found in the self-assessments and participate in continuous improvement projects through work-teams.

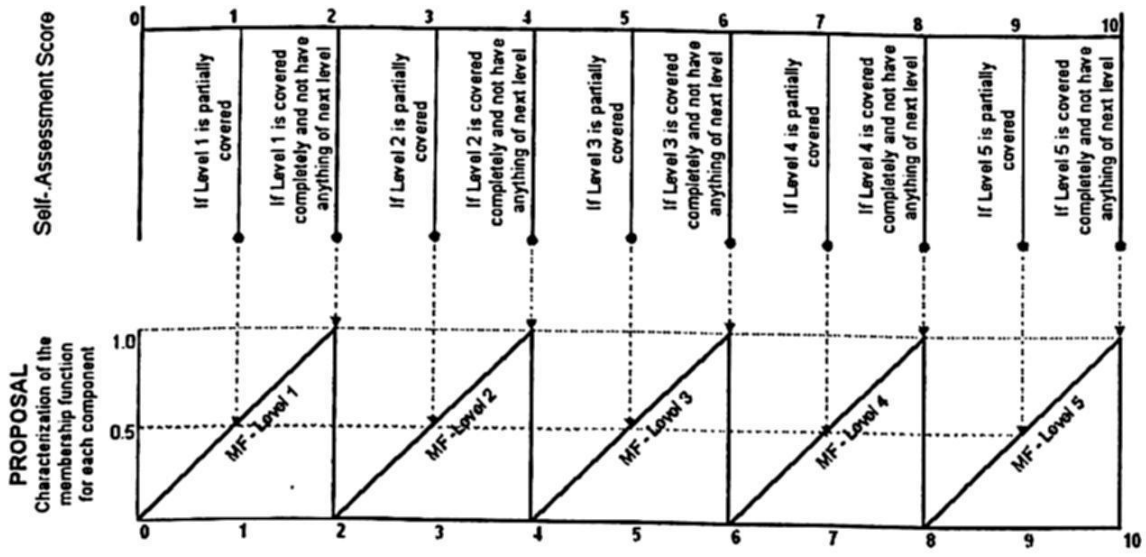


Fig. 2. *Relationship between the qualitative variable and Membership Function for a component.*

Each component is scored individually using a scale of 1-10. Two possible ratings for each of the 5 semantic levels. That is, grades 1 - 2 to level 1, grades 3 - 4 for level 2, grades 5 - 6 for Level 3, grades 7 - 8 for level 4 and 9 - 10 for level 5.

Level 1: 1 If it is partially covered, 2 It is covered completely and not have anything of next level
Level 2: 3 If it is partially covered, 4 It is covered completely and not have anything of next level
Level 3: 5 If it is partially covered, 6 It is covered completely and not have anything of next level

Level 4: 7 If it is partially covered, 8 It is covered completely and not have anything of next level
Level 5: 9 If it is partially covered, 10 It is covered completely.

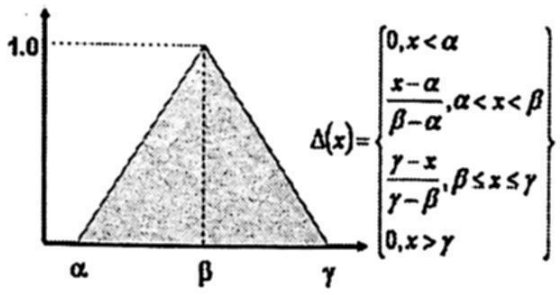
Develop the selection of elements, which in the case of participating companies can generate a standardized model for the exchange of best practices. For this, The overall efficiency index is determined by a scale of 5 levels. If a variable of the company is closer to 1, is major source of weakness for the company, whereas the more close to 5, more clearly represent a of strength.

Table 1. *Characteristics of the semantic scale for overall efficiency index of competitiveness.*

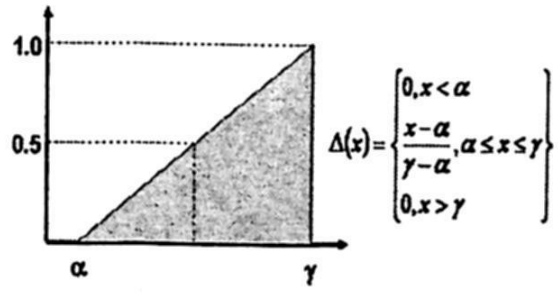
Overall Efficiency Index	Level				
	1	2	3	4	5
	Highly Negative	Negative	Balanced	Positive	Highly Positive
OPERATIONAL BUSINESS STRATEGY	Operations strategy is not functional, It can not be competitive with the competition	Operational Strategy fails to meet the committed results	Operational Strategy can meet the targets	Operational Strategy exceed targets in a sustainable way	Operational strategy allows to drive the market
STRENGTHS AND WEAKNESSES	Companies where there is no possibility of meeting the objectives	Companies where their weaknesses limit the achievement of objectives	Companies that the balance between their strengths and weaknesses in achieving goals and face competition in a sustainable way.	Companies that allow their strengths to lead the market with predictive actions against competition in a sustainable way.	Companies where their strengths allow to innovate and market competition
ACTION PLAN	Take actions for change, under a new organizational strategy	Its priority must be to improve the level 1 components, and react to reduce their operational and transactional problems	Its priority must be to keep the weak level 3 components for a sustainable growth	Its actions to increase their strengths in a sustainable manner.	Solidify its strengths and renew its functional structure according to Generational Plan (long-term vision)
Type of Company	Companies in decline in global markets	Companies in restructuring	Average Companies	Growing Businesses	World - Class Company

The preliminary model uses a proposal of membership functions that is consistent with the definitions of each component. It creates a right triangle to the membership function, which differs from the common form of this type of triangular functions as shown in the figure below.

Common Triangular Membership Function



Proposal Triangular Membership Function



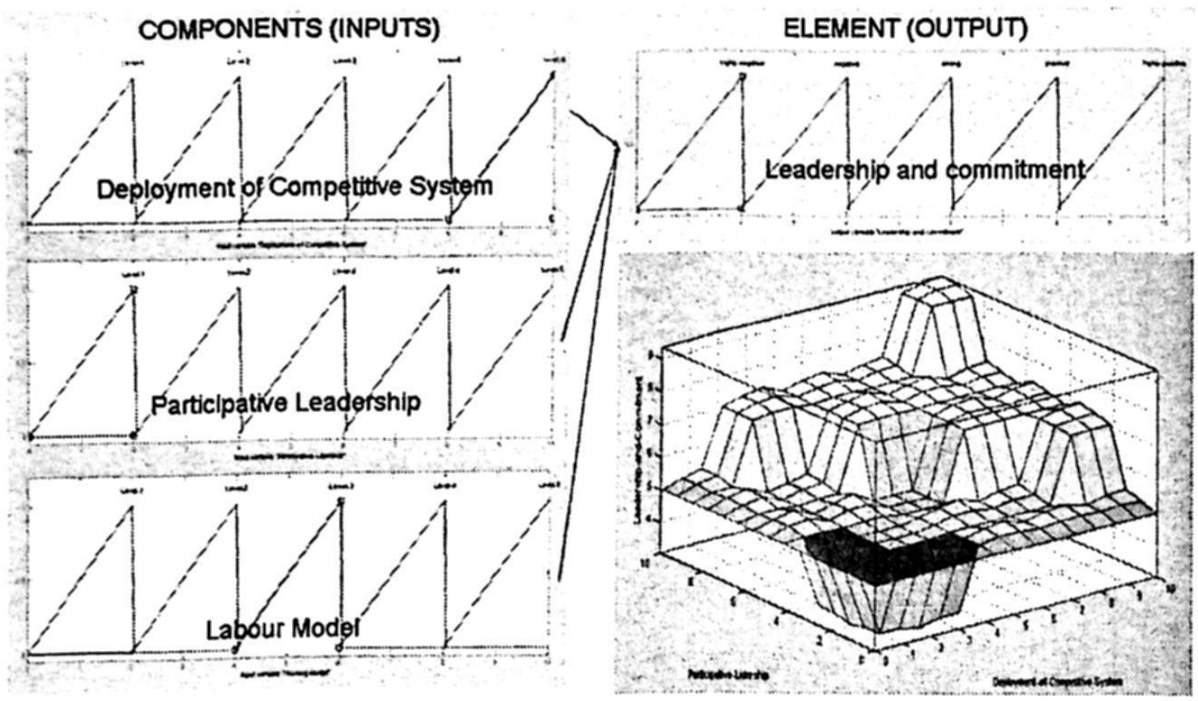


Fig. 3. *Triangular Membership Function (above). Diagram of fuzzy inputs to one element (below).*

The model identifies 10 elements of output, and 35 components that form the group of fuzzy inputs to the system. The interest of using this model is to generate a diagnosis that can be contrasted with the self-assessment and to define future states to address performance improvement actions on the priority elements. In Table 2 presents the list of elements and components included in the model.

In this evaluation process, the fuzzy rules are structured in the IF part and THEN part. The IF part is the relationship between the components of each element, and the THEN part is the computational result of the evaluated element. The number of rules is equal to the 5^k, where 5 is the number of level and k is the number of components of the element under investigation. Example in figure 3, the element "Leadership and commitment" has three components; the number of rules are 125.

4 Graphical Representations

The search for graphics that could be used within the model of competitiveness to ensure their understanding and application in decision making is contrasted to the group of users who make use of the information model, which has 10 components and 35 components.

The use of graphical procedure should help to avoid the complexity of the proposed fuzzy model, given the expertise of users, extracting maximum knowledge with minimum handling of information available to users. The types of graphics used, and combinations of these were:

- Line graphs. To compare the behavior over time and emphasizing the changes in trends.
- Column charts. To compare the differences from one period to the next.
- Clustered Column chart. To study independently multiple data series.
- Stacked column charts. Show each data set as a percentage of the total. Allow to study how to change components of an element over time.
- Area Charts. They are a variant of the line. Keep in mind that whenever they are stacked, which facilitates the display of the totals of the series, but can be confusing for the user if the series are many peaks, there is no simple interpretation of the layers.
- Column or bar graph population pyramid. Used when there are two groups that compare. It proved to be confusing to users.
- Rings or toroidal graph, formed by concentric circles, thereby enabling the representation of various data sets. It is difficult to interpret.
- XY or scatter chart used to show the relationship between two variables. Shows the correlation positive, negative or non-existent between the two variables. Often added a line with the trend. It's sophisticated and therefore may confuse audiences unfamiliar with statistics.
- The bubble chart, as the dispersion but showing an additional data series proportional to the size of the bubble.
- The radial graph. It has a separately for each variable axis that extends from the center of the chart out. Useful for show deviations.
- Box plots. Provide complete information on how visual data is distributed. They can be very useful as a technique for exploratory data analysis.
- Chernoff Faces. It is the multidimensional representation of information by a person's face: eyes, mouth, nose, etc. mean different variables. The study characteristics are associated with different gestures in the face of a person.
- Multivariate Graphics. Multivariate techniques as factor analysis, cluster analysis, multidimensional scales and self-organized neural maps graphically summarized in a large amount of data and variables.

The proposal is based on developing a strategy that may improve the assessment of factors influencing the functional areas which may be related to the comments of stakeholders, generating a self-assessment method to recognize performance problems and causes underlying these inefficiencies.

The function of the variable base is made using a proposal of a modified triangular distributions; this would represent the categories of judgments of experts similar to the functions in figure 3.

5. Results from field data.

The development of fuzzy variables in the model will be compared with the results obtained by the self-assessments in different companies. Te graphical representations of competitiveness model, applied to 12 production plants at Northern Mexico, obtaining the following results, figure 4.

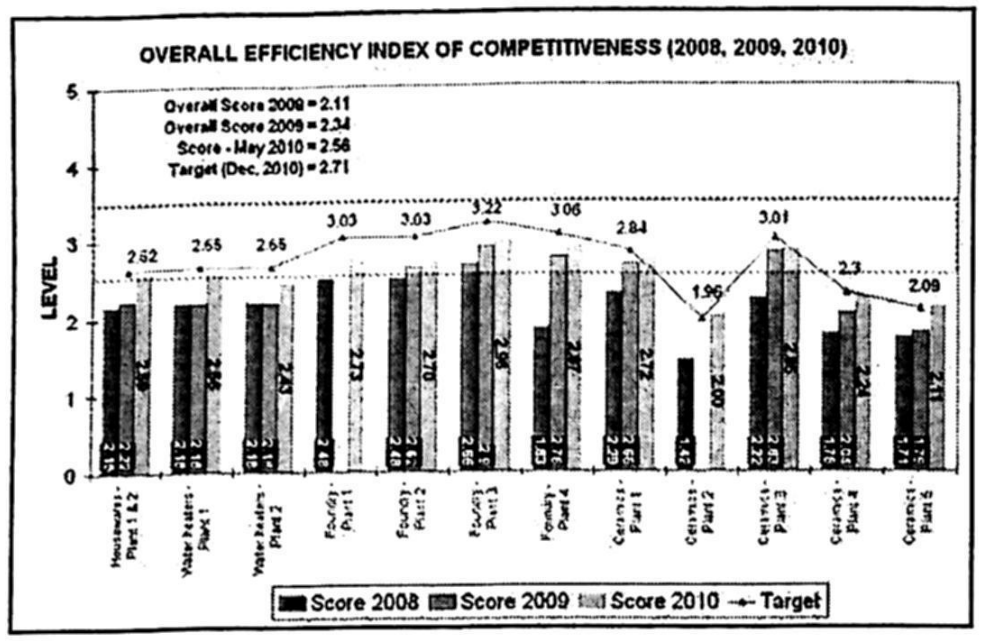


Fig. 4. *Assessment of competitiveness (Selected Graph by users)*

Users found that the use of the graphic above, were allowed to know the history of each assessment, the line denotes the particular objective of each plant, the interval band denotes the region in which you can identify characteristics of the element in a level balance which indicates that under conditions of at least meet its strategic objectives. At the suggestion of users, it was identified that bars use the group's

consolidated performance, created confusion because the information was confused with another plant, which generates a table to add the top left corner with consolidated information.

For the results of each component, it was decided by a mix of radar graphs within a framework of graphics elements and in each corner of the figure represents one component of that element. Figure 5 presents the graphs corresponding to three elements of the Ceramic - 5th Plant.

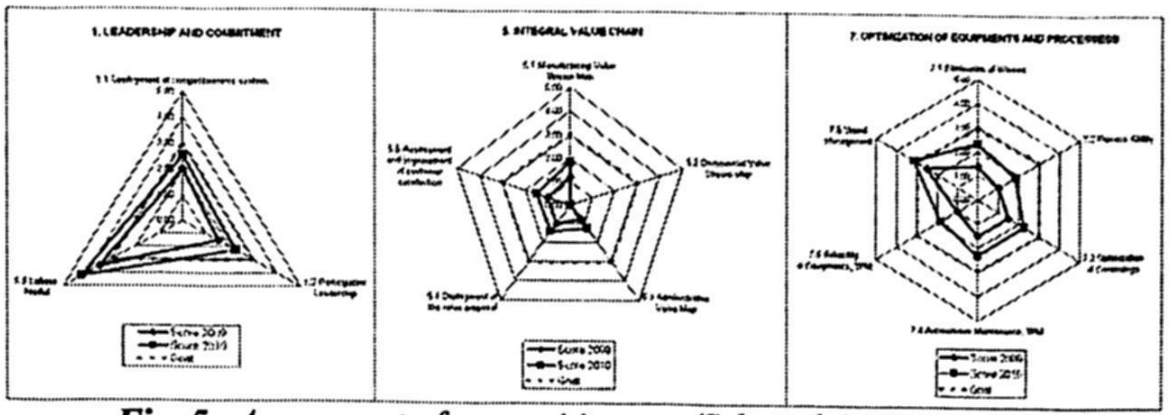
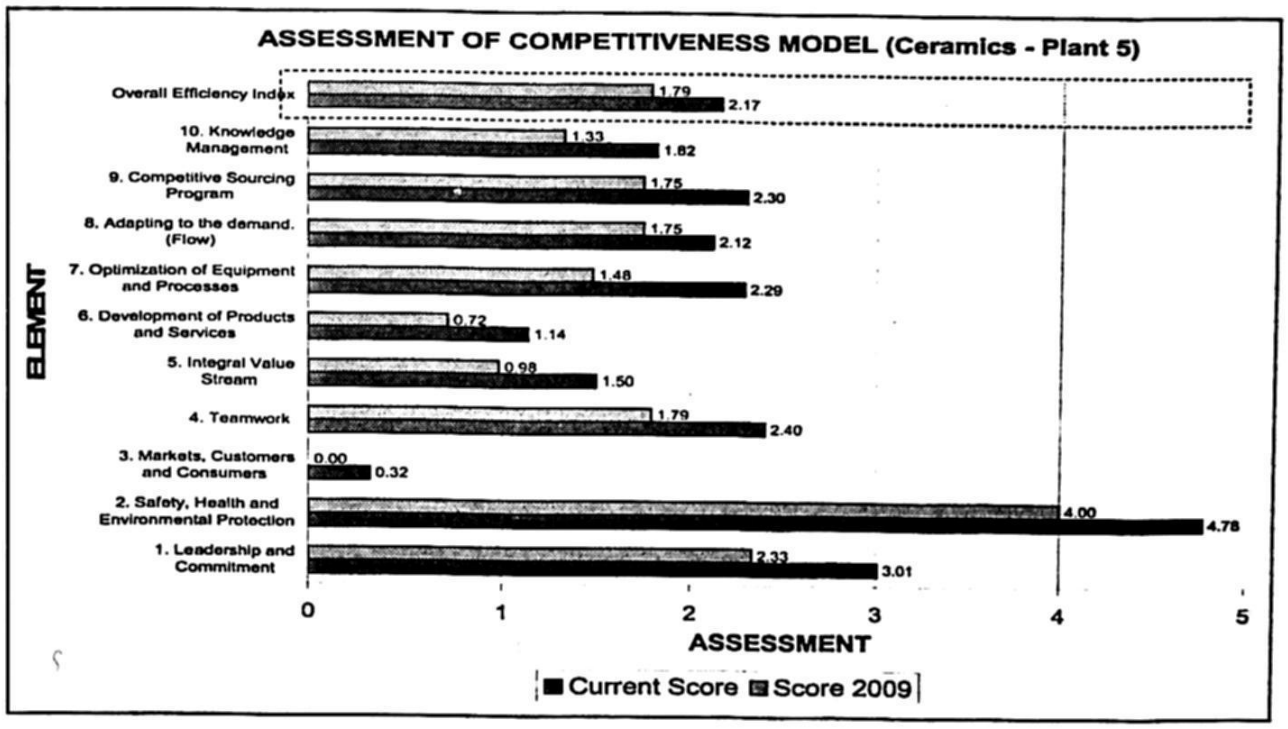


Fig. 5. *Assessment of competitiveness (Selected Graph by users)*

In the following graphs, showing the evaluation of each element in Ceramic - 5th Plant, showing the value of its overall efficiency competitiveness index.



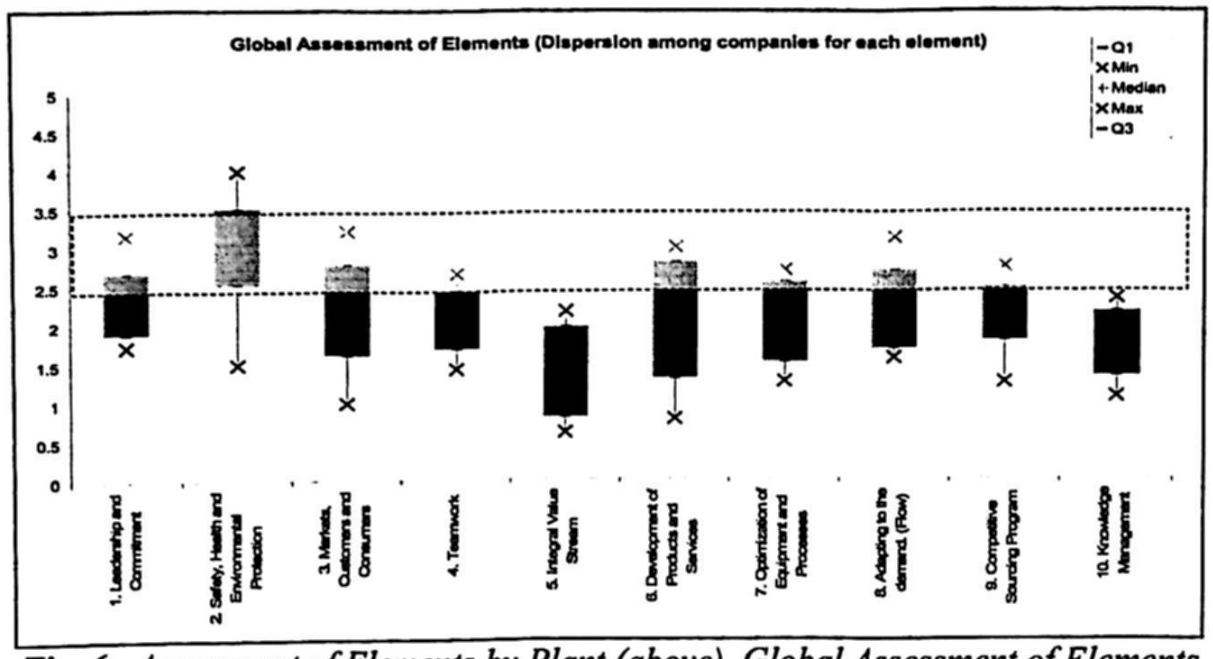


Fig. 6. *Assessment of Elements by Plant (above), Global Assessment of Elements (below)*

For the treatment and behavior of actions, it was decided to use cub Plots, which are used in experimental designs where each level may signify the status or level of one variable, which can be identified in a simple interaction between elements. The scheme can be followed as shown in the following figures.

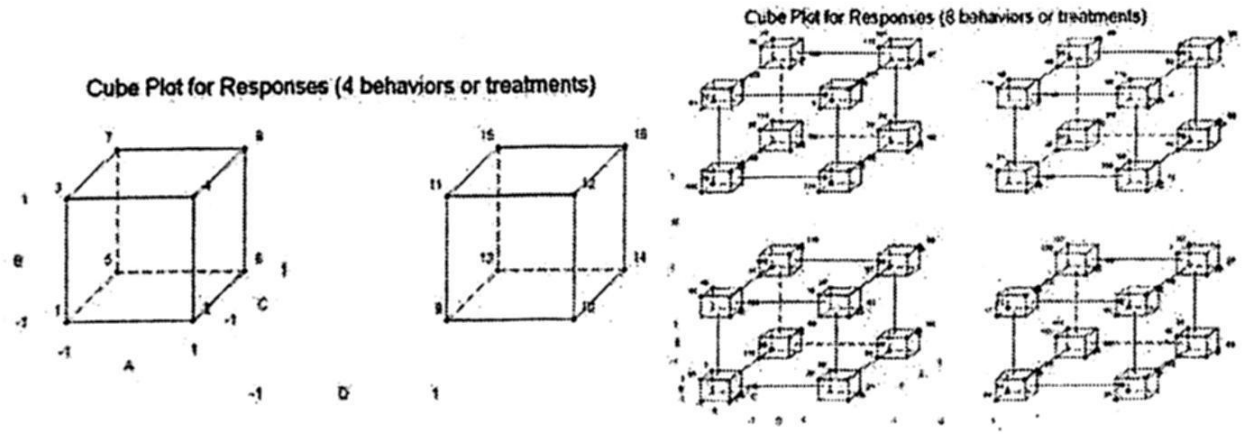


Fig. 7. *Scheme of cub plots to relations between of treatments with elements and components of Competitiveness Model.*

6 Conclusions and Future Researches

The study develops the selection of variables in the application of a semantic interval scale, where the measurement and evaluation processes are different levels of information on the functional areas that affect business competitiveness. The process to define fuzzy variables presented in this article is applicable to any industry and any set of variables. In that sense, there are two main areas that should be of interest to administrators with the use of graphical representations.

First, the graphical representation model can be used to demonstrate the performance and valuation the competitive elements that identify the strengths and weaknesses of companies and to define the lines of action within its strategic planning. This study provides a key focus for the selection of a group of graphics and their treatment that can replace the complexity of fuzzy graph models, giving a reasonable response rates that are used to determine the overall efficiency index of competitiveness. Generate a process of benchmarking between companies of a different nature in the objectivity and understanding of the groups of users.

Second, consciously or unconsciously it is easy to misuse of the graphics, since it must identify the level of expertise to use, so that no errors are induced in decision making. Of this depends on many models can be used consistently, especially when they differ substantially from the common processes that precede them for decision making.

The use of any univariate analysis is simple. The box plots graphically summarize the main statistical and can even become a complementary tool to support decision making. However, as all univariate analysis, is inadequate in a complex issue and therefore necessarily a multivariate analysis with ability to handle several variables simultaneously. Chernoff Parameters can help understand and display up to 10 dimensions, something beneficial with respect to a graph X, Y & Z and color that can only represent four dimensions [4]. The use of Mosaic Images [5] may be characterized more than 40 attributes, but it is important to verify that users can use these for making decisions without extensive training, which resulted in the abandonment of them. The graphics shown in this study, improved employment and use of the competitive model by 67% compared to the initial fuzzy model graphics, and other graphic. This shows the importance of the selection process of graphic representations.

In future research, the main focus of interest is the application and validation of the proposal fuzzy model, including the impact of the indicators of competitiveness in business growth and productivity, given the marginal effects of the decision variables used, considering the use of a fuzzy approach and evolution strategies for optimization and contrast with the field data.

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Intelligent system to emergences based on ant colony

Omar Cano Cendejas, S. Jöns and José Sandoval.

[1] Centro de Innovación Aplicada en Tecnología Competitivas,
omar_kano7@hotmail.com
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Abstract. The problem of the shortest path is a typical problem of optimization. This paper presents the technique of Ant Colony Optimization heuristic used in the solution of this problem applied to the improve of routing vehicles in the H. Fire Department of the city of Leon at Mexico. We describe the diverse components to characterize this problem, and the use of a Bioinspired Algorithm in this case, we propose the use of Ant Colony, thus implementing a Tool in Java which determine the best tracks to the vehicles and realize experiments to probe the validations of this software, focusing in the comparative with Dijikstra algorithm and determine the quality of our results, in the future of this research, we try to determine an innovative perspective related with pheromone evaporation and as this topic is determinative to found and remember best solutions quickly.

Keywords: Ant Colony, Shortest path, vehicle routing.

1 Introduction

Today's digital maps are an increasingly common, with the progress that has been made in technology, these maps are becoming more sophisticated, able to come to find specific locations, draw routes, among others. Also noteworthy that show how the information has improved dramatically, as they can get to show from traditional maps to maps with totally real images taken from the air, satellite, or even a hybrid version of these two.

The motivation of this project is specifically focused on the use of this increased interaction today, to achieve an improvement in logistics H. Fire Department of the Central Apollo in the city of Leon, Mexico to get faster to the scene. To provide assistance to citizens, firefighters need the path of a route to arrive as quickly as possible to an incident, and these in order of importance: Firefighting, rescue and Prevention Action on public hazard.

In all these activities the time is vital, because with a timely arrival can decrease the effect of damage in a fire, to prevent an explosion in the leak case, finding a person alive, among others.

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2 Description of the Model Components

In this section we offer details of each component related with the application domain involve in the problem, in our case Logistics to emergence although the improve of the route of vehicles of Fire Departments by the use of a Bioinspired Algorithm.

2.1 Shortest Route

The problem known as the shortest path or shortest route, as its name suggests trying to find the minimum or shortest route between two points. This minimum may be the distance between origin and destination points or the time to travel from one point to another. Mathematically, this system is described as a weighted graph G= (V, A, d) where vertices are represented by V= $\{V_0, V_1, \ldots, V_n\}$, and arcs are represented by A= $\{(v_i, v_j) \mid i \neq j\}$. The distances associated with each arc are represented by the variable C_{ij} measured by the Euclidean distance.

The objective function of the problem [6]:

$$\min z = \sum_{\substack{\text{Todos los arcos} \\ \text{definidos}}} C_{ij} X_{ij} \tag{1}$$

Decision variables:

X_{ij}: Action to move from node i to node j

0 indicates that there is no displacement and 1 that indicates that yes there is movement.

C_{ij}: Cost or time to get from node i to node j.

Restrictions

Total input flow = Total output flow

$$(\text{External input into node j}) + \sum_{\substack{i \\ \text{Todos los arcos} \\ \text{Definidos (i,j)}}} X_{ij} = (\text{External output from node j}) + \sum_{\substack{k \\ \text{Todos los arcos} \\ \text{Definidos (j,k)}}} X_{jk} \tag{2}$$

This type of optimization problems can't be solved using exact methods, we can't find its optimal solution with acceptable computational efforts. Since the early 50`s many algorithms have been developed to find the solution to this problem by finding good solutions but not necessarily optimal solutions. In the 80 `s, the solution techniques focused on the implementation of general-purpose metaheuristics including between the ant colony, genetic algorithms, tabu search, among others.

2.2 Shortest path algorithm

The shortest path algorithm, also called the Dijkstra algorithm is an algorithm for determining the shortest path given a source vertex to other vertices in a directed graph with weights on each edge. The shortest path algorithm belonging to the greedy algorithm [7] is an efficient algorithm of complexity $O(n^2)$ where n is the number of vertices, used to find the least cost path from a source node to all other nodes in the graph. It was designed by Dutchman Wybe Edsger Dijkstra in 1959 [10]. The foundation on which sits this algorithm is the principle of optimality, the solution is built with the election of local optima in the hope of obtaining a global optimum.

2.3 Ant Colony

Ant colony optimization (ACO) algorithm is a new simulative evolutionary algorithm named ant colony system and was proposed in the 1990s by Italian scholar M. Dorigo. It has been applied to TSP, allocation problem, JSP, and got excellent results. Hence, more attention has arisen to the ant colony system, and the model has been applied to many practical problems [5, 9].

The Ants are social insects that live in colonies and that, because of their mutual cooperation, are capable of displaying complex behaviors and difficult tasks from the point of view of an individual ant. An interesting aspect of the behavior of many species of ants is their ability to find the shortest path between their nest and food sources. This is especially interesting when you consider that many species of ants are almost blind, which avoids the use of visual cues [8]. While make their way between the nest and food source, some species of ants deposit a chemical called pheromone. If there is no trace of pheromone, the ants move essentially random manner, but when there is pheromone deposited, are more likely to be traced [8]. The choice between different ways takes place when several paths cross. Then, the ants choose the way forward with a probabilistic decision biased by the amount of pheromone: the stronger the pheromone trail, the more likely selection. Because ants deposit pheromone on the path to follow, this behavior leads to a self-reinforcing process that concludes with the formation of traces marked by a high concentration of pheromone. This behavior also allows the ants find the shortest path between their nest and food source [2].

As time passed and while the ants are most promising on the roads, they will receive a higher amount of pheromone. This happens with that being the shortest path, the ants that are able to find food more quickly, they begin their return journey before. Then, in the shortest path a trail of pheromone be slightly higher and, therefore, decisions of the following ants will be directed more to the way [8]. In addition, this road will receive a greater proportion of pheromone by ants returning him by returning to the road longer. This process ends by making the probability that an ant chooses the shortest path increases progressively and ultimately the path of the colony converge to the shortest of all possible ways.

3 Tool Developed

Intelligent tool was developed using the Ant Colony algorithm and programming language Java (J2SE), began with the creation of the graph for the central area covering the Apollo fire a total of 2451 streets, avenues and boulevards (edges) and 1710 nodes, subsequently designed an entity called "object" to store information about each node, as the impact to neighboring nodes and their respective distance. These objects were related to a data structure called a multidimensional array which saves computer resources, because it does not cause the waste of memory cells generates a square incidence matrix, it stores only the necessary space.

Once the multidimensional array is implemented the Ant Colony algorithm, which has proven effective in solving NP-Hard problems [2]. The structure of the generic algorithm is as follows [5]:

Algorithm: Optimization based on Ant Colony

```
Inicializar_parametros()
while not condicion_parada()
    for ant=1 to n
          construir_solucion()
          evaluar_solucion()
          actualizar_feromonas()
    end for
end while
```

The software implements the ability to block and alter the meaning of the streets, a fact that occurs in the central city of Leon because of events, accidents, public works, among others. The method Inicializar_parámetros enters the source node, the destination node, blocked streets and the number of ants involved in the search for the solution. Construir_solución takes place ants moving randomly with both probability using the Monte Carlo method if there is already a trail of pheromone. Once an ant has found Evaluar_solución the destination node determines if the journey is of good quality, discarding those paths that do not decrease the distance obtained by other ants, and Updating pheromone if you have found a shorter route.

The system in the user interface displays the found routes to the destination, with the option of displaying all or a particularly within a map (Figure 1), which has the options of adding landmarks (churches, schools , hospitals, parks, rivers, etc.), zoom, view the different layers, stored in the route file, export the map as an image and sent via Bluetooth to a mobile device.

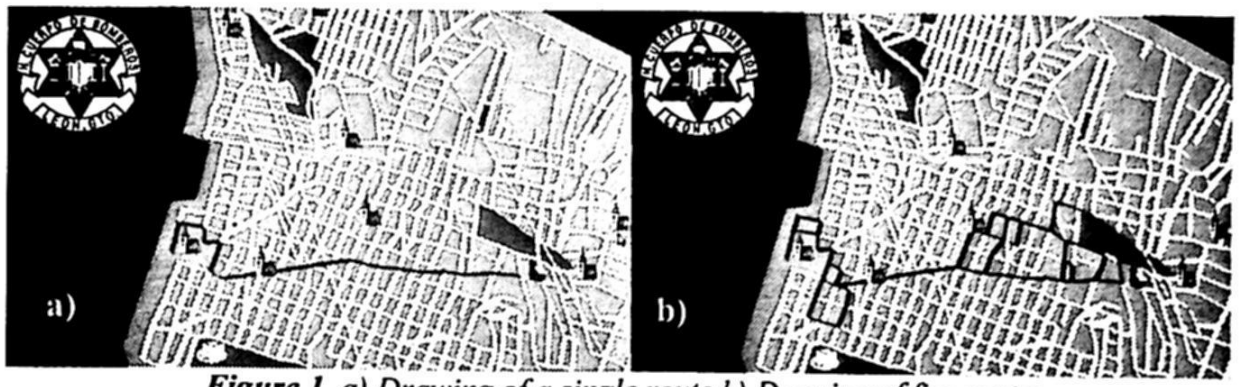

Figure 1. *a) Drawing of a single route b) Drawing of five routes.*

4 Experimental Results

The proposed algorithm was compared with the algorithm of Operations Research: Shortest path (Dijkstra), The comparison was carried out with the generation of 20 runs starting from the central fire (node 759) to different nodes (Table 1).

Table 1. *Results.*

No.	Node		Obtained Distance	
	Origin	*Destination*	*Dijkstra*	ACO
1	759	945	222	212
2		614	464	507
3		903	755	841
4		941	732	698
5		1044	693	709
6		1202	984	1093
7		1094	953	927
8		1057	538	538
9		1418	231	231
10		170	338	328
11		526	347	324
12		462	718	718
13		846	859	1030
14		524	359	333
15		809	365	406
16		1107	886	1011
17		698	302	302
18		1062	517	499
19		1342	519	564
20		1199	885	934

The results were ontained with μ=25.15seg and σ=15.65seg, in 35% of cases the Ant Colony give better results than the shortest path algorithm (1, 4, 7, 10, 11, 14 and 18), in 20% the results were similar (8, 9, 12 and 17) and 45% was surpassed by shortest paths.

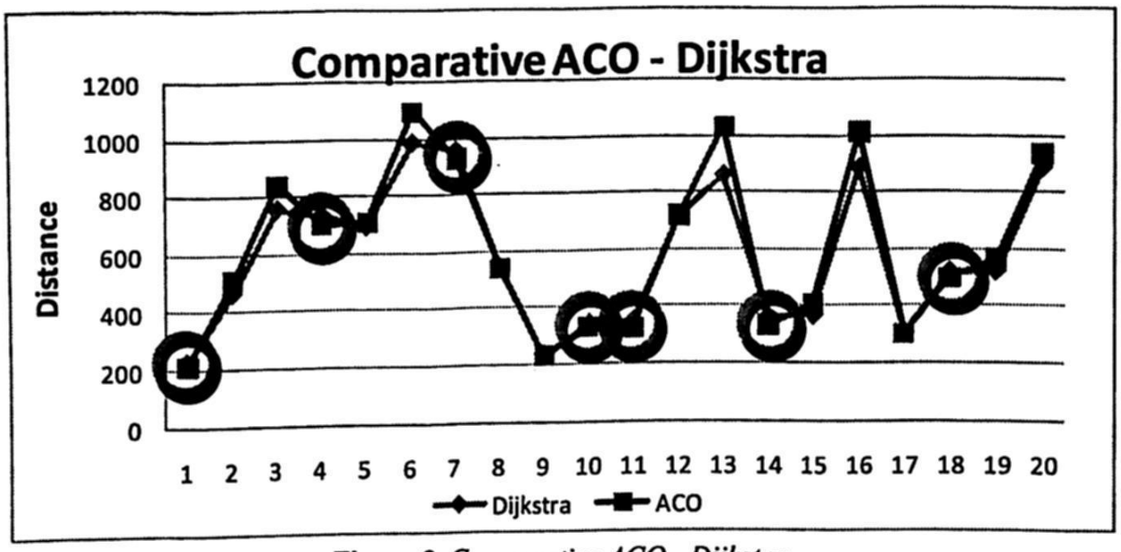

Figura 2. Comparative ACO - Dijkstra

5 Conclusions and Future Work

The algorithm is currently implemented gives good quality solutions to an NP-hard problem, improving by 35% of cases the routes provided by the shortest path algorithm.

In the 45% when the shortest path algorithm exceeds the ACO is attributed to not yet been implemented evaporation of the pheromone, the pheromone in nature may remain from a few hours to several months depending on several different aspects, such as ant species, soil type [8], causing a minor influence on the effect of evaporation in the process of finding the shortest path. Due to the long persistence of pheromone, it is difficult for the ants "forget" a path that has a high level of pheromone but have found a way even shorter. Keep in mind that if this behavior is transferred to the computer to design a search algorithm can find that quickly become stuck in a local optimum.

Based on the results obtained we recommend the implementation of heuristic algorithms such as ant colony, which have proven to do well on a variety of problems [4]. As future work remains to implement the evaporation of the pheromone, find benchmarks that are being used at international level and prove to those instances of the problem, replicate the project using Java (J2ME) for the system to operate on mobile devices which provide advantages to having with the system in units of H. Fire Department.

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Parameter Tuning: Simulated Annealing for Function Optimization

Daniel Cuéllar, Elva Díaz and Eunice Ponce de León

Universidad Autónoma de Aguascalientes (UAA), Computer Sciences Department, Basic Sciences Center, 940 Universidad Ave., Ciudad Universitaria, Aguascalientes, Aguascalientes, México
cuellar_garrido@hotmail.com, elvitad@yahoo.com, eponce@correo.uaa.mx
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Abstract. This work proposes an experimental strategy for calibrating algorithms. A function maximization problem is used to test the strategy. Simulated annealing is selected to this research because it is a heuristic method which requires more initial parameters for its efficient operation than other heuristics. In many cases the success or failure of the algorithm depends greatly on doing this initialization task correctly and despite this difficulty, simulated annealing is a powerful tool, which has provided good results in solving problems of optimization in bioinformatics, medicine, engineering, physics, etc. The calibrating experiment obtains the best combination of parameters, reducing the search space only to the most promising interval, where the optimum is located. Each problem presents special characteristics and needs its proper tuning in concordance with the "No Free Lunch" theorem. The simulating annealing has as training part, the automatic tuning of parameters.

Keywords: Simulated annealing, Function optimization, No free lunch theorem, Algorithms tuning, Parameters.

1 Introduction

The "no free lunch" theorem (NFLT) explicitly demonstrates that all algorithms have the same averaged performance over all classes of problems. The only way that this can happens is that the gaining of performance in one class is paid with the loss of performance in all other classes [9]. If we want to use one algorithm to solve a particular problem, the NFLT gives a foundation to analyze and to select the best algorithm performance for this problem. If it is possible to select the best combination of the algorithm parameters, this particular set of parameter values is named the calibration values, and the algorithm with calibrated values receives the name of calibrated algorithm. The problem of tuning a metaheuristic can be profitably formalized and solved as a machine learning problem [7], so a tuning routine or strategy can be implemented as a training step in the algorithm; for this research, the optimization of functions has been selected because the results can be easily drown, and the simulating annealing algorithm has been selected because has many parameters which makes it difficult to calibrate.

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2 The Simulated Annealing Algorithm

The simulated annealing is an optimization technique that simulates the thermodynamic phenomenon of annealing. It uses concepts directly brought from physics, which needs to be adapted to the physical model of annealing to the case at hand. The simple simulated annealing algorithm is presented below:

Algorithm 1. Pseudocode for the simple simulated annealing algorithm

1. Material selection to anneal with (objective function definition to solve).
2. Parameter initialization (initial temperature, rate of cooling, etc).
3. Modification and evaluation of the actual system energetic state (Acceptance criteria and Metropolis routine).
4. If **thermal equilibrium*** doesn't exists return to step four.
5. If the system isn't **frozen**** decrease temperature based on the cooling schedule and return to step four.
6. End.

* **Thermal Equilibrium:** In simulated annealing, the thermal equilibrium is achieved when enough number of consecutive results is accepted during a certain temperature and new changes produce insignificant results in the optimization function.

** **System Frozen:** In simulated annealing, the system is frozen when no more results are accepted after several temperature decreases during the cooling schedule, or when a certain stop criteria is meet, this circumstances occur generally when the temperature reach or approach to zero.

The principal characteristic of the simulated annealing consists in the implementation of a routine known as Metropolis algorithm that employs a "Boltzmann probability" to prevent the system from falling into a local optimum [4]. While it is easy to run a simulated annealing program, is hard to make it work well [1].

3 Function Selection

The problem we want to solve is to find the global maximum value of an arbitrary mathematical function. The proposed function called M2, is multiplied for a coefficient of 100 and contains several local maximum and a single global optimum. These characteristics make it interesting to test the effectiveness of the algorithm and the tuning strategy. The domain of this function is between -2 to 2 and we can observe a high fluctuation in the values in this range. Its equation and graph are shown next:

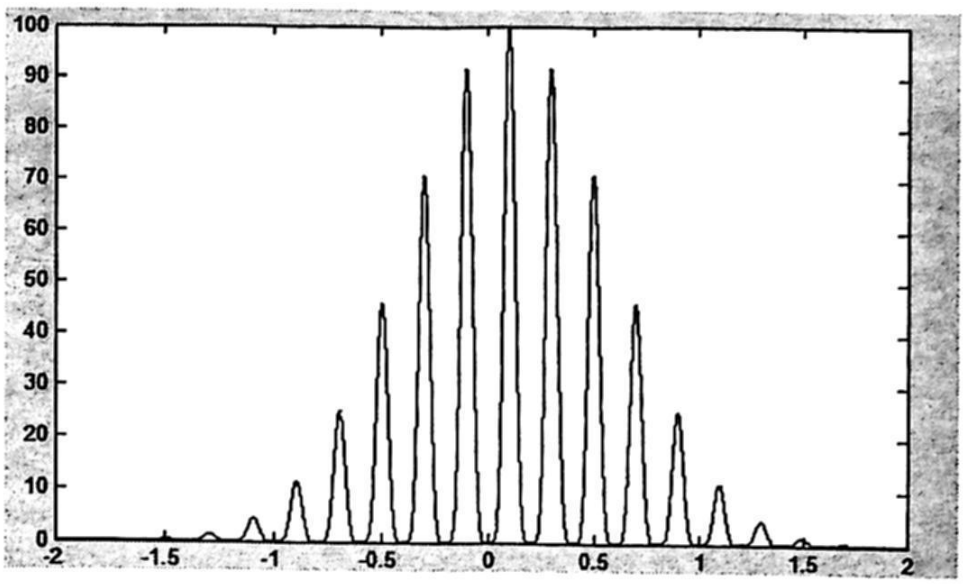

Fig. 1. *M2 Evaluated from -2 to 2 and multiplied for a coefficient of 100*

4 The Tuning Problem

The simulated annealing algorithm is very sensitive to any value assigned to its parameters and the relationship between these, determining the success or failure of it. We can say that this is a crucial and difficult stage to achieve. The first and most natural approach for this task is to perform this initialization manually and get the right combination to achieve a result in an empirical way, but sometimes this can be a hard work. Another problem lies in the resolution and selection range of the parameters, so it is necessary to delimit the potential range of the general parameters of the algorithm (study of the sensitivity of the function) [2].

5 Experimental Approach

5.1 Tuning Experiment

For the computer, this is a black box problem, without information a priori; the only way to know when the tuning is better is when it finds those combinations of parameters that yield best results with each new implementation. For this, we have to try all the possible combinations of parameter values, which is a combinatorial problem of exponential nature, however, it is possible to restrain the number of combinations within a calculable amount and assess their tendency to close up the gap until the range of effect for the desirable result. The results of these combinations should reflect variability in the results, whether these are good or bad results, so that you can see a trend toward what parameters are affecting the problem and what not.

5.2 Experimental Design

In this experiment, three values were combined for each of the five parameters as shown in table 1, this for reducing the number of combinations and thus avoid combinatorial explosion while having a pivot value and two more to tell us whether there is any bias towards one of its sides:

Table 1. Initial value selection for the parameter tuning experiment

Value	Low	Medium	High
Temperature	10	20	50
Equilibrium	2.5	5	10
Cooling	.3	.6	.9
Iterations	10	50	100
Freezing	.000001	.001	1

Then we evaluate all possible combinations of parameters with a total of $(n)^p$ combinations, where p is the number of parameters and n the number of values for each, in other words $(3)^5 = 243$ and in turn make 10 replicas of each combination for a total of $10 * (3)^5 = 2430$ results (simulated annealing results vary randomly because of its stochastic nature so is appropriate to make replicas for each possible combination.) The design of the experiment is run within a nested structure of FORS:

Algorithm 2. General data extraction procedure for the tuning experimental design

```
FOR (i = 1; i < n; i++)
{
        if (i == 1) {Parameter1 = Value^P1_1;}
        if (i == 2) {Parameter1 = Value^P1_2;}
        if (i == n) {Parameter1 = Value^P1n;}
FOR (j = 1; j < n; j++)
{
        if (j == 1) {Parameter2 = Value^P2_1;}
        if (j == 2) {Parameter2 = Value^P2_2;}
        if (j == n) {Parameter2 = Value^P2n;}
        FOR (X = 1; X < Replics; X++)
        {
                Heuristic (Annealing) Program
                Save Actual Parameters Combination in a File (TXT, XLS, etc.)
                Save Results for Parameters Combination in a File (TXT, XLS, etc.)
        }
}
}
```

6 Results and Discussion

Figure 2 shows the results for each of the 2430 parameter combinations, it is interesting to see how the program has some combinations of parameters that yield bad results which allow us to see that in fact there is variability in the results, which means that the parameter combinations affect the results, however, by the nature of simulated annealing these are concentrated in the local maximums and the optimal of the function. In addition, the data were subjected to an analysis of a linear stepwise regression model; the analysis of the problem was performed in SPSS and produced the results shown in the table 2. Regression analysis was used to detect the order of importance of each parameter; the most important parameter that most directly affects the outcome under the analysis was the rate of cooling followed by freezing, the initial temperature and the equilibrium parameter. In turn, the analysis also gives us results about which parameters are insignificant as is the case of iterations, which even ran in the results.

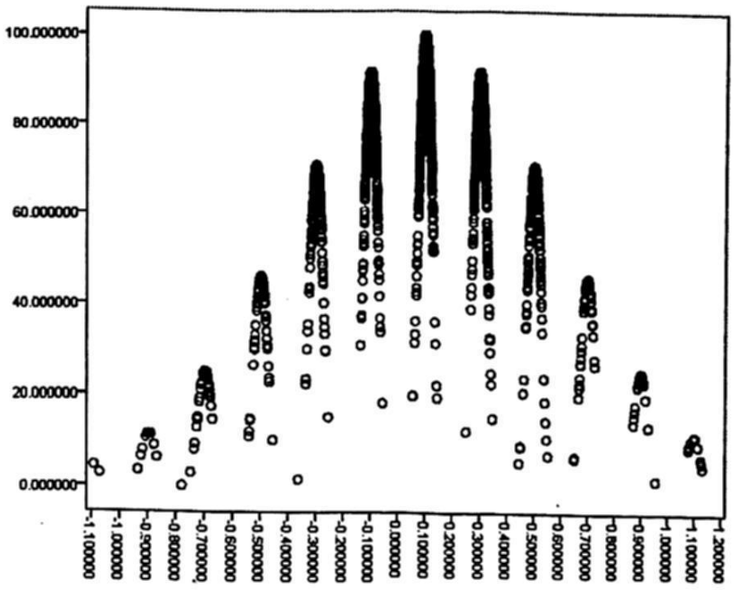

Fig. 2. *Experimental results for the parameter combinations showed on table 1*

Based on this study, we conclude that all are significant except for the number of iterations because it does not affect the variance. This is not necessarily true; the parameter may be that not really significant or the range used might not include the values that affects the results. To find out what is our case, is pertinent to repeat the experiment extending the range, if even changing the range of action we did not find any change, then the variable is insignificant and can be neglected in the algorithm, can be fixed in a comfortably value or can be eliminated if this one doesn't affect the algorithm behavior. Now that we know what parameters are significant, we need to know the range where they exercise action. For this, we took the 20 best results and the combinations of parameters where they were found and based on these results we made the table 3:

Table 2. Stepwise regression test results for the analysis of parameter significance

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	59.387	.688		86.307	.000
	Cooling	39.942	1.062	.403	37.619	.000
2	(Constant)	65.257	.661		98.750	.000
	Cooling	39.942	.985	.403	40.550	.000
	Freezing	-17.595	.512	-.342	-34.359	.000
3	(Constant)	70.311	.752		93.467	.000
	Cooling	39.942	.973	.403	41.052	.000
	Freezing	-17.595	.506	-.342	-34.785	.000
	Temperature	-.190	.014	-.133	-13.516	.000
4	(Constant)	67.166	.872		77.066	.000
	Cooling	39.942	.970	.403	41.190	.000
	Freezing	-17.595	.504	-.342	-34.902	.000
	Temperature	-.190	.014	-.133	-13.562	.000
	Equilibrium	.539	.076	.069	7.079	.000

a. Dependent Variable: MAXIMUM

Table 3. *Frequency table for individual parameter values and its impact in the 20 best results*

Parameters	*Values*	*Frecuencies*
Equilibrium	2.5	2
	5	6
	10	12
Cooling	0.3	0
	0.6	0
	0.9	20
Temperature	10	6
	20	7
	50	7
Iterations	10	10
	50	5
	100	5
Freezing	0.000001	15
	0.001	5
	1	0

As is thought, smaller freezing temperatures and the cooling parameter at .9 are better; With respect to the initial temperature and the number of iterations, there is an evident pattern, when one increases the other decreases, which suggests a correlation between these two parameters. Based on these observations and selecting the best parameters, the parameters were set at the following values in table 4, and then used to generate other 2430 new results with a calibrated algorithm shown in the figure 3:

Table 4. Best parameter combination for the M2 maximization problem

	Temperature	Equilibrium	Cooling	Iterations	Freezing
Value	50	20	.9	50	.000001

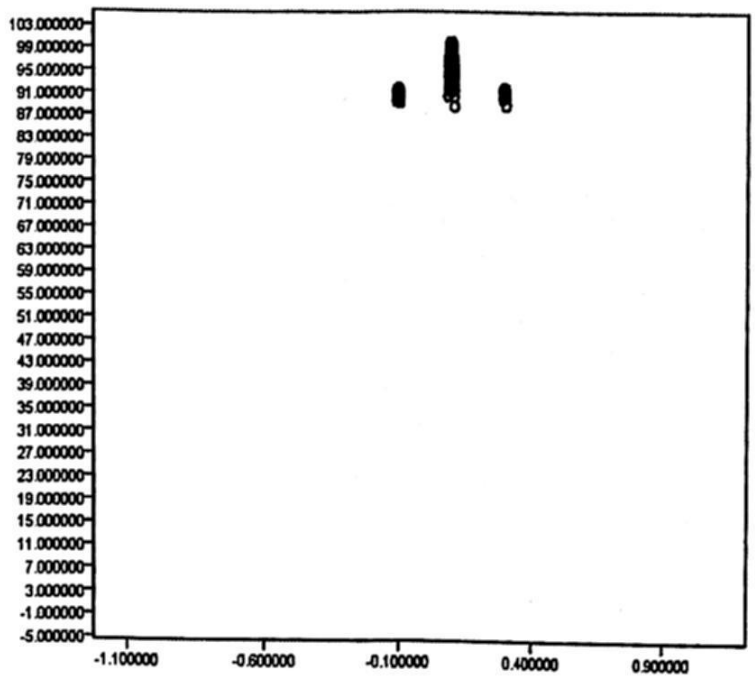

Fig. 3. *Experimental results for the parameter combination showed on table 4*

This is a very good convergence of the algorithm towards the global optimum; on the contrary, if we modify the specific parameters of the function, the tuning loses its effect, therefore requiring a new tuning, as shown in figure 4, with the same parameters but in a search space from -100 to 100 increasing the dispersion of results.

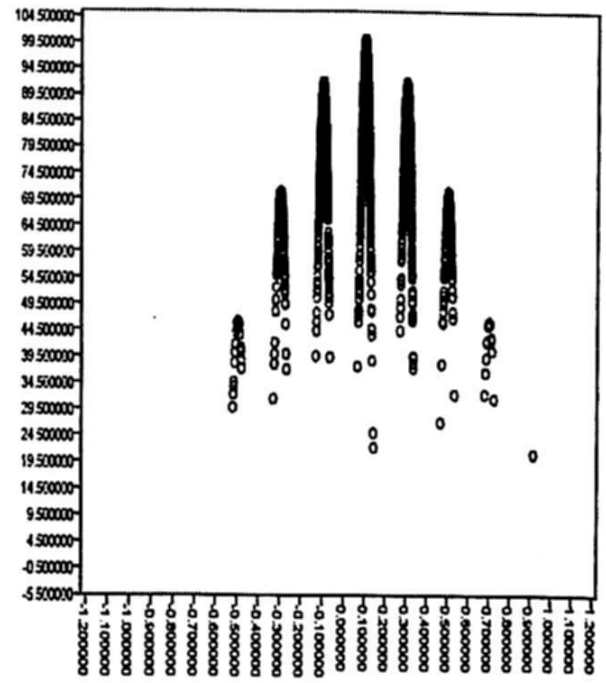

Fig. 4. *Experimental results for the previous combination with a search space from -100 to 100*

7 Conclusions and Further Work

As is shown, the calibrating experiment obtains the best combination of parameters, reducing the search space only to the most promising interval, where the optimum is located. The most important parameters are cooling, freezing and initial temperature, constituting the cooling scheduling. Each problem presents special characteristics and needs its proper tuning. This is according to the "No Free Lunch" theorem of Wolpert and Macready [9]. In the future, we will be implementing this proposed strategy for solving deceptive problems, if the tuning strategy proves to be efficient we will be making a general tuning program such as proposed in [2].

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Artificial Intelligence Industrial Applications II

Controlling the supermarket service

José Antonio Montero and L. Enrique Sucar

[1]Instituto Tecnologico de Acapulco, Av. Inst. Tecnológico S/N, Acapulco, Mex. ,
[2]Inst. Nacional de Astrofisca, Optica y Electronica, Luis Enrique Erro #1
Tonantzintla, Puebla, México,
jamontero1@prodigy.net.mx, esucar@inaoep.mx
(Paper received on September 11, 2010, accepted on October 20, 2010)

Abstract. This work presents an approach that combines queueing the-ory and decision theory to optimize the number of open cashiers in a supermarket. The setting is a simulated supermarket service controlled by policies generated by Factored MDPs to minimize the long-term cost function. Preliminaries tests demostrates that the performance of the simulated model is according with the mathematical counterpart, and the actions selected by the controller are according to the optimal pol-icy.

Keywords: Decision-theoretic systems, Factored Markov decision pro-cess, Supermarket queue control.

1 Introduction

Currently, supermarkets understand that the overall service is the key for suc-cess, and service quality is the key for winning the competition in supermarkets with similar quality and price. For supermarkets, more cashiers mean more in-vestments, however, few cashiers may lead to serious waiting, a ecting service quality and causing loss of costumers. Some times, managers make decisions that not always result in the best option for the business e ciency, so the design of automatic systems that supports management decisions are of great help. In this work, we present the design of a simulator for the queue supermarket joined with a controller based on Factored Markov Decision Process (FMDPs) [1], for optimizing the supermarket service. The designed system suggests the optimal number of cashiers in a planning period, this decision is based on minimum cost approach. For developing the proposed system we integrate aspects of queueing theory and decision theory. In particular, queueing theory addresses problems related to the optimal design and control of queues, the goal is to find optimal values for parameters which, once determined, become fixed characteristics of the queueing system, such as the maximum number of allowed customers [2], maximum waiting time for customers in queue [2] or the total number of avail-able servers [3]. Problems dealing with queue (service) control are dynamic, the goal is to find the optimal operating policy, that is, rules for turning the server in occupied and idle, that result in the lowest long-run cost [4]. Then, this mod-els determine an optimal action to take when the queue is in a particular state.

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[5], [6]. Some previous works also proposed solutions to problems dealing with optimal queue design and queue control [7].

The problem we address in this paper[3] deals with both: queue design and service control, since we would like to determine, based on minimum total cost (cashier cost + waiting cost), the optimal number of cashiers that should be attending in the supermarket and how this cashiers should be selected during a planning horizon. For reaching this, we structured our work as follows: (i) using the queueing theory and based on [8], we designed a simulation model for the supermarket queue system with C servers, then we simulated the behaviour of the parameters (arrival rate and service rate) that occur when customers are waiting for service in the supermarket queue, and (ii) based on the FMDPs framework and using the parameters values of the supermarket queue model previously simulated, we obtain the policy for the controller. The optimal policy is constructed using Spudd [9] and the reward is based on a measurement of minimum cost reached during the planning period.

Preliminary tests indicate that selected actions by the controller are accord-ing to the observed states in the supermarket queue model.

2 Simulation of supermarket service

Computer simulation is a quite e ective way of analyzing the performance of queuing systems. For some aspects of the simulator, we performed a modifica-tion and extension to the simulation computer program for M/M/1 model by Law and Kelton [8]. Particulary we replaced the random number generator by another appropriate to our aim[4], also we added an interface to allow the interac-tion with users, after we included multiple threads to simulate multiple M/M/1 queues. In this work we are interested in how obtain the total cost (cashier cost + waiting cost). The waiting time cost is not easy to obtain, but there are works related with its study [6], [7] that give some ideas. In the proposed model, the simulation of multiple servers is carried out by varying the value of the arrival rate ( ) according to the number of cashiers attending, and maintaining con-stant the service ratio ( ), this is a valid assumption when there are not many interchanges of customers between the rows in the queue. Then, the performance measurements[5] used in this work correspond to the M/M/1 model [5].

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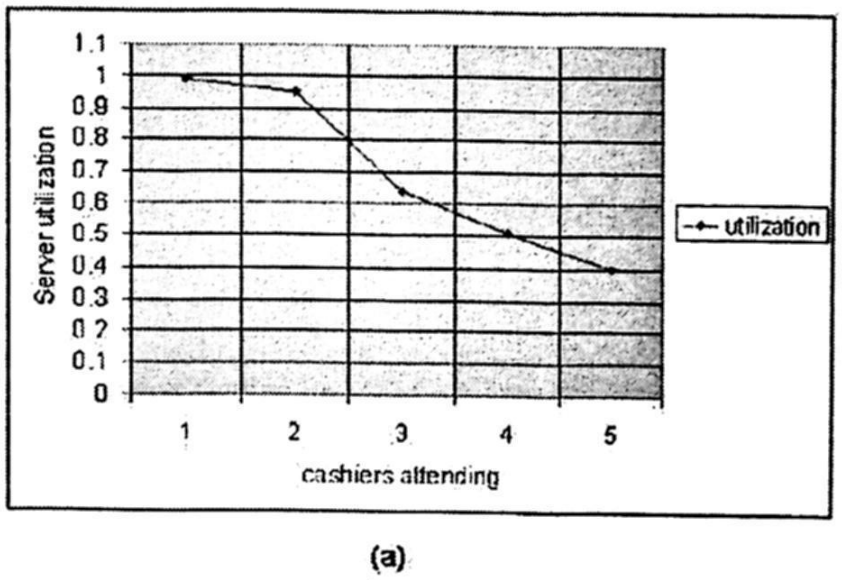
[3] For a full description of this work download the technical report at: http://ccc.inaoep.mx/publicaciones/reportes tecnicos/CCC-10-006.pdf

[4] We are using the Mersenne Twister [10] that generates periods long enough for many practical applications.

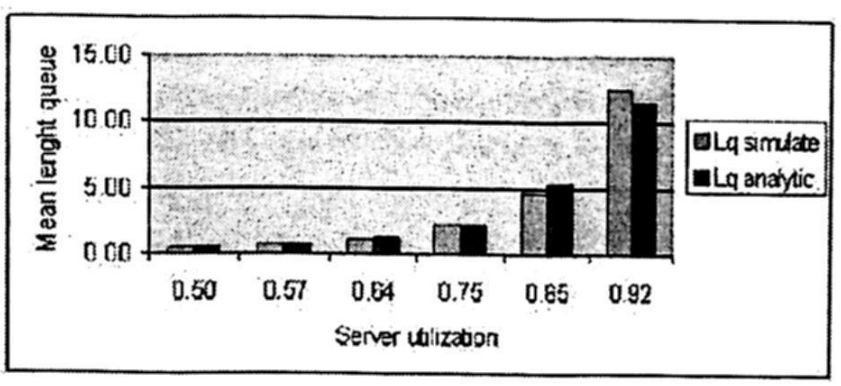
[5] Server utilization ( ), average waitig time that customers spent in the queue (W_q)and the average lenght in the queue (L_q)

2.1 Results from the simulator

The simulator was tested varying the rate of arrivals ( ) and the rate of service ( ). In Figure 1 (a), we observe the variation between the server utilization and the cashiers attending (service rate). When there is only one cashier attending, the system crashes, if one cashier is added the server utilization is 95 percent (the queue may soon collapse under this condition), if a third cashier is added, the server utilization is 64 percent, and the system is under stable conditions. In another test, we realize the comparation between the simulated model $M=M=1$ and the analytical model $M=M=1$ (see Figure 1). The parameters used in this test are: (*a*) the value for the arrival rate is 60 customers per minute and is maintained fixed, (*b*) the values for the service rate are varying with the follow-ing values = *f*120; 105; 90; 80; 70; 65*g* customers per hour. Results obtained for both models exhibited a variation ranked from 4% to 14%. Then, we conclude that results generated by the designed simulator are reliable.



(a)



(b)

Fig. 1. *Operation of the simulator: (a) Behaviour of the server utilization and the number of actives cashiers C when arrival stream is bigger than service rate, (b) Com-paration between analytical results and simulated results for the queue service model.*

3 SuperMarket queue controller

Determining the optimal number of cashiers is one of the problems that addresses queueing theory. Basically, there are two approaches to solve this problem: (i) Decision cost-based model and (ii) Decision accept-based model [5]. In this work we applied the last approach, in which, the goal is to balance conflicting measurements, like the average waiting time (W_q) and idle server time (X). Generally the values for this variables are adjusted using a subjetive approach for each particular application [5]. In this work, the value for W_q is determined by the simulator queue model under steady operation conditions (<) . The value obtained for W_q variable must be less than 7 minutes (value obtained when the server utilization value is 81%). To determine the idle time value, some re-searchers [5], [8] suggest that optimal values for idle time server are ranking from 20% to 30%. In this work, we consider interval values computed by the simulator of the supermarket queue model under steady operation, then com-puted values for the X variable are ranking from 19% to 33% (very similar with the suggested values). However, it is not always possible to match these values, then the management must to decide the best action. For example, Figure 2 illustrates values for W_q and X variables, when the value of the arrival rate ( ) and service rate ( ) are varying. Taking into account the values observed in this Figure, the optimal number for cashiers are indicated by the shadowed areas. This means, that in the first row the average customer waiting time is 5.43 min-utes (less than 7 minutes) and the idle server time is 18.6% (very close to 19%), then the optimal number for cashier is 1, in the second row the values of waiting time and idle server time suggest that 2 cashiers are the optimal number under this operation conditions.

Next, we are interested in determining the optimal number of cashiers during a planning horizon (what action should be taken in a particular state of the queue), for getting it, we construct an optimal policy using Factored MDP's.

3.1 MDP for queue control

The policy for the supermarket service queue is defined using an MDP frame-work [11] . A Markov decision process (MDP) is a mathematical framework for sequential decision making problems in stochastic domains. The solution of a MDP provides an optimal policy, a decision rule for each decision time point of the process that optimizes the performance of the system measured by a utility function. This function assigns to each policy, a value according to optimal-ity criteria, which generally is a metrics of the total expected reward over an horizon (finite or infinite). Classical dynamic programming solving methods for MDPs present a big problem: they grow up exponentially when the number of domain features increasing, so, a considerable e ort has been devoted to devel-oping representational methods for MDPs that obviate the need to enumerate the state space, like abstraction techniques [12] and factorized representations [1]. FMDPs [9], [1] allow us to represent complex uncertain dynamic systems

	Cashiers attending					
	1	2	3	4	5	parameter values
Wq	5.43	0.88	0.27	0.26	0.19	μ=65, λ=60
X	18.6	54	73	77	83	
Wq	41.17	1.12	0.57	0.38	0.21	μ=65, λ=70
X	2	48	67	73	81	
Wq	43.5	1.9	0.78	0.56	0.38	μ=50, λ=60
X	1	35	63	71	78	
Wq	52.7	3.74	1.36	0.73	0.47	μ=40, λ=60
X	0.73	28	49	76	77	
Wq	59.7	18	1.85	0.97	0.63	μ=60, =120
X	0.17	6	34	47	63	

Fig. 2. *Illustration of the optimal cashiers attending, the parameter values are deter-minated by the simulator under steady operation conditions, recommended values in each case are appearing by shadowed boxes.*

very compactly by exploiting the problem specific structure. Specifically, the state of the system is described by a set of variables that evolve stochastically over time using a compact representation called a dynamic Bayesian network (DBN) [13].

We defined a FMDP model for the supermarket queues including states, ac-tions and rewards; which are detailed below.

States. The state space in the Supermarket queue model is characterized by three variables. Next, the interpretation of each one is presented:

nca (number of attending cashiers). The valid values[6] for this state variable were obtained from the simulator under steady operation and considering the goals of the designed system: (i) optimizing the number of cashiers and (ii) op-timizing the waiting time (see Figure 2). The optimal values for the *low* interval values were obtained from the variable, then for the interval [0:84 0:91], means that the server utilization is ranked from 84% to 91%.

tep (average waiting time). The valid values for this state variable under steady operation conditions are: *low* [1:8 3:8], *normal* [3:9 5:9] and, *high* [6:0 8:0].

npc (number of customers in the queue). The valid values for this state vari-able under steady operation conditions are: *low* [1:13 2:83], *normal* [2:84 4:54] and, *high* [4:55 6:25].

[6] The unit considered for this variable is a real number indicating the number of cashiers attending.

Actions. In this work we are using an DBN approach to represent actions. At the moment, the actions defined in the MDP model are:

Continue action. The controller selects this action, when the operation of queue supermarket system is in stable conditions. Its e ect on the system is like a null action.

Add a cashier action. When the controller is observing during the planning period that the operation model is under unestable conditions, this means: (i) the average waiting time in queue is *high* is over the *normal* expected value , (ii) the expected number of customers in queue override the *normal* operation conditions, and (iii) the rate of performance is high -over 90%-, then the con-troller indicates that appropriate action is *Add a cashier*. Generally this action is sugested when during the planning horizon the arrival rate is bigger than the service rate, and maintained under that condition during several planning period.

Eliminate a cashier action. This action is suggested when the operation con-dition reported by the queue supermarket simulator is below the *normal* opera-tion or steady condition system is operating with many cashiers .

Rewards. In this work, the reward function represents a compromise be-tween the goal of the supermarket management (optimal cashier number with minimum cost) and the goal of the customers (minimum waiting time). These goals are reached based on the: (i) optimal number of cashiers using an accept-cost model approach (see Figure 2) and, (ii) optimal values for the queue param-eters (*nca, npc, tep*) based on the steady operation conditions of the simulated supermarket queue model (see Figure 3). *Normal* condition of operation is the combination of the two goals.

To solve the FMDP we have used the SPUDD (stochastic planning using decision diagrams) system. SPUDD implements classical value iteration, and uses ADDs to represent value functions and CPTs, this often yields substantial savings in both space and computational time. Figure 4 illustrates the policy obtained with Spudd and that our controller uses to select the best action.

4 Conclusions and future work

We presented the design of a simulator for the queue supermarket combined with a controller based on MDPs. The designed system selects the optimal num-ber of cashiers in a planning period, this decision is based on a minimum cost approach. For developing the proposed system we integrated two powerful tech-niques: queueing theory and decision theory. We provided experimental evidence illustrating that the performance of the simulated model was according with the mathematical counterpart, and the actions selected by the controller were ac-cording the optimal policy constructed by Spudd. FMDPs is an approach to derive an optimal control policy to maximize the expected utility for a planning period, this is a useful

characteristic for a variety of industrial applications, like: machine maintenance, inventory control, plant operation, among others.

	npc			*nca*			*tep*		
	low	*normal*	*high*	*low*	*normal*	*high*	*low*	*normal*	*high*
Elimina-les a cashier	0.7	0. 3	0.0	0.0	0.3	0.7	0.7	0.3	0.0
Conti-nue	0.5	0.5	0.0	0.5	0.5	0.0	0.5	0.5	0.0
Add a cashier	0.0	0.3	0.7	0.7	0.3	0.0	0.0	0.3	0.7

Fig. 3. *Adequate balance between optimal number of cashiers and minimum waiting time. Customers preferences are minimum waiting time: then, many cashiers attend-ing. Supermarket preferences are: minimum cost, but, few cashiers attending. Then, to equilibrate these preferences, and to maintain the operation system under steady operation conditions, prefered action is Continue and prefered value for the state vari-ables is Normal. Prefered actions are represented by a value indicating an associate cost value in the interval 0 1, where 0 value indicates minimum preference.*

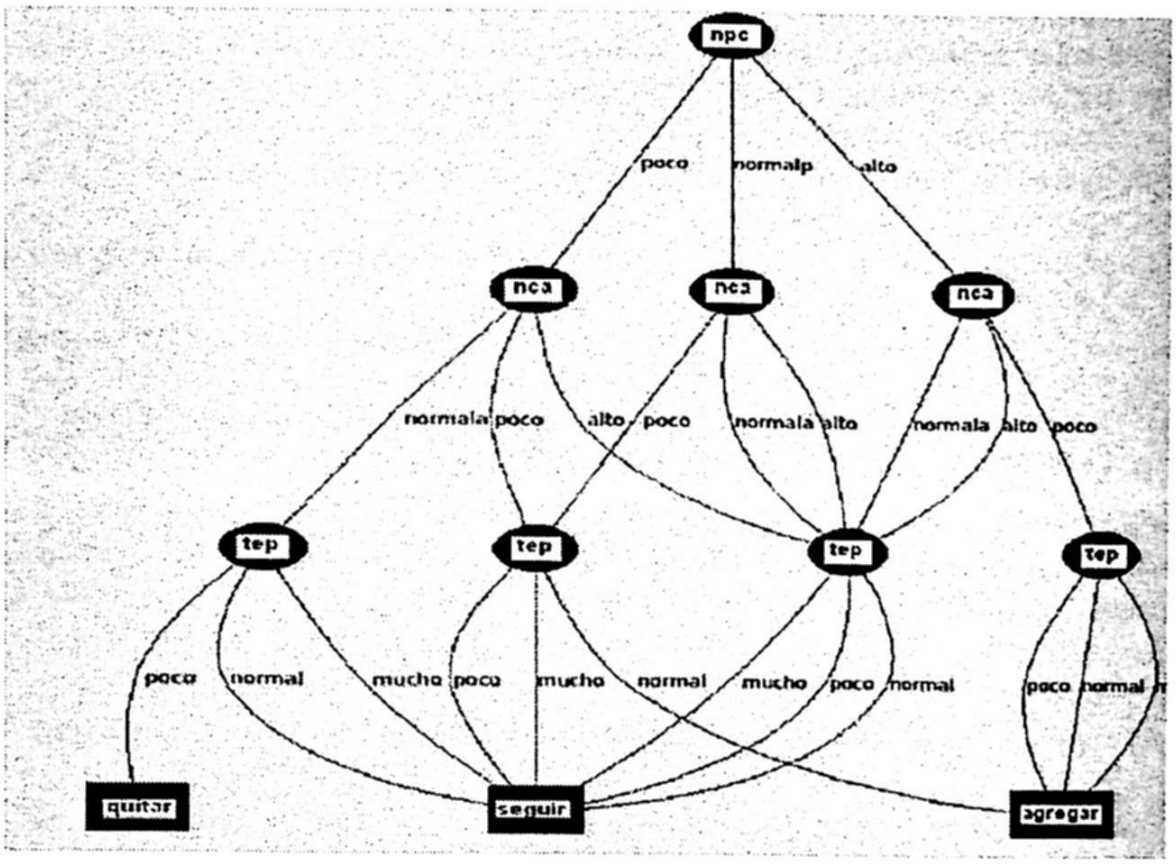


Fig. 4. *Optimal policy computed by Spudd. State variables are the following: npc represents the number of person waiting in queue, nca represents the number of cashiers attending customers, and tep represents the waiting time in the queue, each variable has three values. Actions are enclosed by rectangles, these are the following: eliminate a cashier (quitar), continue (seguir) and add a cashier (agregar).*

At the moment we have assumed that the underlying supermarket queue planning problem is fully observable, but in more general formulations, the con-troller may be able to make noisy observations about the world. Then, such planning problem can be formulated as a partially observable Markov decision process (POMDP) this is the target of future work.

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An innovative data quality diagnostic tool in a business intelligence context

Manuel Mejía-Lavalle, Ricardo Sosa Ríos[1]

Instituto de Investigaciones Eléctricas, Reforma 113, 62490 Cuernavaca, Morelos, México,[1]Centro Nacional de Control de Energía, Comisión Federal de Electricidad, México DF, México

mlavalle@iie.org.mx, ricardo.sosa@cfe.gob.mx

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Abstract. Nowadays, database technology is a computing area with a great growth. Today is common that we can hear about databases with huge volumes of information and also we can hear about Business Intelligence projects related with these huge databases. However, in general, little attention has been given to the quality of the data. Here we propose and present an innovative software tool designed to perform a basic task related to the Data Quality issue, this is, the diagnosis. Our tool takes ideas from the Artificial Intelligence discipline to realize the diagnosis task in an automatic and in a human-like way. The initial results that we obtained when we apply this tool to a very large and real world database encourage us to continue this research.

1 Introduction

Databases are one of the computing areas with more acceptance and growth, especially since the devices for storing large volumes of data have become very efficient and inexpensive. Not many years ago we can found that a database close to the Gigabyte (10^6 bytes) was already very large. Currently is common that we can hear about databases that store, for example, Terabytes (10^{12} bytes) and Yottabytes (10^{24} bytes) of information, and the trend is increasing.
But this high growth has generally accompanied with little attention to data quality that these databases contain, being now more than ever true the old phrase at the beginning of the computer days that said "garbage in, garbage out". And while there is abundant literature on the subject, there are few concrete proposals for software tools that directly address the issue of data quality for large databases.

Given this problem, in this paper we propose and present a software tool designed to perform one of the key tasks related to data quality, i.e. diagnosis, which involves measuring the level of quality in a database. The proposed tool integrates ideas taken from the Artificial Intelligence (AI) area to perform an automatic and human-like diagnosis. This tool has been tested with a very large database of the electric sector and the results that we obtained have been satisfactory, as described in this article.

For developed these ideas, first we will address the issue of Business Intelligence, diagnosis by means of AI and Data Quality in general, and then we will present the tool that we propose, describing a new measure designed by us and used to establish an objective diagnosis of the data quality; also we will describe how this tool operates, being designed in a generic way to work with various databases and platforms; finally

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we will summarizes the results and we will discuss the conclusions and the work to be performed in the immediate future.

2 Business Intelligence, AI and Data Quality

Nowadays, huge corporations are seeking to know more about their business processes. They usually have enormous and valuable data repositories, but they do not know what to do with these data. It is common to hear the phrase: "worse than have too little (or any) data, is to have many data and not knowing what to do with it" [1].
Business Intelligence (BI) can be a useful approach to meet the challenge. BI is focused on transform data into knowledge (or intelligence) to improve corporation central process. At the end, BI is a discipline formed with tools emerged from AI and Database technology, which main purpose is to give people the information or knowledge that they need to do their jobs.
The term BI was coined by Howard Dresner about twenty years ago [2], to describe an emerging discipline concerned with the discovery of information (that was not known before) in a corporation. BI includes methodologies and tools like:

- Data Warehouses [3],
- On Line Analytical Processing (OLAP) and related methods (MOLAP, ROLAP, etc.) [4],
- Knowledge Discovery in Databases (KDD) and Data Mining [5],
- AI areas and algorithms like, for example, Machine Learning, Intelligent Multi-Agents Systems, Artificial Neural Networks, Fuzzy Logic, Case Base Reasoning, Pattern Recognition, Genetic Algorithms, Expert Systems, etc. [6],
- Statistical analysis,
- And, in general, any algorithm, tool or method that serve to transform data into knowledge.

It is predicted that, in the near future, BI will become a need of all huge corporation [2].
But maybe the first great challenge of BI is manage information that contains data with appropriate quality. Speaking in a broad context Data Quality refers to conduct a thorough investigation of the data in the database. This research can be done before to the creation of the database or for those already in operation. It includes determine who are the users of the database, what they need, what is the essence of the business, what are the important variables, how often the information is required, what level of detail is required, with what levels of safety and risk is needed, etc. And, for those databases in operation, we need measure the current quality of information, in order to known and improve that information.
The activities of defining, measuring, analyzing and improving the data in the database results in the total quality management data cycle, which sees information as a product and is a powerful methodology to develop and maintain databases that contain quality data which is required by the business and is based on the principles of quality proposed by Deming [7]. According to Hufford [8] Data Quality consists of

five basic dimensions: completeness, validity, consistency, timeliness and accuracy, which together mean that the data are appropriate for a particular purpose.

Although Data Quality should be a starting point must for every computer system with databases, in practice this objective is not met in most of the cases. And even with a quality system in place, the experts are agree in the sense that any large database can have a 100% quality, as mentioned by the international computer systems analyst company Gartner [9].

Thus, since we cannot achieve a perfect database that meets all the requirements expressed by the Data Quality theory, a remedy to ensure that a database is useful, initially, is to focus only on the dimension named "accuracy", identifying dirty data and diagnosing the quality of data in order to apply cleaning (data cleansing or data cleaning). This cleaning process can include removing those records or variables that, according to some criterion, are dirty, duplicate or unuseful. Another more sophisticated type of cleaning is by means of estimate statistically the possible value of dirty data based on data believed to be clean, or by inferring it, applying AI ideas [10], [11].

A special form of data with noise is when the data is unknown, and then Kononenko [12] identifies several types: forgotten or lost, not applicable, irrelevant, or omitted in the design. Brazdil [13] has proposed ways of dealing with unknown values, and in particular Quinlan [14] has worked with AI top-down induction of decision trees techniques for the handling of unknown values, and has proposed up to seven different treatment schemes.

An important part of data cleaning is to check the consistency of records, i.e., detect whether there are cases with the same values of attributes (or similar) with different classes [15]. A special case is when the cleaning process is over non-numeric attributes, i.e., they are text descriptions, such as names of people, products, address, etc.: in that case the cleaning has to be developed based on an AI parser program to detect similarities and standardize and verify the data [16].
For the innovative software diagnostic tool proposed here, we have used the concepts of BI, AI, Data Quality and data cleaning described above to identify dirty data and thus obtain a general analysis of the database. These topics are detailed in the next section.

3 Proposed Software Diagnostic Tool

Among the objectives of the tool that we present for the diagnosis (in an AI fashion) of the quality of a database, we can mention the following:

- Obtain an initial approach to the problem,
- Getting a general idea of the status of data (global view – focused on the business data),
- Measuring data quality,

- Establishing patterns of data quality,
- To detect critical points in the data, and
- Being able to have a starting point to develop the cleaning business rules to be applied to the data.

To describe the tool that we developed, first we will discuss the metrics that we devised to obtain a numeric indicator of the quality level of the data, in an objective way. Then we will describe how this tool operates, being designed in a generic way to work with various databases and platforms. Finally we will discuss the results that we obtained by applying this tool to a large database of the electric sector.

3.1 Proposed Metric

There are a number of metrics designed to obtain an indication of the quality of the data. In particular we focused our research work on the dimension "accuracy" of data. We seek for a metric that was simple, so it could be easily understood, yet robust, to be able to get data quality information at different levels of data aggregation, i.e. at the attribute level, the table level or at the database level. Additionally, we seek that our metric can accept a weighted schema (assigning costs depending on the importance of each attribute or table), and we seek that it was supported by the experience of other companies related in the quality issue. We also seek that the metric may include different types of dirty data, from the most common, even those who are less frequent. Our metric is based on the "Frequency check" that is used by: Cambridge Research Group [17], Knowledge Integrity Incorporated [18], Business Objects (recently acquired by SAP) [19], Group 1 [20] and Gartner [9], all these are solid companies in the Information Technology area.
In our case, we have one error per each incorrect or missing data, and we sum all occurrences and we named like "#incorrect". The accumulated error is expressed as a percentage according to:

$$\% \text{ Error} = \#\text{incorrect} / \text{total data} \quad (1)$$

where "total data" is obtained in various ways, depending on the level of aggregation. For an attribute the variable "total data" is equal to the total number of records; for a table the "total data" value is obtained by multiplying the number of attributes in the table by the number of records; for a database it is calculated by the sum of the "total data" of each table in the database.
In the event that a field has no data, an error is registered. In the case of an attribute with no data, it is assigned a 100% error to this attribute. In the case of a table with no data, also it is assigned a 100% error to this table.
To assign weights to the attributes or important tables, 100 points should be considered for all attributes of a table. Then these 100 points are distributed according to the importance of each attribute (representing the weight assigned for the user). If we have a total of 10 attributes, each would have 10 points if we want that all the attributes had the same weight. Thus, the weight serves as a factor that is applied to each attribute to obtain the value of "%Error" in a weighted schema. In other words,

"% Error" reflects the fact that there are attributes with greater weight than others. The same idea would be applied to the table level.
According to the above expressed, the quality is calculated as:

$$\text{Quality} = 100 - \%\ \text{ERROR} \qquad (2)$$

Then, if "Quality" is 100% we have a perfect database and if "Quality" takes a value of 50% we can say that the database is wrong in a half of its data. The importance of this measure is that it permits to have an objective measure such that it is able to independently evaluate certain attributes of interest for a particular user, or evaluates a single table that is of particular importance, or show, in a comprehensive manner, the quality of a complete database, all this depending on the special information needs of each user.

3.2 Tool Description

The diagnostic tool that we propose allows for an automatic human-like analysis of the data quality of a specific database, through three aggregation levels: a) Attribute, b) Table, and c) Database. The tool based his diagnosis by means of identify missing values (blanks), zero (never caught), repeated characters, dates and numbers out of range, etc. The diagram in Figure 1 shows the relationship among the several windows that are part of the tool: the hierarchy is shown in terms of how each window interacts with the user.

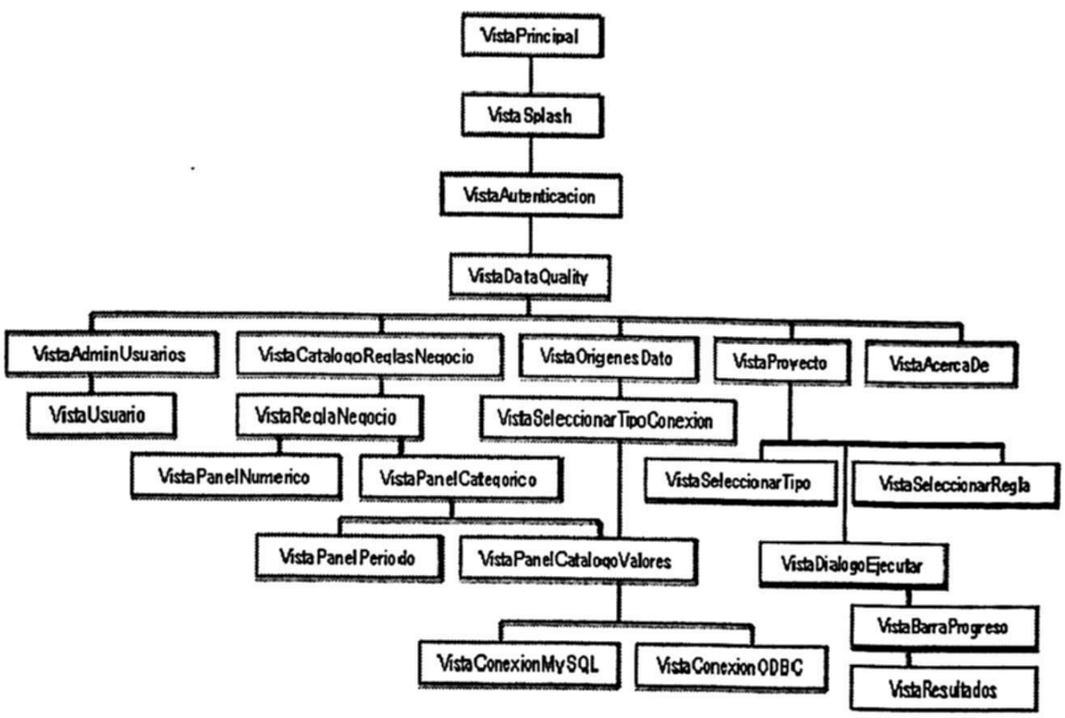

***Fig. 1** Schematic hierarchy windows diagram of the proposed diagnostic tool.*

The central idea to search for and identify bad data is to conduct a count of the number of occurrences of each of the values of an attribute occurs in the table: data that appear very infrequently can be considered as "suspicious", and this basic idea is

applied by us to numerical values and also to text values of an attribute. This idea is detailed paragraphs below.

An innovative feature is that the tool is designed for flexibility, since it has the characteristic of being configurable to access various sources of data (platforms) to create various BI rules that are capable of detecting suspicious quality in data.
The tool has the ability to connect to various data sources by means of JDBC (Java Data Base Connectivity) technology or via ODBC (Open Data Base Connectivity). Additionally, the tool manages business rules and they assist the diagnostic process, serving as indicators to identify incorrect or anomalous values. In our tool it is possible to define a business rule catalog (or knowledge base), which can later be used in different "cases of diagnosis", relating each rule with multiple attributes to support the process of quality data diagnosing.

The business rules are a particular type of production rules, traditionally used in Expert Systems. We design our tool like an Expert System Shell [21] in order to gain several advantages from this area, like: capability to create and increase expert knowledge by means of new production rules, include common sense knowledge, obtain permanent expertise, achieve easy to transfer and document rules, gain consistency, capability to verify knowledge and obtain expertise in an affordable way.

In our tool there are two types of business rules: for text data and numeric data. In the case of text data, the business rule can detect out of range data (only accepts a set of predefined valid descriptions), incorrect data, dates out of range, null data, data with repeated characters and missing data. For numeric data, the tool detects out of range values by grouping into 21 intervals all the data, being the first and last intervals (often with infrequent data) those that can be considered suspect. The basic ideas were taken from the AI area, according to [10]-[16] and from de Data Quality area [9], [17]-[20].

For example, to create a business rule to detect strange symbols, null values and repeated characters, the user just have to select the "Text type" button, followed by the "Special characters" option and click the "Ok" button. To create a business rule to detect values out of range of a numeric attribute, the user only have to select the "Number type" button, then define a valid range and click the "Ok" button. Once defined and stored all the necessary business rules, the user have created a catalog (or knowledge base) of business rules, which may be applied to the attributes which she or he considers necessary and appropriate to link.
The tool also allows to the user to create and store cases of diagnosis: this tool feature allows to the user easily run this pre-defined diagnoses cases, without necessity of rewriting the business rules. This feature is similar to have several domain experts like in Expert System is realized. To do this, the user specifies a title of the event (diagnostic case), the period of data to analyze, the business rules assigned by attribute, and sets the data source, tables and attributes to diagnose. Figure 2 shows a tool interface as an example of how diagnosis cases are introduced using simple graphic elements. We summarize the data quality diagnosis method in Figure 3.

After the execution of a "diagnosis case" the tool automatically generated three types of reports: a) Frequency Values Report: the tool generates an outline of the analyzed data by means of a frequency list of values that each attribute has. If some assigned business rules is related, the report also shows a column with the number of errors found by that rule, b) List of rules applied, and c) List of detail records where errors were detected.

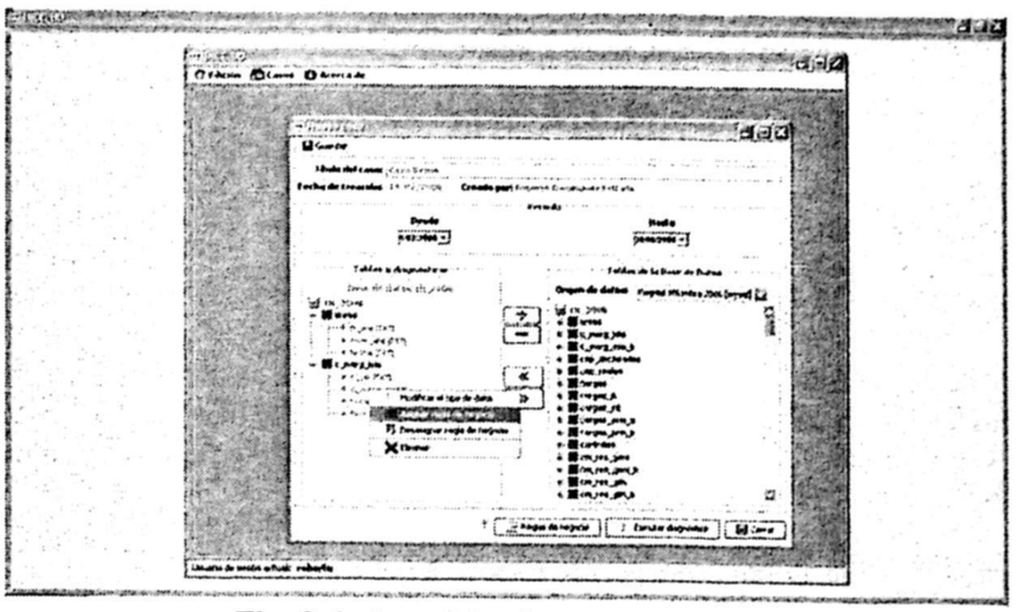

***Fig. 2** A view of the diagnostic tool interface.*

Given a database with M tables, and each table with D attributes and N instances,

1. Initialize variables *%Error*, *Quality*, *#incorrect*;
2. Assign user-expert estimated weights to attributes and tables;
3. For each M, D and N:
   Apply business rules from knowledge base to numeric or text data
   If an error is detected, increment *#incorrect*,
4. Calculate global metrics *%Error*, *Quality* at different aggregation levels;
5. Print quality reports.

***Fig. 3** Summarization of the proposed tool (data quality diagnosis phase).*

At the moment to publish this paper, the data cleaning phase is not applied yet. But the same scheme of business rules for diagnosis can be used for the data cleaning phase. In Figure 4 we show a possible algorithm proposed by us to infer unknown data, following the ideas from [14]. In particular we propose step C2 to use the well known ID3 algorithm applied to the unknown data problem.

3.3 Results

The tool described here was used successfully to analyze and diagnose a large database of the Mexican Federal Electricity Commission (CFE) related with the electricity market. Our tool was capable of analyzed nearly 200 tables containing

more than 2,000 attributes that represents about 2 billion data. With the tool was able to detect whether there were attributes with errors, and if there were some tables more problematic than others. For reasons of confidentiality we do not show details. But in general, we can say that the information obtained using the proposed diagnostic tool is appropriate to improve the quality of the data, like the final users point out during the test period.

A. Find the attribute that better divides the data set into homogeneous subsets: for each attribute, calculate the disorder or entropy according to the following formula:

$$E = \sum_{r} [Nr/Nt] [\sum_{c} \{-(Nrc/Nr) \log_2 (Nrc/Nr)\}]$$

Nr = number of examples in branch r
Nt = total number of examples in all branches
Nrc = total of examples in branch r of class c

B. The attribute which has the smallest value of E is taken as the root node of the tree (attribute-node) and there will be one branch for each value that the attribute has[1].
C. For each value of the attribute-node, select all the examples (rows) with the same attribute value. For each subset do the following:

C1. If all examples belong to the same class, the branch is labeled with the class.

C2. If the subset is empty, find the most similar example (smaller distance) to the current branch; if the distance is acceptable (according to certain threshold previously defined), label the branch with the class of the most similar example, otherwise label the branch as "unknown class".

C3. If the examples in the subset belong to different classes, go to step A, with this subset as the new data set.

D. If there are branches without labels, go to step A, otherwise finish.

Fig. 4 ID3- based algorithm to infer unknown data (data cleansign phase).

In particular, we consider that the results were successful because we can meet the initial project objectives like: a) To obtain an initial approach to the problem: at the beginning we don't know the CFE's databases data quality situation, and after apply the tool we obtain a better idea of the dimensions of the problem and then it could be possible propose to CFE several future action schemes in order to increase database quality, b) To get a general idea of the status of data, detecting in a global view and focused on the business data, the reality of the data, c) To obtain a objective measuring of the data quality, i.e., a qualification or score, that represents a starting point to initiate a total quality management project, d) To establish a group of initial detect critical points in the data that needs immediate attention, and f) To be able to

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[1] The idea of a complete tree was taken from [22].

have a starting point to develop the cleaning business rules to be applied to the data in order to increase in an automatic and human-like way the quality of the database.

4 Conclusions and Future Work

We present a novel software tool for the diagnosis of the quality of data in large databases, in the context of BI and taken ideas from the AI area. In particular we describe an innovative measure in an objective way to measure this quality on the dimension "accuracy" of the data and able to obtain indices at different levels of data aggregation, i.e. at the attribute level, the table level or at the Database level. The results obtained by applying this AI based tool to a large database of the electric sector have been successful, because the tool was capable to detect wrong data immersed in billions of data. With the data conveniently clean, we can now initiate properly a BI development.

As future work, we see that it would be important to add to the diagnosis tool the ability to create business rules to find dirty data in an inter-relationships among attributes way, i.e. to find when one or more data make that other data be "dirty "because they lack the proper context. To give a simple example, one can consider the case of an attribute or field of "personal names" that could be validated against the attribute of "sex of the person", so this require that the name of the person was appropriate to their gender, otherwise, would be marked as an error or a like a wrong captured data. Additionally, we need aggregate a more complete inference mechanism to the tool, in order to take more advantage from the Expert Systems ideas (i.e., symbolic reasoning) and can manage more sophisticated diagnosis schemas. Also it will be important add an explanation facility to justify how the tool reaches a particular data quality diagnosis.

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New codification for genetic algorithms with crossed binary coding

Youness EL Hamzaoui, José A. Hernandez

Centro de Investigación en Ingeniería y Ciencias Aplicadas (CIICAp), Universidad Autónoma del Estado de Morelos (UAEM); Av. Universidad No.1001 Col. Chamilpa, C. P. 62209, Cuernavaca, Morelos, México.
{youness, alfredo}@uaem.mx

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Abstract. Genetics Algorithms (GAs) are based on the principles of Darwins evolution which are applied to the minimization complex function successfully. Codification is a very important issue when GAs are designed to dealing with a combinatorial problem. An effective crossed binary method is developed. The GAs have the advantages of no special demand for initial values of decision variables, lower computer storage, and less CPU time for computation. Better results are obtained in comparison the results of traditional Genetic Algorithms. The effectiveness of GAs with crossed binary coding in minimizing the complex function is demonstrated.

Keywords: Genetic Algorithms, crossed binary coding, mathematical functions.

1 Introduction

In mathematics, a function is a relation between a given set of elements called the domain. and a set of elements called the codomain. The function associates each element in the domain with exactly one element in the codomain. The elements so related can be any kind of thing (words, objects, qualities) but are typically mathematical quantities, such as real numbers. The concept of function can be extended to an object that takes a combination of two (or more) argument values to a single result. This intuitive concept is formalized by a function whose domain is the Cartesian product of two or more sets. A linear function, whose graph is a straight line which has an equation that can be written in the form of $y = mx + b$. However, equations whose graphs are not straight line or they are called nonlinear functions, some non linear functions have specific names. For example, a quadratic function is non linear and it has an equation in the form of : $y = ax^3 + bx + c$, where $a \neq 0$. Another nonlinear function is a cubic function which has an equation in the form of: $y = ax^3 + bx^2 + cx + d$, where $a \neq 0$. In mathematics and computer science,

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optimization, or mathematical programming, refers to choosing the best element from some set of available alternatives. Combinatorial optimization is a branch of optimization. Its domain is optimization problems where the set of feasible solutions is discrete or can be reduced to a discrete one, and the goal is to find the best possible solution. In the simplest case, this means solving problems in which one seeks to minimize or maximize a real function by systematically choosing the values of real or integer variables from within an allowed set. This formulation, using a scalar, real-valued objective function which is probably the simplest example; the generalization of optimization theory and techniques to other formulations comprises a large area of applied mathematics. More generally, it means finding "best available" values of some objective function given a defined domain, including a variety of different types of objective functions and different types of domains.

The increasing importance of nonlinear programming with mathematical programming (MP) is commonly used [1]. Because of the nonlinearity nature in minimization the complex function, unbearable long computation time will be induced by the use of MP when the nonlinear function is somewhat complicated [2]. Severe initial values for the optimization variables are also necessary. Moreover, with the increasing size of the nonlinear function, MP will be futile. Heuristics needs less computational time, and severe initial values for optimization variables are not necessary, but it may end up with a local optimum due to its greedy nature. Also, it is not a general method with respect to the fact that special heuristic rules will be needed for a special problem [3]. Many authors applied traditional Genetics Algorithms (GAs) to solve the problem. Traditional GAs performs effectively and gives a solution within 0.5% of the global optimum. However, traditional GAs has the disadvantage of long searching time and so needs more CPU time. The application of GAs analysis to solve complicated problems has been the subject of numerous review articles. The article published by Çelebi Mehmed describes the new approach based on two explicit rules of mendel experiments and mendel's population genetics for the genetic algorithm [4]. However, we have seen, to solve the proposed problem more effectively, we apply GAs with crossed binary coding method which is developed, an intelligent problem-solving method that has demonstrated its effectiveness in solving complicated problem, and satisfactory results are obtained.

The rest of this paper is organized as follows. Section 2 presents the methodology including the new codification to demonstrate the effectiveness of GAs with crossed binary coding in solving the proposed problem, section 3 presents four problems with three objective functions and their computations results using GAs with crossed binary coding in comparison with traditional GAs are also given. Finally, the conclusions on this work are drawn.

2 Methodology

2.1 Genetics Algorithms

The term genetics algorithms, almost universally abbreviated now a days to GAs, was first used by John Holland and his colleagues [5]. A genetics algorithms is a search

technique used in computing to find exact or approximate solutions to optimization and search problems, however the canonical steps of the GAs can be described as follows: The problem to be addressed is defined and captured in an objective function that indicated the fitness of any potential solution.

A population of candidate solutions is initialized subject to certain constraints. Typically, each trial solution is coded as a vector X, termed a chromosome, with elements being described as solutions represented by binary strings. The desired degree of precision would indicate the appropriate length of the binary coding. Each chromosome, Xi, $i = 1, ..., P$, in the population is decoded into a form an appropriate for evaluation and it is then assigned a fitness score, $\mu(Xi)$ according to the objective.

Selection in genetics algorithms is often accomplished via differential reproduction according to fitness. In a typical approach, each chromosome is assigned a probability of reproduction, P_i, $i = 1, ..., P$, so that its likelihood of being selected is proportional to its fitness relative to the other chromosomes in the population. If the fitness of each chromosome is a strictly positive number to be maximized, this is often accomplished using roulette wheel selection [6]. Successive trials are conducted in which a chromosome is selected, until all available positions are filled. Those chromosomes with above-average fitness will tend to generate more copies than those with below-average fitness.

According to the assigned probabilities of reproduction, P_i, $i = 1, ..., P$, a new population of chromosomes is generated by probabilistically selecting strings from the current population. The selected chromosomes generate "offspring" via the use of specific genetic operators, such as crossover and bit mutation. Crossover is applied to two chromosomes (parents) and creates two new chromosomes (offspring) by selecting a random position along the coding and splicing the section that appears before the selected position in the first string with the section that appears after the selected position in the second string and vice versa (see Figure 1). Bit mutation simply offers the chance to flip each bit in the coding of a new solution.

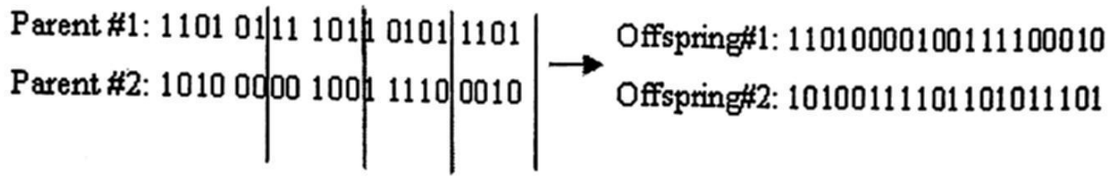

Figure 1. *Four-points crossover operators*

The process is halted if a suitable solution has been found or if the available computing time has expired, otherwise, the process proceeds to step 3 where the new chromosomes are scored, and the cycle is repeated.

2.2 Implementation and Empirical Methods.

Mapping Objective Functions to Fitness Form. In many problems, the objective is more naturally stated as the minimization of some cost function *g(x)* rather than the maximization of some utility or profit function *u(x)*. Even if the problem is naturally stated in maximization form, this alone does not guarantee that the utility function will be non negative for all *(x)* as we require in fitness function (a fitness function must be a non negative figure of merit [5]. In normal operations research work, to transform a minimization problem to a maximization problem we simply multiply the cost function by a minus one. In genetic algorithm work, this operation alone is insufficient because the measure thus obtained is not guaranteed to be non negative in all instances. With GAs, the following cost-to-fitness transformation is commonly used:

$$f(x) = C_{\max} - g(x) \qquad \text{when } g(x) < C_{\max}$$
$$= 0 \qquad \text{otherwise}$$

$C_{\max}$ may be taken as the largest g value observed thus far. For the problem of nonlinear function in this paper, we take this transformation form.

Fitness Scaling. In order to achieve the best results of GAs, it is necessary to regulate the level of competition among members of the population. This is precisely what we do when we perform fitness scaling. Regulation of the number of copies is especially important in small population genetics algorithms. At the start of GAs runs, it is common to have a few extraordinary individuals in a population of mediocre colleagues. If left to the normal selection rule $(pselect_i = f_i / \sum f)$, the extraordinary individuals would take over a significant proportion of the finite population in a single generation, and this is undesirable, a leading cause of premature convergence. Later on during a run, we have a very different problem. Late in a run, there may still be significant diversity within the population; however, the population average fitness may be close to the population best fitness. If this situation is left alone, average members and best members get nearly the same number of copies in future generations, and the survival of the fittest necessary for improvement becomes a random walk among the mediocre. In both cases, at the beginning of the run and as the run matures, fitness scaling can help.

Constraints. We deal with the dimension constraints by coding equations and deal with time constraints this way: a genetics algorithm generates a sequence of parameters to be tested using the system model, objective function, and the constraints. We simply run the model, evaluate the objective function, and check to see if any constraints are violated. If not, the parameter set is assigned the fitness value corresponding to the objective function evaluation. If constraints are violated, the solution is infeasible and thus has no fitness.

Codings. When GAs manages a practical problem, the parameters of the problem are always coded into bit strings. In fact, coding designs for a special problem is the key to using GAs effectively. There are two basic principles for designing a GAs coding [6]: (1) The user should select a coding so that short, low order schemata are relevant to the underlying problem and relatively unrelated to schemata over other fixed positions. (2) The user should select the smallest alphabet that permits a natural expression of the problem. Based on the characteristic and structure of nonlinear function, instead of choosing the concatenated, multiparamerted, mapped, fixed-point coding, crossed binary coding is designed according to the two principles above. The coding method of a nonlinear function is as follows: The studied case considers two optimization variables encoded using a binary system, which consists in altering one bit of each variable. Then we place the highest bit of reach local string at the site from 1st to *n*th in nonlinear function chromosome and place the second highest bit of each local string at the site from (*n*+1)th to 2*n*th, and so on. Then we can obtain a nonlinear function chromosome (see Figure 2).

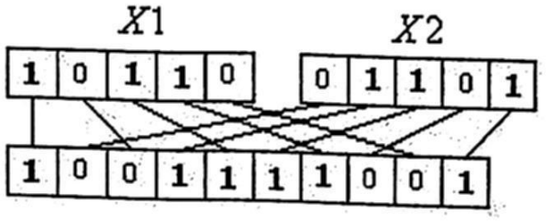

Figure 2. *Illustration of the encoding method for a small size example*

The reason for using crossed binary coding, because this codification is suitable for the continuous and discontinuous variables, and can be analyzed in theory as follows:

- Because of the strong relationship among the parameters, the highest bit in each local string in binary codings determines the basic structure among every parameter, and the second highest bit in each local string determines finer structure among every parameter, and so on for the third, the forth, etc.
- The schema defining length under crossed coding (n) is shorter than the length under concatenated, mapped, fixed-point coding *(nK-K+1).*

According to the schema theorem: short schemata cannot be disturbed with high frequency, the schema under crossed coding has a greater chance to be reproduced in the next generation. Due to its combining the characteristics of function optimization with schema theorem and successful binary alphabet table, crossed coding demonstrates greater effectiveness than the ordinary coding method in our implementation.

Local string formation is achieved this way: for a parameter $x \in [x_{\min}, x_{\max}]$ that needs to be coded, transform it to a binary coding $X \in [0, 2^K]$ first (appropriate length K is determined by the desired degree of precision) and then map it to the

specified interval $[x_{\min}, x_{\max}]$. In this way, the precision of this mapped coding may be calculated as $\delta = \left(x_{\max} - x_{\min} / 2^K - 1 \right)$. In fact, this means that the interval from $x_{\min}$ to $x_{\max}$ is divided into $2^K - 1$ parts, because the biggest binary string that has a length of K equals the decimal number $2^0 + 2^1 + 2^2 + ... + 2^{K-1}$. Then, we can obtain $x = x_{\min} + \delta X$, and a local string for parameter x with a length of K is obtained.

To illustrate the coding scheme to the size variables more clearly, we also want to give a simple example. For the minimization problem: $\min z = f(x, y)$ in which $x \in [300,700]$ and $y \in [700,1200]$, if we adopt a string length of 5 for each local string and X:10110, Y:01101 is an initial solution, we will get the chromosome 1001110001 (see Figure 3) and obtain:

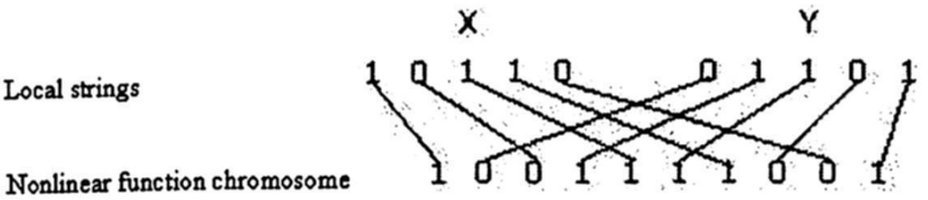

Figure 3. *Multiparameter crossed binary codings*

$$x = x_{\min} + \delta_x X = 300 + \left[(700-300) / (2^5 - 1) \right] (2^4 \times 1 + 2^3 \times 0 + 2^2 \times 1 + 2^1 \times 1 + 2^0 \times 0)$$
$$= 300 + (400/31) \times 22$$
$$= 583.871$$
$$y = y_{\min} + \delta_y Y = 700 + \left[(1200-700) / (2^5 - 1) \right] (2^4 \times 0 + 2^3 \times 1 + 2^2 \times 1 + 2^1 \times 0 + 2^0 \times 1)$$
$$= 700 + (500/31) \times 13$$
$$= 909.677$$

Reproduction. The reproduction operator may be implemented in algorithmic form in a number of ways. In this paper, we take the easiest methods Roulette wheel [6].

Crossover. Crossover operator can take various forms, i.e., one-point crossover, multi-point crossover [7]. It is commonly believed that multi-point crossover has better performance. The number of crossover points in a multi-points crossover operator is determined by the string structure. In this paper, four-points crossover operator is adopted. The crossover rate plays a key role in GAs implementation. Different values for crossover rate ranging from 0.4 to 1.0 were tried, and the results demonstrate that the values ranging from 0.6 to 0.95. In this paper, we take 0.6 as a crossover rate.

Mutation operation. After selection and crossover, mutation is then applied on the resulting population, with a fixed mutation rate. The number of individuals on which the mutation procedure is carried out is equal to the integer part of the value of the population size multiplied by the mutation rate. These individuals are chosen randomly among the population and then the procedure is applied .The mutation rate using in this paper is 0.40.

Elitism. The elitism consists in keeping the best individual from the current population to the next one. In this paper, we take 1 as elitism value.

2.3 Population-Related Factors.

Population Size. The GAs performance is influenced heavily by population size. Various values ranging from 20 to 200 population size were tested. Small populations run the risk of seriously under covering the solution space, a small population size causes the GAs to quickly converge on a local minimum, because it insufficiently samples the parameter space, while large populations incur severe computational penalties. According to our experience, a population size range from 50 to 200 is enough our problem. In this paper and according to our experience, we take 200 as a population size.

Initial Population. It is demonstrated that a high-quality initial value obtained from another heuristic technique can help GAs find better solutions rather more quickly than it can from a random start. However, there is possible disadvantage in that the chance of premature convergence may be increased. In this paper, the initial population is simply chosen by random.

Termination Criteria. It should be pointed out that there are no general termination criteria for GAs. Several heuristic criteria are employed in GAs, i.e., computing time (number of generations), no improvement for search process, or comparing the fitness of the best-so-far solution with average fitness of all the solutions. All types of termination criteria above were tried; the criteria of computing time are proven to be simple and efficient in our problem. In our experience, 200-1000 generations simulation is enough for a complicated problem as our problem. The best results were obtained when the numbers of generations were taken as 1000 for our problem. However, we need to stress that the Genetics Algorithms parameters for traditional GAs and GAs with crossed binary coding are the same. As shown in Table 1 presents the Genetic Algorithms parameters used in this study.

Table.1 Genetic algorithms parameters

Population size	200
Generation number	1000
Survival rate	0.6
Mutation rate	0.4
Elitism	1

3 Examples and Analysis

Four problems are given here to demonstrate the effectiveness of GAs. The mathematical functions are composed of four problems with three objective functions, each one depending on two independent variables (*X1* and *X2*), the choice of these mathematical functions is due to their particular behavior [8]. The results are presented in Table.1

Table. 1 Results founded by traditional GAs and GAs with crossed binary coding

Functions	Variable X1	Variable X2	Minimum	CPU time(s)*	
				GAs [a]	GAs [b]
Problem 1					
$f_1 = \frac{(x_1-2)^2}{2} + \frac{(x_2+1)^2}{13} + 3$	2	-1	3	10	<1
$f_2 = \frac{(x_1+x_2-3)^2}{36} + \frac{(-x_1+x_2+2)^2}{8} - 17$	2.5	0.5	17	13	<1
$f_3 = \frac{(3x_1-2x_2-1)^2}{175} + \frac{(-x_1+2x_2)^2}{17} - 13$	0.5	0.25	-13	17	<1
$x = (x_1, x_2) \in [-4,4]^2$					
Problem 2					
$f_1 = \frac{(x_1-2)^2}{2} + \frac{(x_2+1)^2}{13} + 3$	2	-1	3	10	<1
$f_2 = \frac{(x_1+x_2-3)^2}{36} + \frac{(-x_1+x_2+2)^2}{8} - 17$	2.5	0.5	-17	13	<1
$f_3 = \frac{(3x_1-2x_2+4)^2}{18} + \frac{(x_1-x_2+1)^2}{27} + 15$	-2	-1	15	20	<1
$x = (x_1, x_2) \in [-4,4]^2$					
Problem 3					
$f_1 = \frac{x_1^2}{2} + \frac{(x_2+1)^2}{13} + 3$	0	-1	3	10	<1
$f_2 = \frac{x_1^2}{2} + \frac{(2x_2+2)^2}{15} + 1$	0	-1	1	10	<1
$f_3 = \frac{(x_1+2x_2-1)^2}{175} + \frac{(2x_2-x_1)^2}{27} - 13$	0.5	0.25	-13	15	<1
$x = (x_1, x_2) \in [-4,4]^2$					
Problem 4					
$f_1 = 0{,}5(x_1^2 + x_2^2) + \sin(x_1^2 + x_2^2)$	0	0	0	10	<1
$f_2 = \frac{(3x_1-2x_2+4)^2}{8} + \frac{(x_1-x_2+1)^2}{27} + 15$	-2	-1	15	20	<1
$f_3 = \frac{1}{(x_1^2+x_2^2+1)} - 1{,}1\exp(-x_1^2 - x_2^2)$	0	0	-0.1	25	<1
$x = (x_1, x_2) \in [-4,4]^2$					

**CPU time was calculated to this method on Microsoft Windows XP Profesional Intel(R)D CPU 2.80 Ghz, 2.99 GB of RAM.*

GAs[(a)]: Traditional GAs

GAs[(b)]: GAs with crossed binary coding.

From these results, we can see that better results are obtained in comparison with the traditional Genetic Algorithms. In addition, GAs with crossed binary coding results in a faster convergence and the computing time is less than that of traditional GAs. This demonstrates the effectiveness of GAs with crossed binary coding in solving the complicated problem quickly.

Now, several works about some important aspects in our implication of GAs and some problems in practice.

The most important of all is the method of coding. Because of the characteristics and inner structure of the nonlineal function, the commonly adopted concatenated, multiparamerted, mapped, fixed point coding is not effective in searching for the global optimum as soon as possible. However, as is evident from the results of application, crossed binary coding method is well fit for the proposed problem.

Another aspect that affects the effectiveness of genetic procedure considerably is crossover. Corresponding to the proposed coding method, we adopted a four point crossover method. It is commonly believed that multi-point crossover is more effective than the traditional one point crossover method. Nevertheless, we find that it is not the case that the more points to crossover, the better. It is also important to note that the selection of crossover points as well as the way to carry out the crossover should take in account the bit string structure, as is the case in our implication. Despite the demonstrated advantages of GAs algorithms, the feeling persists that there is much to learn about effectively implementing a genetic algorithms. One problem in practice is the premature loss of diversity in the population, which results in premature convergence. Because premature convergence is so often the case in the implementation of GAs according to our computation experience. Something has to be done to prevent it. Our experience makes it clear that the elitism parameter could solve the premature problem effectively and conveniently.

4 Conclusions

Genetics Algorithms are applied to minimize nonlineal function. Satisfactory results are obtained. The obtained experimental results showed that the performance of the GA depends on the codification chosen. Moreover, crossed binary coding method is the best schema, with this codification GAs converges faster and the computing time is less than that of traditional GAs. However as it does not seem easy to envisage a method to select in advance the best schema for a given problem instance, in principle the only way is trying various schemas at the same time and take the value provided for the best one.

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Intelligent systems and their application to power systems

Gustavo Arroyo-Figueroa

Instituto de Investigaciones Eléctricas, Gerencia de Tecnologías de la Información
Reforma 113, Col. Palmira, 62490, Cuernavaca, Morelos, México
garroyo@iie.org.mx
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Abstract. The purpose of this paper is to show the relevance of Artificial Intelligence (AI) techniques to support the operation of Electric Utilities. Under the current demanding conditions of operation and the introduction of the smart grids the power system operators require support systems to operate successfully. Intelligent systems have demonstrated their ability to integrate, analyze and process information (incorrect, imprecise or with uncertain) properly and timely. Intelligent systems can be used to support the operation of power systems, such as planning (operation, design, etc), monitoring (fault diagnosis, alarm processing, etc), control (normal and emergency control), information security and quality (unauthorized access, reability), and others. The paper shows some of the efforts developed at the Instituto de Investigaciones Electricas for monitoring, diagnosis, control, planning, learning, and system analisys of power systems.

Keywords: diagnosis, planning, control, data mining, intelligent systems, power systems.

1 Introduction

The growing needs for supplying vast amounts of electricity energy with high quality have necessitated more sophisticated approaches to power systems. A power system can be described by a great variety of processes with multiples state variables, events and disturbances. The processes include power generation, transmission, distribution and energy control.

The above requirements have so far been achieved partly by great efforts of experience operators and partly by automated systems. The computer and information technology have been extensively used in power systems operation. Distributed control systems (DCS) and management information systems (MIS) have been playing an important role to show the plant status.

Despite the remarkable progress in the extent and quality of the automation technology, much still depends on the judgement of human experts, that is "experienced operators" capable of making intuitive and yet efficient decisions on the basis of the comprehensive knowledge of the operation conditions. In non-routine operations such as equipment failures and extreme operation (start up phase, changes

in the load, emergencies, natural disasters etc.), human operators have to rely on their own experience.

The more complicated power system operating problems such as monitoring and control under emergency conditions, security and stability enhancement, load forecast, optimization, training, etc, demands new computer integrated technologies that reduce operator's working burden by providing operation support systems. Artificial Intelligence (AI) has been considered promising to deal with problems that require both, human expertise and heuristic combined.

The potential use of AI techniques in power systems lies in that while there are so many tasks which are difficult to be handled by the conventional approaches, intelligent systems have capabilities of dealing with such problems very efficiently an precisely. The strong motivation for introducing intelligent systems into power systems comes from the following factors which are likely to occur in the alert state, during disturbances, while load shedding, handling alarms, and during system restoration: mass data, complexity of network structure, combinatorial nature of solutions, incomplete information, data conflict [Tamura, 1987]. In power systems, the state variables change over time in response to events and disturbances, as well as the transition of time itself. In these processes, a variable (or signal) exceeding its specified range of normal operation is considered an event, and a sequence of events that have the same underlying cause are considered as a disturbance. During disturbances or faults, the operator must determine the best recovery action according to the type and sequence of the signals received.

The goal of this paper is to show an overview on intelligent system applications to power systems. To identify the potential areas to which intelligent systems can support the operation of power systems. To classify the AI techniques used for power systems. Finally an analysis of the future applications of intelligent systems on power systems is presented.

2 Potential applications in power systems.

The AI applications to power systems can be classificated by the process application [Tamura, 1987]. Some of the potential applications and expected improvement include:

Contingency Analysis – a more robust selection of cases to be studied, an evaluation of the solution accuracy of using a steady state algorithm, and a more concise presentation of the solution results.

Alarm Processing – a more concise statement of the problem and to provide a priority to the importance of each alarm.

State Estimation – a more complete method of bad data and of blazed data identification, an alternative method of tap estimation, and to adapt the bus section load models of conforming and of nonconforming loads.

External Model Estimation – the buses which should be reduced, the pseudo measurements which are the best indication of the state of other power systems, and an analysis of the present state of the total power system.

Remedial Action – the controls which should be considered, the control order (generation or tap position changes), and the controls which should be used after the next contingency.
Automatic Generation Control – selection of regulation participation factors for units under control, unit not responding logic, and automatic tuning of unit and system parameters.
Economic Dispatch – generation of energy conversion curves, selection of curves, more complete handling of forbidden unit operating regions and valve points.
Unit Commitment – decision of when to re-execute the algorithm, selection of algorithm (e.g., full, sequential or truncated dynamic programming), selection of constraints to be enforced, and models to be used.
Short Term Load Forecast – selection of base curve, selection of weather variables, selection of model parameters (e.g., degree of differencing, number of components in a Multiple Autoregressive Moving Average process), and estimation of the impact of exogenous variables (e.g., Wielson ratings).
Interchange Evaluation -- selection of possible schedules to be evaluated, pricing of potential schedules, and execution of an evaluation algorithm.
Dispatcher's Optimal Power Flow – selection of control variables to use, selection of control variable ordering, and selection of constraints to enforce.
Contingency Analysis – selection of contingencies to be evaluated, selection of equipment loadings to be checked, selection of contingency cases for remedial action.
System Restoration – selection of cranking path(s), selection of load restoration, selection of generation restarting schedule.
Contingency Relay Arming – selection of relays to be armed or disarmed, selection of key system parameters (equipment, status) to be used as triggers, selection of equipment(s) to be removed for each contingency.
Energy Cost Reconstruction – selection of costing algorithm, selection of unit(s) to be used for costing, selection of transaction schedules to be used for costing, and selection of transmission loss model for costing.
Load Shedding – selection of distribution feeders to open which will most likely remedy system overload or voltage violation.
Load Management – selection of load curtailment strategy based upon expected load and weather trends.
Trouble Call Analysis – faster identification of outaged equipment based upon equipment reliability, weather conditions and load demand in addition to customer complaints.

3 Intelligent systems applications for power systems

In the development of Artificial Intelligence systems for power systems it is important to solve the problem of coupling numerical methods (used in engineering) with heuristic manipulation (used in intelligent systems) [Arroyo et al., 1994]. In this work the functions of the intelligent systems applied to power systems are classificated into

six categories, mainly, monitoring, control, planning, learning or training, system analysis and others.

3.1 Monitoring.

Monitoring is the main application of intelligent systems on power systems. Monitoring categories include real time monitoring of sequential events, alarm processing, identification of the cause of alarms, fault diagnosis, identification of process behavior, detection of malfunctions in protective systems, event prediction among others.

3.2 Control.

The operation of the power systems must be optimal considering higher production profits, safer operation, pollution regulations and life extension. Additionally the power system should meet the demanding conditions of the electrical systems. To meet these requirements, the computer and information technology have been extensively used through DCS and MIS. However, these DCS and MIS use a classic PID Controller, which does not have a good performance to meet the demanding conditions of the power systems, especially in non-normal operation. The complexity of these problems and difficulties to implement PID conventional controllers motivate to research the use of advanced control techniques such as intelligent controllers.

3.3 Planning.

A planning system provides a set of suggested actions or operation recommendations to optimize safety and process. The planning system automatically chooses and organizes actions, by anticipating their expected outcomes, to achieve some preset goals. Every time a recommendation is executed, the process state process changes into a new state which directly maps to another recommendation. The sequential concatenation of these recommendations produces an optimal action plan that manages the process behaviour to achieve a desired goal state.

3.4 Learning and training.

Education applications of intelligent systems on power systems is being intensively studied and applied. Training of operators is an important problem faced by power systems: updating knowledge and skills. The process of learning how to control, maintain and diagnose in power systems takes years of practice and training. For safety efficiency reasons it is not recommend training operators on real equipment. The training requirements of power systems ask for powerful interfaces, a more efficient and better adaptive training, using artificial intelligence techniques, adaptive interfaces, simulations tools, learning objects based on multimedia and virtual reality components.

3.5 System analysis.

Systems analysis applications of intelligent systems on power systems include static and dynamic analysis. In the area of static analysis, the applications can be for load flow engine, decision of remedial measures MVar instability index, security assessment, system model validation and user interface of stability program.

4 IIE Intelligent systems applications for support Power Systems

The Electrical Research Institute of Mexico (IIE) has been working in various fields related to operational support of power systems using AI.

Some works have been made about the monitoring, control and planning in power plants. The architecture f an intelligent system for power plant, shown in Figure 1, is integrated by four modules: signal validation systems, monitoring, diagnostic and control [Arroyo et al., 1994].

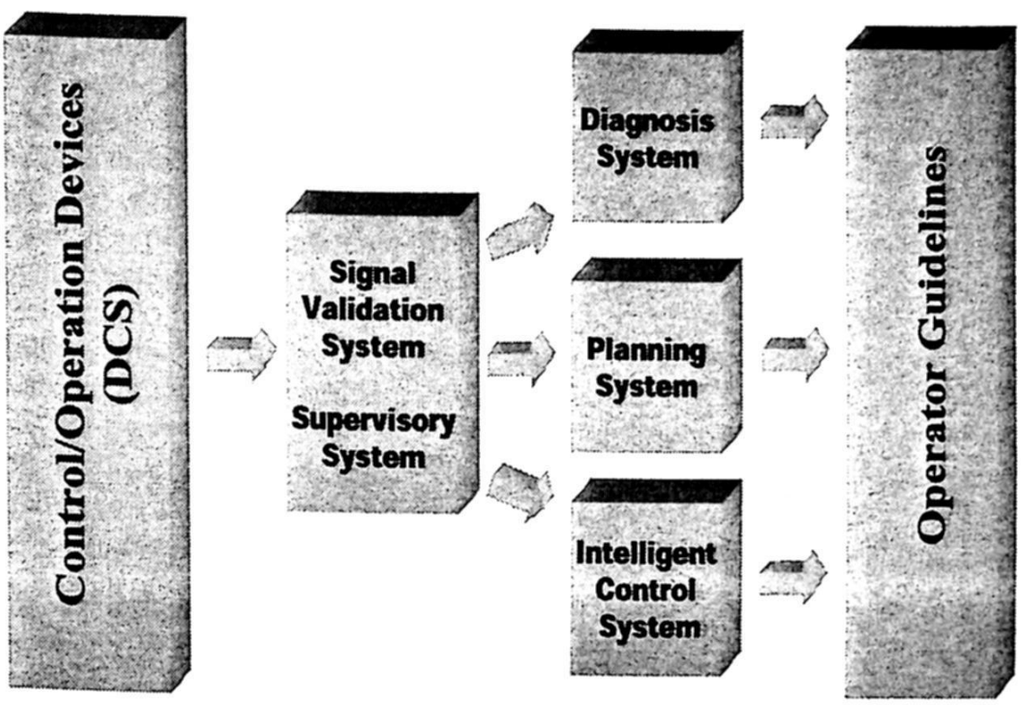

Figure 1. *Architecture of intelligent system for power plants.*

4.1 Signal validation system.

In power systems operation, monitoring and control are complex tasks which require a great number of sensor, alarms and displays. The operator depends on the input data that he receives. The process control assumes that the input data are a set of valid and reliable data. However, due to common cause failures in power plants, the input data may be faulty, and thus, the data may require validation routines. IIE conducted a probabilistic model for validation of sensors [Ibarguengoytia, 2006]. The model

represents relationships between variables using Bayesian Networks and utilized probabilistic propagation to estimate the expected values of variables.

4.2 Monitoring system.

Many monitoring systems have been developed at the IIE for support the operation of power systems. All developed with the aim of showing the status of the process, some of them contain intelligent mechanisms that show operating guidelines in accordance with the existing process conditions.

4.3 Diagnostic system.

The objective of a diagnosis system is to determinate the main cause of a fault or disturbance. The analysis starts when an event (signal out range) is detected by the monitoring systems. The IIE has been working in different approaches for the diagnosis of fault or disturbances based on the following requirements: early detection and diagnosis, isolability, robustness, multiple faults, explanation facility, adaptability, reasonable storage, and computational requirements.

A network of events is a probabilistic network designed to deal uncertainty and time [Arroyo et al., 2005]. In the network each node represents an event or state change and an arc corresponds to a causal-temporal relationship between the events. The inference mechanism consists in the propagation of evidences through the net using a probabilistic inference mechanism. When an event is detected, the inference mechanism updates the marginal probabilities of each node (variable) of the network. This probabilities are used to determinate the most probable disturbance and the most probable event occurrence. An empirical evaluation is presented for a subsystem of power plant, in which this approach is used for fault diagnosis and event prediction with good results. The model can be used for the diagnosis of cascade of anomalies arising with certain delays; this situation is typical when an emergency or abnormal operation is presented. This approach can be extended to other power systems.

Other examples of diagnosis systems developed at the IIE are: on-line diagnosis of gas turbines using probabilistic and qualitative reasoning [Flores, 2005]; on-line diagnosis system using influence diagrams for gas turbine systems [Morales, 2004].

4.4 Control system.

The aim of this system is to control the critical parameters of the power system. The control objective of the power systems steam is to adjust the variables as quickly as possible in response to changes in the electrical utility. The objective is to design a controller that guarantees stable and efficient power system operation under a wide range of abnormal conditions.

The IIE has been working in several approaches for process control. Special interest has been developed in power control and power plant control, given the complexity of the applications. For example the temperature control of the steam generator.

Temperature control is considered to be the most demanding control loop of the steam-generation process. The control of the steam temperature is performed by two methods: to change the spray water in the steam flow, mainly before the super-heater; and to change the burner slope in the furnace, mainly in the reheated. The main objective of this manipulation is to keep constant the steam temperature when a change in load is made. Dynamic Matrix Controller (DMC) and Fuzzy Logic Controller (FLC) were applied to regulate superheated and reheated steam temperature [Sanchez, 2004]. The results show that the FLC controller has a better performance than advanced model-based controller, such as DMC or a conventional PID controller. The main benefits are the reduction of the overshoot and the tighter regulation of the steam temperatures. FLC controllers can achieve good result for complex nonlinear processes with dynamic variation or with long delay times.

Other recent approaches are fuzzy logic controller [Garduño, 2000], neuro-fuzzy controller [Ruiz-Hernandez, 2002], knowledge based controller [Lara, 2002].

4.5 Planning system.

The IIE has been working in an approach for planning system based on markov decision process methodology [Reyes, 2009] wich provide a powerful framework for solving sequential decision problems under uncertainty. Given a problem specification, the objective is to obtain the optimal policy getting the plant to a state under optimal operation. The planning system was tested in the steam generation subsystem of a thermal power plant simulator. The idea is to obtain a control strategy that considers stochastic commands on the valves and, according to an experience-based preference function, maximizes the security in the drum, and/or the power generation. The experiments, developed in a power plant simulator, demonstrated that probabilistic automated planning can solve complex problems successfully.

5 IIE Intelligent systems applications for Learning and Training.

IIE has been working in intelligent systems for learning and training of operators of power systems. An example is the intelligent environment for training; this intelligent environment is composed of four main components (see Figure 2): the domain knowledge module, the tutor, the operator model, and the learning management system (LMS) [Arroyo, 2006].

The first module contains the knowledge of the domain in form of learning objects and concept structure maps. The tutor module is the component that generates the sequence of learning objects to be presented to operator in form of course. Taking as a basis the concept map, the pedagogical component and the operator model, the training course planner generates a specific course for each operator. The operator model is used to adapt the intelligent environment (IE) to each specific operator. The operator model is divided into three subcomponents: cognitive component, operator profile and affective component [Hernandez, 2007 and 2008]. Finally, the LMS controls the interactions with the operator, including the dialogue and the screen layout. The main purpose of an LMS is to present to the operator the learning

materials in the most effective way. In contrast with a classical ITS, the IE builds a course based on cognitive, affective and pedagogical aspects. The intelligent tutor module will be a dynamic course generating system interacting with the operator model to produce training material specific to each operator.

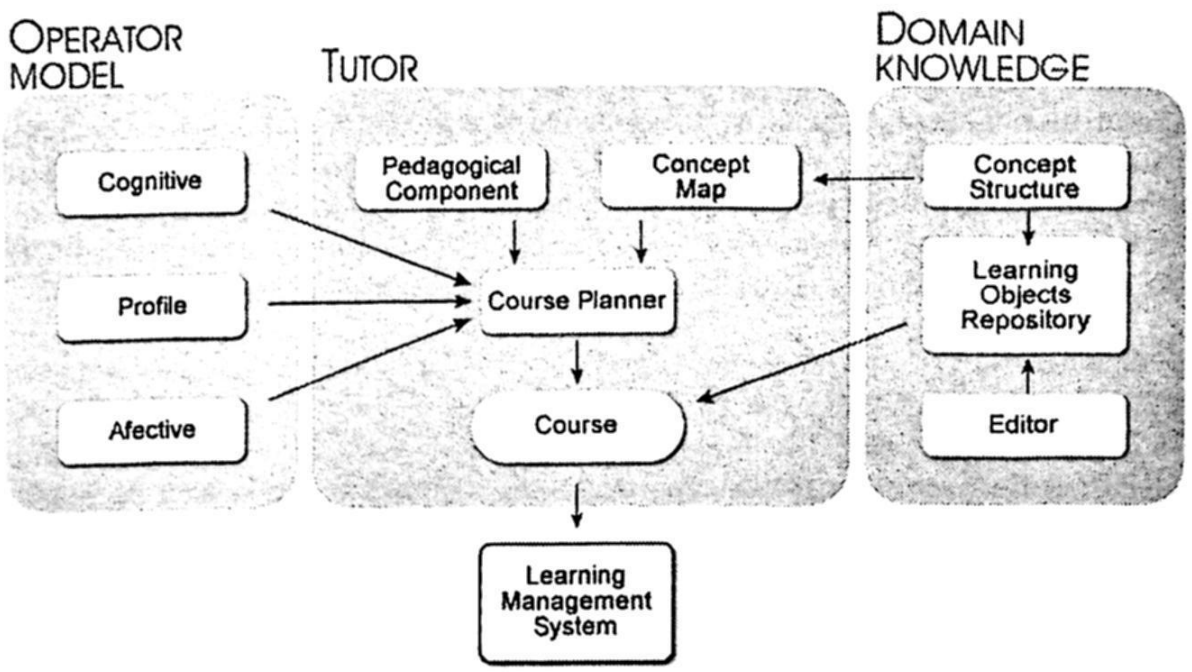

Figure 2. *Architecture of the intelligent environment*

6 IIE Intelligent systems applications for system analysis.

IIE has been working in system analysis to obtain the knowledge that resides in the databases operational, technical and administrative. One example is the knowledge discovery and data mining. Data mining is applied to huge volumes of historical data mainly with the expectation of finding knowledge, or in other words, when it is sought to determine trends or behavior patterns that permit to improve the current procedures of marketing, production, operation, maintenance, or others. Using different knowledge discovery approaches, the IIE has worked in several power systems domains [Mejia, 2008].

The first domain is about electric generator diagnosis using expert systems plus a novel neural network paradigm. The second one is related to flashover forecasting in high-voltage insulators, where we proposed several tools to approach this problem. The third case is about obtaining expert knowledge, applying and comparing well known data mining techniques to hydroelectric and thermoelectric utilities databases. The last case approaches a pattern recognition problem to detect potential electric illicit users, where we proposed and realized a pre-processing feature selection method.

The table 1 presents the successful and bad practices, and comment about possible solutions for future work that we think it have to be done to maximizing the usefulness of the data mining approach.

Table 1. Our experiences and recommendations

Approach used	Advantage	Our contribution	Drawback	Possible solution
Expert System	Representation of human-expert knowledge in a natural way.	Electric Generator Failure Diagnosis Expert System.	Complex elicitation process.	Develop more sophisticated and computer aided elicitation tools.
Neural Network	Captures knowledge from numeric data.	PHAF II Paradigm.	It needs manual tuning. Discovered knowledge is in a black box.	Develop tools for dynamical tuning and to extract knowledge from neural inter-connections.
Induction Tree	Captures and shows knowledge from nominal data in an explicit way.	Tools that combine the ID3 algorithm and the Nearest Neighbor Case-Based Reasoning method .	It needs previous data discretization. Obtained results are not very precise.	Develop tools for automatic and efficient data discretization. Improve output thru post-processing-visualization tools.
Data Mining	Discovers and shows hidden knowledge from data.	Tool conceptualization that combine and integrate a user interface, pre-processing, mining and post-processing facilities.	It needs an integration of the pre-processing, processing and post-processing phases.	Construct a integrated system with: data quality process, final user easy of interpret knowledge representation and visualization tools.
Feature Selection	Detects relevant attributes and reduces problem size.	Metrics and algorithms considering inter-dependencies among attributes.	There is no infallible method.	Research for metrics that evaluate attribute relevance (numeric and nominal data at once) in an effective way.
Bayesian Network	Models that deal with uncertainty and time.	A temporal event bayesian network model (TEBN).	Difficult to scale it for real fossil fuel power plants.	Developing a network structure automatic learning mechanism based on process data.

7 Summary and future work

This paper shows how intelligent systems can support the operation (monitoring, control, and planning) the learning and training and the analysis of power systems, The application of intelligent systems to power systems is an hot area of research. The application of intelligent systems in power system is adequate and useful for solving some problems for which traditional programming techniques are not able to provide good solutions.

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Artificial Intelligence Social Applications

Bayesian Network Application on Information Security

Isai Rojas González, José Omar García Gallardo

Instituto de Investigaciones Eléctricas, Gerencia de Tecnologías de la Información,
Av. Reforma 113, 62490 Cuernavaca, Morelos, México.
{irojas,gallardo}@iie.org.mx

Abstract. This article presents a bibliographic analysis of main applications of Bayesian networks in terms of security. We described an overview of the use of artificial intelligence techniques to create mechanisms that protect information, emphasized in the use of Bayesian logic as the basis for the development of Intrusion Detection Systems (IDS) and predict threats and security risks. We show an oriented probabilistic model of computer security, which had has as main objectives to detect anomalies and to provide predictive information attacks.

Keywords: Bayesian network, computer security, treats predictive, intrusion detection.

1 Introduction

Nowadays, computer systems are of great importance in our lives, one way or another We interact with them and we use data that they provided to us. These systems interconnected through global networks, opening doors for access to the information contained therein. Data is critical, secrets and / or necessary, when this kind of information stolen by an attack, or used improperly, which can cause damage ranging from minor alterations innocuous information to real disaster of global proportions. Therefore, becomes crucial protect the information.

There are several security mechanisms that have developed along the evolution of information, however, computer systems are larger, and complex, it requires to implement more advanced security techniques. Artificial intelligence is a science that emulates human intelligence and learning based on use of computers, this science offers several methods of processing complex information using techniques that developed on robust computer security mechanisms.

Bayesian networks are an artificial intelligence technique, used to determine the probability of occurrence of an event; the determination made through the analysis of relationships between different variables, which influence the occurrence of the event. According to [1], Bayesian networks are "graphical structures to represent the probability relations between a large number of variables and doing probabilistic inference with these variables."

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Computer security Bayesian networks have many different applications, the most commonly used as part of expert systems are focused to detect intruders in computer systems, are also widely used to determine the likelihood of threats or attacks on computer systems.

2 Conceptual Framework

2.1 Information Security

Computer security known as the set of techniques, policies, and controls that allow adequately protect data information systems. We protect information through virtual computer programs such as antivirus, antispyware, firewalls, intrusion detection system (IDS), systems analysis, and prediction of seizures, among others. Information systems often exposed to risks and threats that may affect its availability, reliability, and integrity. The origin of threat usually classified as accidental or natural or provenance deliberate or intentional, in both cases can manifest as disruptions in the continuity of service, interception, modification, and / or data generation. The Bayesian network techniques are use to create computer programs that offer security through classification and prediction of future events using Bayesian logic.

2.2 Artificial Intelligence

Artificial intelligence and intelligent behavior have as main goals produce useful and intelligent machines. We could summarize as the principal goal of artificial intelligence in the "study of the process of thought and intelligent behavior of humans and produce machines and systems that represent these processes" [2]. Then, represent Artificial intelligence into various techniques, each simulating a different section of the reasoning process:

- Fuzzy logic.- Form of multi-valued logic derived from fuzzy set theory to deal with reasoning that is approximate rather than precise and accept values as "certainly true" and "half truly"
- Genetic algorithm.- Heuristic search that mimics the process of natural evolution and genetic raised by J. Holland at 70's. This heuristic routinely used to generate useful solutions to optimization and search problems.
- Expert systems.- Is software that attempts to provide an answer to a problem, or clarify uncertainties where normally one or more human experts would need to be consulted, Expert systems simulate the behavior of a human expert learning, memorizing, reasoning and communicating in a specific knowledge domain used to support take decisions.
- Intelligent Agent. - Autonomous entity, which observes and acts upon an environment and directs its activity towards achieving goals, intelligent agents may also learn or use knowledge to achieve their goals.

- Network neural. – The term used to refer to a network or circuit of biological neurons and interconnect between them; each neuron has an established specific value and way out functions, those factors determine behavior of neural network.
- Bayesian networks. – It´s a model based on fundamentals described in 1763 by Thomas Bayes, based on conditional probabilities and statistics to predict event future.

In [2] details on these and other artificial intelligence techniques applied to computer security issues.

2.3 Bayes Theorem

Bayesian logic is basis on Thomas Bayes' theorem, so it is important to understand it´s operation and implementation. Probabilistic models that aim to predict future events based on known statistics and management of uncertainty variables:

Given two variables X and Y, such that P(x) > 0 for all x P(y) > 0 for all met:

$$P(x_i|y) = \frac{P(x_i) * P(y|x_i)}{\sum_{j=1}^{k}[P(x_j) * P(y|x_j)]} \quad (1)$$

Where *k*: total number elements *x*

"In practice, it is used to determine the posterior probability of some variable of interest given a set of findings [4].

2.3.1 Example

Three machines, A, B, and C, producing 800 beach balls, the production is distributed as follows:

A: 300, 30% reds, 30%blues, 15 % blacks and 25 % whites.
B: 360, 25% reds, 18%blues, 20 % blacks and 37 % whites.
C: 140, 10% reds, 15%blues, 40 % blacks and 35 % whites.

All the balls discharged into a common container without any ranking. Taking a ball at random from the container:

a) ¿Which is the probability that have made for machine C?
b) ¿Which is the probability that besides the ball will be white?

Solution:

a) Probability that: $P(x_i) = P(C) = \frac{140}{800} = 0.175 = \mathbf{17.5\%}$ P
b) Order the data to has a better vision:

Table 1. Occurrences probabilities distribution

P(y|x)	A (x_1)	B (x_2)	C (x_3)
Red (y_r)	0.30	0.25	0.10
Blue (y_a)	0.30	0.18	0.15
Black (y_n)	0.15	0.20	0.40
White (y_b)	0.25	0.37	0.35

Applying Bayes' Theorem has that:

$$P(x_i|y) = P(x_a|y_b) = \frac{P(x_a) * P(y_b|x_a)}{\sum_{j=1}^{a}[P(x_j) * P(y_b|x_j)]}$$

$$P(x_a|y_b) = \frac{0.175 * 0.35}{(0.375 * 0.25) + (0.45 * 0.37) - (0.175 * 0.35)}$$

$$P(x_a|y_b) = \frac{0.06125}{0.09375 + 0.1665 + 0.06125} = \frac{0.06125}{0.3215} = 0.1905 = \mathbf{19.05\%}$$

2.4 Security Ontology

In philosophy, ontology is the study of the nature of being, existence, or reality in general, as well as the basic categories of being and their relations. For example the relationship that exists in a universe (red), and an individual (the apple), or the relationship between an event and its participants.

In computing, the term adopted to refer to the formulation of a detailed and rigorous conceptual schema within one or multiple domains, in order to facilitate communication and interchange of information between different systems and entities.

Today, the concept of computing is widely used ontology in artificial intelligence. In some applications, several schemes are combining in a full facto structure of data containing all relevant entities and their relationships within the domain, under this approach, software used for purposes such as inductive reasoning, data classification, and various problem-solving techniques.

The ontology information is use to feed data to patterns of Bayesian networks. The data provided deducted under the assumptions of ontology, analysis of the participating entities and their relations of domination.

3 Bayesian network applications

Bayesian networks use Bayesian logic to represent the model as directed acyclic graphs. Bayesian classification is a technique unsupervised data classification [2]. The prediction methods Bayesian networks are widely used in computer security

issues, for example, to filter spam e-mails messages, are often used Bayesian networks to determine whether the words contained in the message have a high probability of belonging to a type email spam.
In computer security issues is crucial to anticipate risks and threats to computer systems. Bayesian networks are a powerful tool to determine the probability of attack on information systems. The analysis of these variables is essential for decision-making and adjusts of safety measures.
In general, preventive measures are vital, they seek to anticipate an unwanted event to prevent this happen; however, we must remember that there is no foolproof security as there are sometimes inappropriate or malicious intrusions on information systems. When an intrusion occurs, our security scheme should be able to identify and correct it. In this manner, Bayesian networks are very important to analyze the situation and establish the likelihood of an atypical situation that indicates a possible intrusion.

3.1 Prediction of treats and risks

The National Institute of Standard and Technology (NIST) defines risk management information security as the process that allow to the CIO (Chief Information Officer) balancing operational and economic costs of implementing protection measures and the advantage to have protected information systems and data they contained, which contribute to the mission of the organization [5].
Managing security risks is priority to have identified the risk involved. Understanding as a risk, the probability of an unwanted event occurs affecting the suitable functioning of information system and cause damage to the organization.
The risks that menace the computer systems can be frame in unauthorized access, disclosure of important information, denial of service, loss of resources, vandalism, and sabotage. Threats mainly affect the hardware, software, and data.
Therefore, these phenomena are due to interruption, interception, modification, and generation. The threats in computer security issues are situations that may affect the suitable functioning of an information system, causing inherent risks consequently.
Bayesian networks are widely used to establish and determine the levels of risk information systems. The method used to model the variables identified as important aspects of the process you want to ensure, should consider factors that correlated and infer the probability of risk.
The software can use the point of view of ontology for a variety of purposes, including inductive reasoning, classification, and a variety of problem-solving techniques [6].
In [5] proposes a model to determine the likelihood of threats where T is considered as a set of variables (T1, T2, ..., Tn) and each of them represents a threat whose probability of occurrence should be determined. The proposal is premised on each threat has exactly one value from a finite set of possible values. The figure below shows the proposed model.

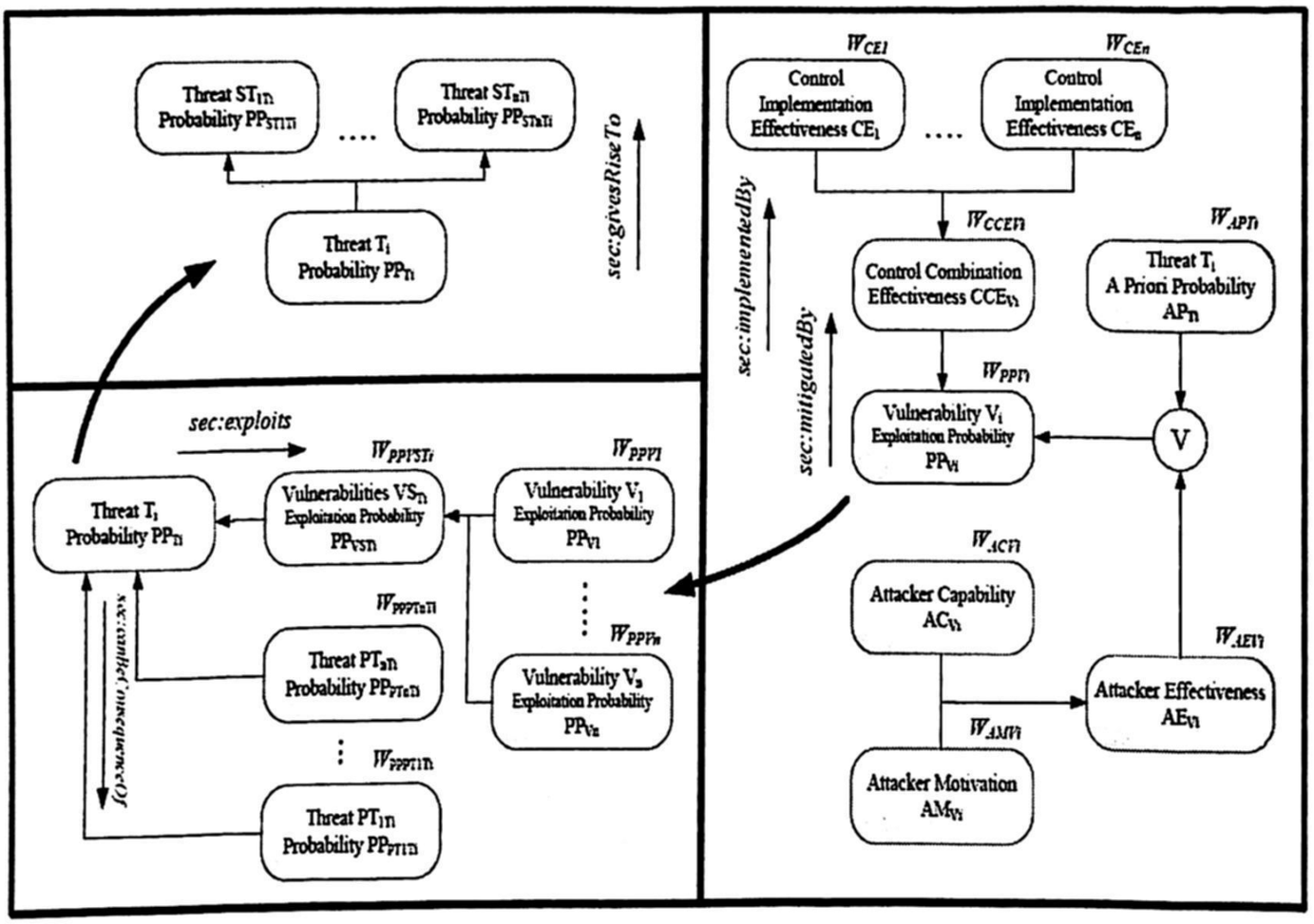

***Figure 1** This diagram utilizes security ontology for the Bayesian threat probability determination.*

The probability of a threat and the influential factors are not determined quantitatively, therefore using a qualitative rating scale, for example, high probability, medium and low. This allows a better understanding human language, providing precise information on model inputs, and obtained results are easier to interpret. Determine the probability of the threat should consider various factors of influence, including the following that have been identified: threats predecessors (PT ¬ 1Ti, ..., PTnTi) that influence the threat in question (Ti) which turn influences threats successors (ST1Ti, ..., STnTi). Each threat (Ti) should include one or more vulnerabilities to become effective, concluding that the probability of the threat has seen significantly affected by the existence of the mentioned vulnerabilities. You can use security controls to mitigate identified vulnerabilities, the degree of mitigation depends on the effectiveness of the possible combination of security controls (CCEVi) which depend on the effectiveness of security controls that are part of this combination (CE1, ..., CEN). We must consider also the threat of deliberate origin, when exist, the likelihood of exploitation of vulnerability is determined by the effectiveness of a potential attacker and this in turn is determined by motivation and capabilities of the attacker. In cases of threats of accidental or natural origin, the probability of exploitation of vulnerability (LVPP) is determined by the prior probability (APTI) of the threat (Ti) corresponding.

Figure 1 shows a proposed model to determine the likelihood of threats using Bayesian networks in combination with ontology in computer security. It's note that the risk managers only need to classify the nodes of motivation (GAVI) and capacities (ischemic stroke) of the attacker. The rest of the inputs and intermediate nodes are deriving by security ontology. The results of each extinction risk interpreted as a distribution of values chosen as a rating scale, for example, high probability, medium, and low.

The concept of *sec: Probability* and *property sec: security* ontology probability distribution is relations that connect each threat of a particular physical location with its prior probability. The specific gravities of all threats equally distributed according to threats and vulnerabilities influential.

The advantage of Bayesian determination of the probability of threat is that it provides the manager of risk management, a structured methodology to determine the likelihood of the threat, adding security ontology [6].

3.2 Intrusion detection

Computer systems are susceptible to attacks and security breaches, this happens despite preventive safety measures have been implemented. This kind of situation is imperative to detect the anomaly as soon as possible, to make good decision. The intrusion detection systems (Intrusion Detection System, IDS) are widely used to address security threats in computer networks. We could define Intrusion detection as the process to identify malicious behavior that threatens the computer network and its resources [7].

There are various types of intrusion detection systems, some are based on "misuse" (Misuse-based), this type of system uses a list of alerts of attacks, the descriptions are tested against data obtained from audits and monitoring systems, what is done in the comparison is to look for evidence that matches any of the attacks previously cataloged. The disadvantage of this method is that it can detect unknown attacks, because the detection based on documented information known attacks.

Another type of IDS's are those based on anomaly detection, this kind of initial information systems use is a reference to determine the normal behavior of users, network traffic, and applications. When there is a deviation in the behavior specified then the event should be classify as an anomalous situation, however, remains to be determined whether this really an attack is.

Systems based on anomaly detection, have the advantage of anticipating attacks by unknown information inference, on the other hand, a drawback of this technique is that it usually has a high rate of false positives, for example: situations identified as intrusions unusual but completely legitimate.

In [7] proposes a model of intrusion detection that combines the techniques of systems based on misuse (Misuse-based) and those based on anomalies (anomaly-based) with the use of Bayesian networks and mechanisms learning. The model describes an operation in which there is an initial registration of known attacks and the events raised these patterns are compared against known,

complemented by the use of anomaly detection techniques, this would cover known attacks and attempts to prevent unknown attacks.

Bayesian networks used in the detection mechanism and classification of anomalies, the heuristic technique used to determine, with any degree of accuracy, the possible existence of a security violation. Together with an additional learning mechanism, analyzes the events that occur and the results of their classification, positive and false positives are stored in a dynamic framework that serves for future comparisons. All this reduces the rate of false positives and thus have a much more robust IDS and effective. This type of dynamic schema naturally becomes a work environment adaptive and evolutionary. The intrusion detection model proposed in [8] consists of six modules as shown in Figure 2. Data gathering module (sensors) and parsing, is responsible for collecting data and analyzing the monitored network connections. The connection understood as a session between two hosts on the network. The Bayesian Network Inference module is the IDS analysis engine responsible for processing the information gathered by the sensor. The knowledge base (Knowledge base) contains an intelligent model (Bayesian Model) which learns from observing the traffic and has the ability to predict when a network connection is an attack. The system configuration (System Configuration) provides information about the current state of IDS. The component of response (Response) triggers actions when an intrusion detected. The Bayesian Network Learning module used to generate knowledge from training data set that is not online.

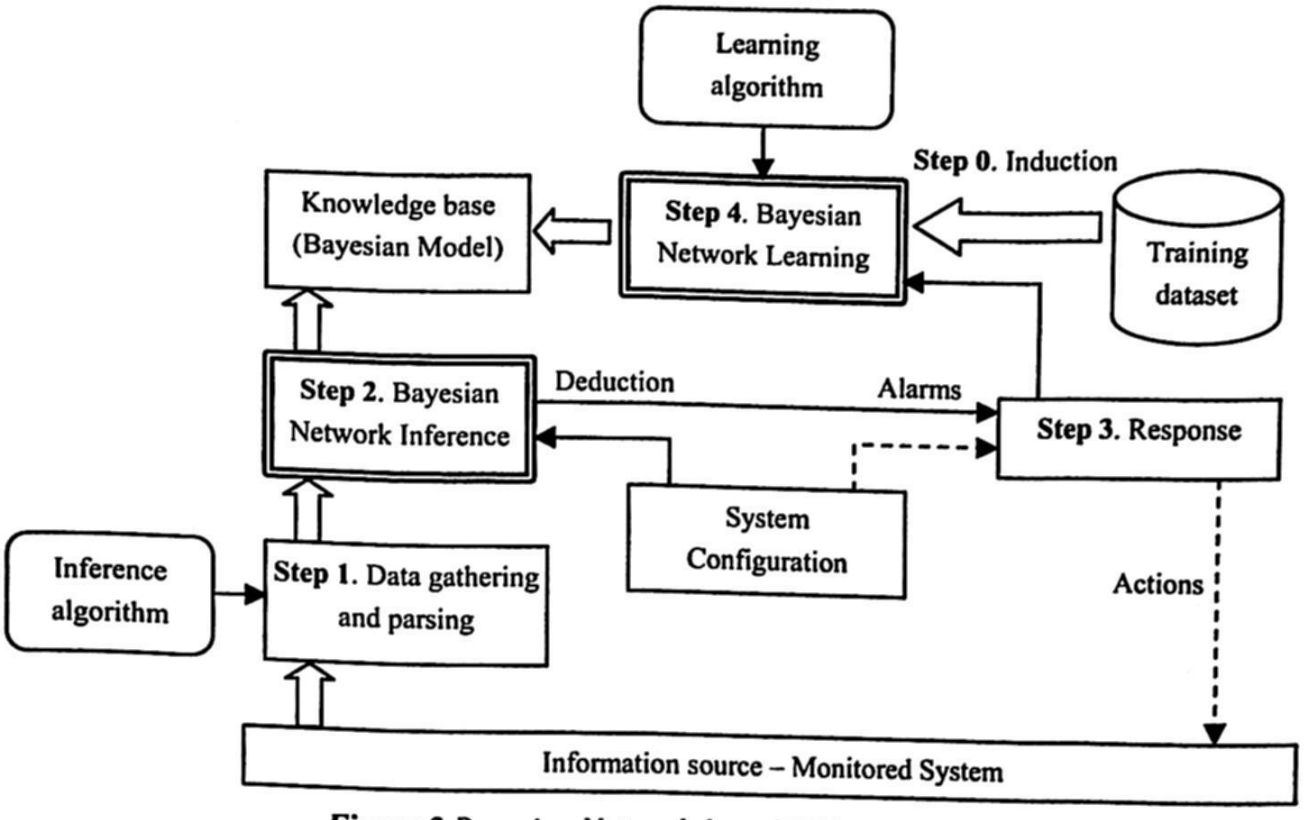

***Figure 2** Bayesian Network-based IDS architecture.*

4 Conclusions

Throughout this article, we noted that several artificial intelligence techniques used to implement powerful computer security mechanisms. These systems, which simulate human intelligence and reasoning, may be as large and complex as needed; This must determined by the balance cost - benefit to be made for each organization. Bayesian networks are a very valuable contribution of artificial intelligence, the method is widely used in various fields of knowledge [9] [10].

The application of Bayesian networks, security systems, provides mechanisms that are more robust and efficient to establish appropriate measures of protection of information. Based systems using Bayesian networks, are often highly effective and have a very low error rate, however, consider that the accuracy of such systems directly related to the clarity, precision and accuracy of data input, which used as initial variables and influence. The use of qualitative ratings in the range provides better management of both the input information, and the interpretation of results. Finally, we note that, due to the high dependence of the input values should be further research on more accurate methods for the collection, storage and delivery of the initial information required by the systems, the purpose is to ensure maximum accuracy and precision possible in the results of probability calculations that perform Bayesian networks.

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Outlier analysis for plastic card fraud detection a hybridized and multi-objective approach

Arturo Elías_Ramírez, , Alejandro Padilla_Díaz
[1] Universidad Autónoma de Aguascalientes
{aeliasr,apadilla}@correo.uaa.mx
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Abstract. Nowadays, plastic card fraud detection is of great importance to financial institutions. This article presents a proposal for an automated credit card fraud detection system based on the outlier analysis technology. Previous research has established that the use of outlier analysis is one of the best techniques for the detection of fraud in general. However, to establish patterns to identify anomalies, these patterns are learned by the fraudsters and then they change the way to make de fraud. The approach applies a multi-objective model hybridized with particle swarm optimization of typical cardholder's behavior and to analyze the deviation of transactions, thus finding suspicious transactions in a non supervised scheme.

Keywords: Credit Card Fraud, Outlier Detection, MOO, PSO, Unsupervised scheme.

1 Introduction

Fraud is an activity almost as old as mankind, which tries to take advantage of some kind, usually economic, by the fraudster with respect to shame. Specifically in the case of plastic card fraud there are several variants [1]. The total cost of plastic card fraud is high relative to other forms of payment. The first line of defense against fraud is based on preventive measures such as the Chip and PIN cards. Subsequent methods are used to identify potential fraud trying to minimize potential losses. These methods are called fraud detection systems (FDS) and usually employ a variety of proposals with the idea of detecting the majority of potential fraudulent behavior.

There are two major frameworks to detect fraud through statistical methods. If fraud is conducted in a known way, the pattern recognition techniques are typically used, especially supervised classification schemes[2]. On the other hand if the way in which fraud is done is not known, for example, when there are new fraudulent behaviors, outlier analysis methods are recommended[3]. Some studies show simple techniques for anomaly detection analysis to discover plastic card fraud.[4].

The idea of the proposal is to use time series in which transactions that have a similar behavior are grouped, so that subsequent transactions that deviate strongly from the clusters formed are candidates to be considered to have an anomalous behavior. The problem with this approach is not always abnormal behaviors are fraudulent, so a successful system must locate transactions that are detected as fraud, but they really are fraud and not only appear to be fraudulent, where time is a factor against it, because to reduce losses, fraud detection should be done as quickly as possible. With this in mind,

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the proposal is strengthened by a multi-objective approach in order to improve the performance of FDS.

The remainder of this paper is organized as follows: Section 2 describes the theoretical framework of the methodologies employed in the paper. In Section 3 we provide some basic concepts to establish the formulate hypothesis for this approach. The proposed method is formulated and discussed in Section 4; In Section 5 implications of the study are presented; Section 6 draws the conclusions with a few lines of open research.

2 Theoretical Framework

2.1 Clusters and Outliers

The clustering is primarily a technique of unsupervised approach, although the semi-supervised clustering has also been studied frequently in recent days[5]. Although often clustering and anomaly detection appear to be fundamentally different from one another, have developed many techniques to detect anomalies based on clustering, which can be grouped into three categories which depend on three different assumptions regarding[6]: a) Normal data instances belong to a pooled data set, while the anomalies do not belong to any group clustered. b) Normal instances of data are close to the cluster centroids, while anomalies are further away from these centroids. c) The normal data belongs to large, dense clusters, whereas the anomalies belong to small and sparse clusters.

Each of the above assumptions has their own forms of detect outliers which have advantages and disadvantages between them.

2.2Particle Swarm Optimization (PSO)

Swarm intelligence (SI) simulates the social and collective behavior of living creatures such as ants, bees and termites[7], but also develops global models of local interaction behavior of artificial agents. Diverse swarm intelligence algorithms have been designed and implemented; some algorithms like ant colony optimization (ACO) and particle swarm optimization (PSO) have been studied and applied in many studies and investigations[8].

In an attempt to find an efficient technique for search and optimization, the PSO algorithm was proposed [9] and later was explained in detail for them[10]. From the perspective of PSO, a swarm can be defined as '*a population of elements that interact and are able to optimize some objective function through collaborative search of a space*'[11]. PSO does not require information from a gradient of the objective function and method features are developed with simple mathematical operators. Ease of use have caused many designed variants of PSO which was applied in several studies.

In the PSO algorithm, particles fly in the course of a search space and each particle has a corresponding position and velocity at any instant of time. The position of a particle to the origin corresponds to one of the solutions to the problem of search.

The movement of particles in the search space to new positions means the generation of a set of solutions. The convenience of these solutions is quantitatively measured by a fitness function[12].

When starting the PSO algorithm, the positions of the particles and their velocities are randomly initialized. The position and current speed of the particles is represented by $X_i(t)$ and $V_i(t)$, respectively. As the algorithm evolves, the positions of the particles are influenced by positional information, $P_i(t)$. If the position information is evaluated using the complete neighborhood cluster of particles then the knowledge of the position is called the global best or simply gbest, P_g. Furthermore, as small neighborhoods used in the evaluation of the position of particles then the position information is the local best or lbest P_l .[13]

In one dimensional space problem *D*, in each iteration of PSO algorithm, particles using the positional information, P_l and P_g, to adjust their speeds and their subsequent positions as indicated by the following equations

$$V_{id}(t+1) = V_{id}(t) + c1.(P_{id} - X_{id}(t)) + c2.(P_{id} - X_{id}(t)) \quad (1)$$

$$X_{\downarrow}id\ (t+1) = X_{\downarrow}id\ (t) + V_{\downarrow}id\ (t+1)) \quad (2)$$

The update process of the particles is compensated by the random numbers, c_1 and c_2 whose values typically have an upper limit of 2.0[14].

2.3 Multi-Objective Optimization

In real life most of the problems facing not only an objective optimization, actually there are several objectives to be achieved to have the arguments needed to make a decision. These problems must be addressed as a multi-objective optimization (MOO), bearing in mind that generally, the improvement in the achievement of a goal causes deterioration of other or others objectives. So with regard to the problems of clustering approach there are also multi-objective clustering (MOC) proposals. These methods consist in decomposing a dataset into similar groups to optimize multiple objectives in parallel.[15]. Some researchers have suggested that multi-objective search and optimization could be a problem area where evolutionary algorithms (Multi-objective Evolutionary Algorithms (MOEA)) can achieve better performance compared to other search strategies[16], and later other bio-inspired mechanisms was proposed like social behavior [17]. The latest trends in bio-inspired strategies have been collective intelligence or swarm intelligence. For many years scientists have studied ants, wasps and bees because they reach high efficiency from their collective efforts, although a technique that has become popular is the particle swarm optimization. Thus, swarm intelligence has become a valuable tool to optimize operations in different businesses.

3 Research model and Hypotheses

This approach is conducted under premise of improving the efficiency for detect fraudulent activity on plastic card transactions. In order to do this; the system is developed with a foundation of multi-objective clustering, which places the problem of detecting fraud in an appropriate context to reality. In the same way, the system is strengthened through hybridization using PSO for the creation of clusters, then find the anomalies using Mahalanobis distance.

The research model consists of two main dimensions: an unsupervised approach and a hybridized clustering model to identify the standard behavior in card transactions. Fig. 1 describes these claims.

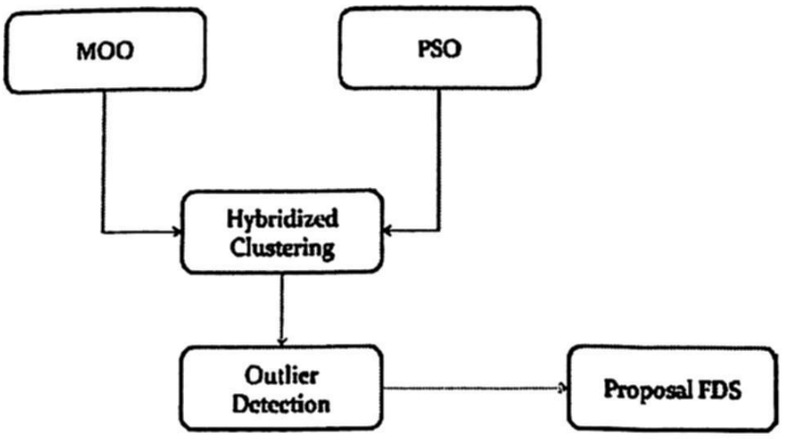

Fig. 1 Research Model

3.1Precision

Overall accuracy is simply the percentage of correct predictions of a classifier on a test set of "ground truth". TP means the rate of predicting "true positives" (the ratio of correctly predicted frauds over all of the true frauds), FP means the rate of predicting "false positives" (the ratio of incorrectly predicted frauds over those test examples that were not frauds, otherwise known as the "false alarm rate".)[18].

Other two types of rates are considered for the results delivered by FDS, FN means the rate of predicting "false negatives" (the ratio of no predicted frauds over all the true frauds) and TN means the rate of predicting "true negatives" (the ratio of normal transactions detected). Table I shows the classification rate of results obtained by the FDS after analyzing a transaction.

The accuracy of the FDS is represented as the fraction of total transactions (genuine and fraudulent) that are detected as correct, which can be expressed as follows [19]

$$Presicion = \frac{\#\ of\ TN + \#\ of\ TP}{Total\ of\ carry\ out\ transaction} \quad (3)$$

Accuracy is the key part of the proper functioning of a FDS. We thus formally

hypothesized:

Hypothesis 1 **(H1).** The level of accuracy determines the success of a FDS.

Table I. Classification rate of results

Outcome	Classification
Miss	False Negative (FN)
False Alarm	False Positive (FP)
Hit	True Positive (TP)
Normal	True Negative (TN)

3.2 Hybridization

As in many aspects of artificial intelligence to detect abnormalities very current trend is the hybridization. The reason is because many developed algorithms do not follow entirely the concepts of a simple classical metaheuristic[20], to solve this problem is looking for the best from a combination of metaheuristics (and any other kind of optimization methods) that perform together to complement each other and produce a profitable synergy, to which is called hybridization[21],[22].

Some possible reasons for the hybridization are: 1.- improve the performance of evolutionary algorithms, 2.- improve the quality of solutions obtained by evolutionary algorithms and 3.- incorporate evolutionary algorithms as part of a larger system.[23].

The different instances of hybridization of metaheuristics with *bio-inspired and evolutionary algorithms* (BEAs) can be grouped into different categories. The first two groups are derived from well developed taxonomy for hybridization of metaheuristics[21], which developed on the basis of their control strategies: collaborative hybrid metaheuristics and integrative hybrid metaheuristics. A third method to construct hybridization of metaheuristics with evolutionary algorithms is through the incorporation of the intensification and diversification (I&D) which are the two biggest issues when designing a global search method [20] where a component I&D is defined as any algorithmic or functional component having an effect of identification or diversification in the search process. Hybridization is a technique that aims to improve the performance of metaheuristics and BEAs. We thus formally hypothesized:

Hypothesis 2 **(H2).** The hybridization affect positive the process of cluster construction.

3.3 Multi-objective Pareto Front Clustering

Bio-inspired and evolutionary algorithms have been the most frequently used for clustering. However previous research in this respect has been limited to the single objective case: criteria based on cluster compactness have been the objectives most commonly employed, as the measures provide smooth incremental guidance in all parts of search space.

In recent years there has been a growing interest in developing and applying BEAs in

multi-objective optimization[24].

The recent studies on BEAs have shown that the population-based algorithms are potential candidate to solve multi-objective optimization problems and can be efficiently used to eliminate most of the difficulties of classical single objective methods such as the sensitivity to the shape of the Pareto-optimal front and the necessity of multiple runs to find multiple Pareto-optimal solutions.

In general, the goal of a multi-objective optimization algorithm is not only to guide the search towards the Pareto-optimal front but also to maintain population diversity in the set of the Pareto optimal solutions. In this way the following three main goals need to be achieved: (i) maximize the number of elements of the Pareto optimal set found; (ii) minimize the distance of the Pareto front produced by the algorithm with respect to the true (global) Pareto front (assuming we know its location); (iii) maximize the spreads of solutions found, so that we can have a distributions of vectors as smooth and uniform as possible[25].

Currently PSO has been presented as an efficient population-based heuristic technique with a flexible and well balanced mechanism to enhance and adapt the global and local exploration capabilities. So, the relative simplicity of PSO and its population based approach have made it a natural candidate to be extended for MOO [17].

Hypothesis 3 **(H3).** The multi-objective Pareto front solution using PSO affect positive the process of cluster construction.

4 Research Methodology

The FDS is running on the plastic card issuing institution. When a transaction arrived is sent to the FDS to be verified. The FDS receives the card details and purchase value to verify if the transaction is genuine, by calculating the anomalies, based on the expenditure profile of each cardholder, purchasing and billing locations, time of purchase, etc. When FDS confirms that the transaction is malicious, it activates an alarm and the financial institution decline the transaction. The cardholder concerned is contacted and alerted about the possibility that your card is at risk.

To find information dynamically observation for individual transactions of the cardholder, stored transactions are subject to a clustering algorithm. In general, transactions are stored in a database of the financial institution, which contain too many attributes. In this paper we analyze three factors, the amount spent, time and location where the transaction takes place. So, if the purchase amount exceeds a certain value, the time between the uses of the card is low or the locations where different transactions are distant are facts to consider activating the alarm.

All this required the calculation of anomalies through the clustering of transaction information through a multi-objective Pareto front with the support of PSO.

Based on the population nature of PSO, it is desirable to produce several (different) non-dominated solutions with a single run. So, as with any other evolutionary algorithm, the three main issues to be considered when using PSO to multi- objective optimization are: (i) how to select g_{best} particles in order to give preference to non-dominated solutions over those that are dominated? (ii) how to retain the non- dominated solutions found during the search process in order to report solutions that are non-dominated with respect

to all the past populations and not only with respect to the current one? Also it is desirable that these solutions are well spread along the Pareto front; (iii) how to maintain diversity in the swarm in order to avoid convergence to a single solution?

When solving single-objective optimization problems, the g_{bcst} that each particle uses to update its position is completely determined once a neighborhood topology is established. However in the case of multi-objective optimizations problems, each particle might have a set of different g_{bcst}s from which just one can be selected in order to update its position. Such set of g_{bcst}s is usually stored in a different place from the swarm that we will call external archive denoted as EX_ARCHIVE. This is a repository in which the non-dominated solutions found so far are stored. The solutions contained in the external archive are used as global bests when the positions of the particles of the swarm have to be updated. Furthermore, the contents of the external archive are also usually reported as the final output of the algorithm.

Once clusters are established, new transaction is entered and evaluated in the FDS, to see if it belongs to a cluster set or is outside of him, seeing the transaction as an anomaly and becoming a candidate to be fraudulent.

The idea of the proposal is to work at the level of cardholder's account, keeping in main that the transaction flow of transaction logs is complex (more than 60 fields), including a unique account number. For the i_{th} account transaction has the following sequence:

$$X_i = \{x_t | x_t \in \mathbf{R}^N, t = 1, 2, \ldots\} \quad (4)$$

Where, X_i represents the i_{th} account, while x_t is the sequence of transactions for that account at time t.

Outliers detection conform the aim of this approach. Computing the outliers is a process based on Mahalanobis distance.

Transactions outside of clusters are candidates to be considered fraudulent, however as mentioned above the accuracy of the system is a factor to be considered, which is expected to maximize in order to increase the functionality of the FDS. Fig. 2 shows the idea of the full flow of the process proposed for the FDS.

5 Implications

Evaluate FDSs for plastic cards' using real data is too complex. Banks are generally not agree to share their data with researchers, as well as the absence of a data set for comparison (benchmark) available for experiments[1, 26]. Therefore large-scale simulation is developed to prove the effectiveness of the system. Simulator is used to generate a mixture of genuine and fraudulent transactions. The number of fraudulent transactions in a defined amount of mixed transactions is normally distributed with mean and standard deviation specified by the user, taking the cardholder's spending behavior in his account. The mean specifies the average number of fraudulent transactions in a given transaction mix. In a typical scenario, the FDS of the card issuing institution receives a large number of genuine transactions mixed moderately with fraudulent transactions, where legitimate transactions are generated from profiles of cardholders.

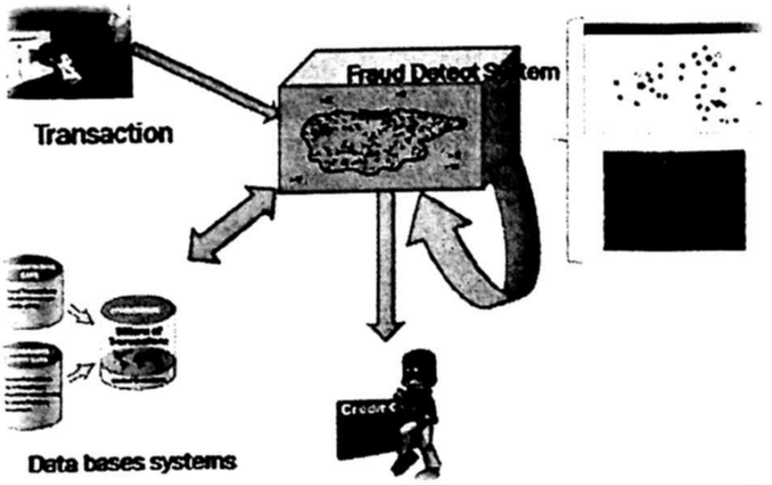

Fig. 2 Full flow of the process

6 Conclusions

It is noteworthy that achieve exact replication of the problem is not possible; although it is assumed that many of the more general features of the data used could be reproduced in subsequent data. Fraud, however, is a known phenomenon changing in response to market conditions, as well as to measures taken by financial institutions against it, so it is quite possible that not only this but any proposal made in this regard not be accurate and universally applicable, although a fairly good approximation, which is reliable in many cases.

The methodologies for the detection of fraud have their own strengths and weaknesses characteristics. The overall strength of FDS using anomaly detection is the adaptability to new patterns fraudsters, in the particular case of this study is strengthened with the application of hybridization clustering processes giving a greater dynamism to the system and making it look like a promising component within the fraud detection systems with potential advantages in regard to: upgrade and management of the heterogeneity of customers and their transactions, achieving a better accuracy in the results, and greater dynamism in the system.

Additionally, the multi-objective approach place it in a better position compared to other systems, due to the characteristics of fraud detection problem where there are several factors to consider for best results.

Future work establishing the need for FDS to be increasingly proactive in order to adapt to the greatest extent possible so changing the behavior presented by fraudsters.

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Hello from Mars: A Sociolinguistic approach to Mars 500 Twitter

Alberto Ochoa[1], Emmet Kaudallis[2, 3], Arturo Hernández,[4] & Sandra Bustillos[1]

[1]Instituto de Ciencias Sociales y Administración, UACJ; México, [2]ISTC-CNR, Rome; Italy, [3] Kaunas University, Lithuania, [4] CIMAT, México.
cbr_lad7@yahoo.com.mx
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Abstract. The present paper discusses a research related to Sociolinguistics using Weka, a tool that mine information of the structure and content of speech of a Italian Cosmonaut, Diego Urbina Vallessacchi whom participate in Mars 500 project (A simulation of a travel to Mars) with the purpose of discovering hypostasis and parataxis in his speech and in his followers, which consists of relation in formal and informal use of language induced by the relation with another speakers in different languages (He write daily in three languages: Italian Spanish & English), this phenomena has been documented recently, but with few detailed research with truly information, for this purpose we record speeches in Twitter related with a social networking of followers (1600) whom send messages to him during the time of this mission (Mars 500), to explore a detailed sociolinguistics analysis.

Keywords Sociolinguistics, Speech Analysis, Multilanguage analysis.

1 Introduction

Social Data Mining Systems allow the analysis of the society's behavior. These systems do that by mining and redistributing the information on computer files storing the social activity. Although, we generate two general questions to evaluate the performance of such systems: (1) is the extracted information of any value? And (2) is possible to determine if a set of physical separated people can show a similar way of thinking about likes and preferences based on their language spoken?

We made an analysis that provides positive answers for both questions. We live in an age plenty of information. The Internet offers endless possibilities. Web sites to experience, music to listen, chats rooming, and unimaginable products and services offering to the consumer an endless options varying in quality. People are experiencing difficulties to manage the information: they can not and do not have time to evaluate the whole options by themselves, unless the situation seriously forces them to do that. In this paper we try to analyze a group of individuals following a Twitter user, and if he can understood conversations with many people at same time, because this Italian Cosmonaut send these messages in three different languages. A task to

manage information which several internet users must do is "the subject management", searching, evaluating and organizing information resources for a specific subject sometimes Users search for professional interest subjects, some other times just for personnel interest. Our approach to this problem combines social data mining with information about sociolinguistics. In the daily life, when people desire forming part of a social group, without having the knowledge to chose among different alternatives, they trust frequently on the experience and opinions of others. They look for advice in their linguistic-social group with certain likes and ways of thinking. When evaluating the offered perspectives by similar persons to them, or from recognized experts on a subject. For instance, a Usenet of users of Italian origin can recommend certain type of food and where to buy the ingredients also, when registers of these activities exist, these can be analyzed. For our research we need this information to understand how these sites on the web are populated and conformed. Social data mining can be applied to analyze the records generated on the web [5] (answering the question: Which are the most visited sites for the most of people?), online conversations [7] (Which are the sites where people purchase "thematic" things for a community.

This paper is organized in five sections. In section one, we introduce our paper. En section two, we describe our Sociolinguistic approximation focusing in Social Data Mining. In section three we discuss the application of WEKA to confirm the hypothesis of our research. In section four, we discuss the tests made to the analyzed information. In section number five, we discuss the results generated for the tests, and finally on the last section, we give the conclusions of our research.

2 Sociolinguistic approximation

Distinction between emotional grammatical and is not clear but it is possible to be conceited that emotional is pejorative and that thinks that the hypostatical style is superior. An analogy can be realized that "While a masculine oration usually is like a game of Chinese boxes, one fits within the other, a feminine one is like a Rep necklace them united by a thread of Greek is and other similar words", is for that reason that parataxis is common in British prose and the hypostasis are common in Renaissance prose.

2.1 Social Data Mining

The motivation to make an approach by means of applications with Data Mining is based on previous works of Social Data Mining in this research area. This research area emphasizes the role of the collective analysis of conduct effort, rather that the individual one. A social tendency results from the decisions of many individuals, joined only in the location in where they choose to coexist, yet this, still it reflects a rough notion of what the researchers of the area find of what could be a correct and valid social tendency [6]. The social tendency reflects the history of the use of a collective behavior, and serves like base to characterize the behavior of future descendants [3] or another new speaker of a language.

3 System Development

The system will be able to analyze the behavior for three samples of messages from the daily information write by Diego Urbina Vallessachi of a twit list recorded in Twitter: Italian, Spanish & English was used for this purpose, by means of WEKA use, which has demonstrated being an efficient tool for searching hiding parameters that must be discovered [5]. The compiled information was analyzed to discover behavior patterns that share these individuals, and based on their gender (the females tend to send more large messages and with more emotional support), we determine if this behavior was an innate or induced tendency by their linguistic community.

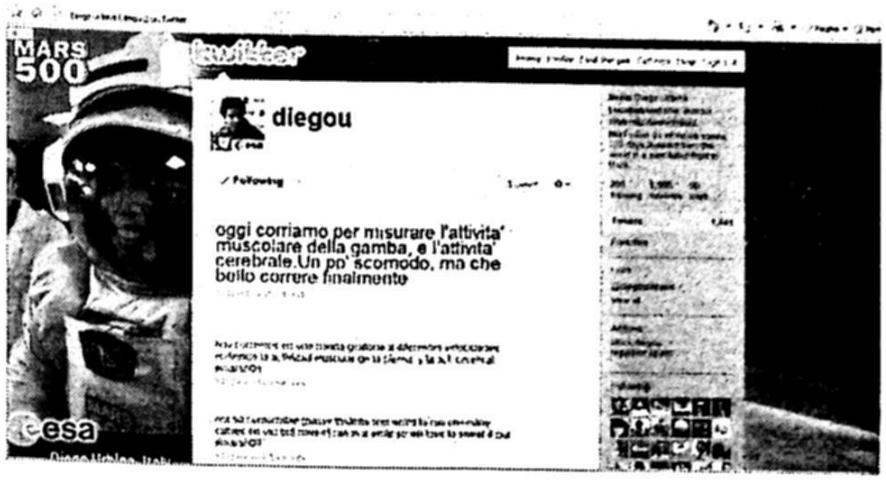

Figure 1. *Twitter's Diego Urbina from the Mars 500 Project.*

The name of Data Mining derives from the similarities between looking for valuable information in great data bases - for example: to find information of the tendencies of the society behavior in great amounts of stored Gigabytes – and mining a mountain to find a vein of valuable metals. Data mining automates the process to find predictable information in great data bases (See Figure 1). Questions that traditionally required an intensive manual analysis now can be directly and quickly answered from data [3].

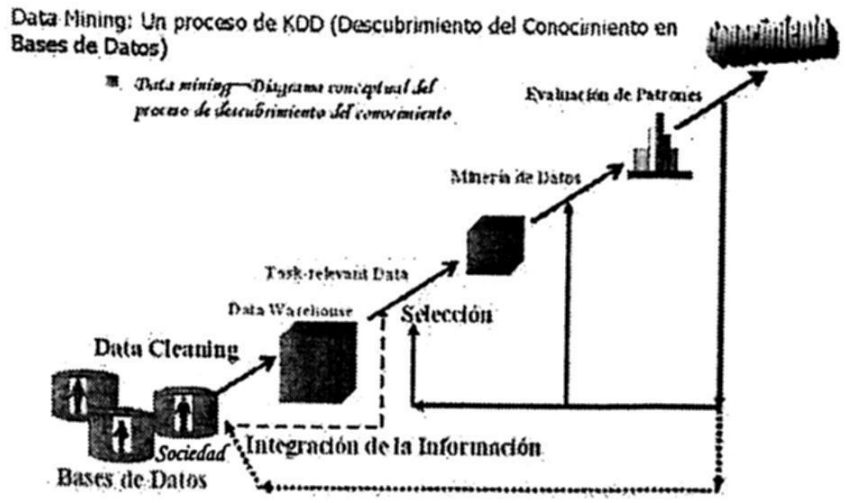

Figure. 2. *Data Mining process.*

The society information inside a *Data bases* is cleaned and stored in a *Data Ware House*, then is mined by means of a loop back *selection* and *patterns evaluation* process processes.

4 Applied tool

Use Data mining tool WEKA to analyze data. First, we proceed to develop a model that allows explain the behavior by three samples of people, and how affects their speech style. Figure 3 and 4 discover the existent relation among hypostasis and parataxis parameters, used by the different languages, the speakers communicate with the Italian Cosmonaut.

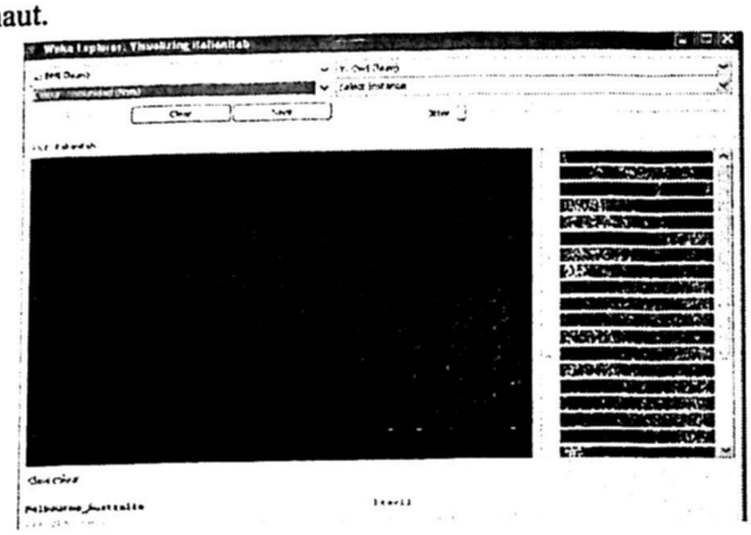

Figure. 3. *WEKA justifying the relation among Hypostasis found in several messages from Mars 500.*

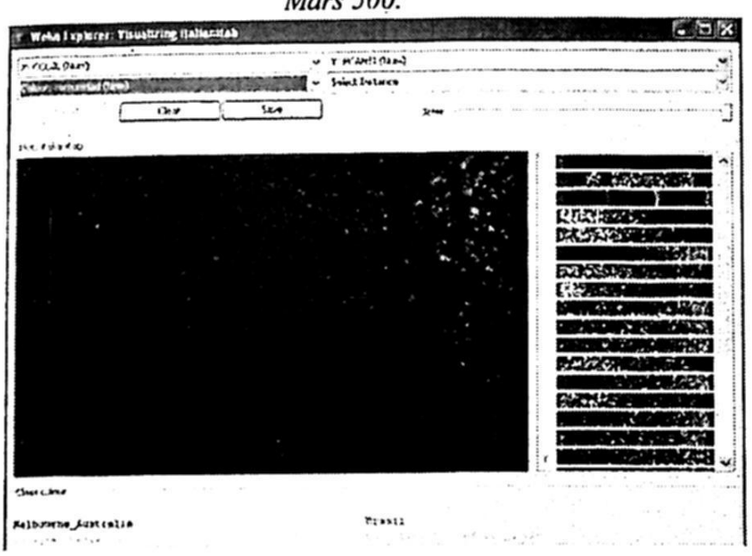

Figure. 4. *Relation of Parataxis found in users of Twitter following to Diego Urbina.*

We found in both cases that the Italian speakers showed a higher hypostasis and lowest parataxis regarding speakers of Spanish & English. This can be explained by the use of informal speech of Italian because they try to assimilate more easy at peo-

ple with commonly ancestors (the mother of Diego Urbina is Italian native speaker), and purchase decision is highly influenced induced by the language Community.

5 Results

We took in consideration a sample of 587 messages send and received (-212 Italian Messages, 190 Spanish Messages & 185 English Messages-) in Diego Urbina's Twitter during four months (04/06/10 – 05/10/10) conformed by three samples (Sample 1 with Italian Messages, Sample 2 with Spanish Messages and Sample 3 with English Messages), and using their conversations in a social networking, to identify different behaviors (See Table 1).

Table 1. Distributions of demands by category and sorted by three analyzed samples.

	Sample 1	Sample 2	Sample 3
Language	Italian	Spanish	English
N	212	190	185
Imperatives	12%	36%	26%
Directives declaratives	5%	6%	7%
Directives of Simulation	11%	4%	5%
Interrogatives Directives	2%	0%	1%
Interrogatives Postscripts	35%	16%	28%
Joint Directive	15%	3%	11%
Explosive Questions	2%	11%	4%
Information Questions	16%	22%	17%
Mechanisms of attraction of the attention	2%	2%	1%
Total	100%	100%	100%

The use of Data mining in social aspects has demonstrated being key part to corroborate the linguistics tendencies of a group established within of a common social networking, we found variations depending the intention of message and the linguistic resource used in different Languages, see Table 2.

Table 2. Contributions realized to the speech by a social networking according at different words including turns used by language.

	Volume of Speech		
People	Total of Emitted Words	Total of Turns	Average of words in turn
Italian	788	127	5.9
Spanish	567	93	6.1
English	492	88	4.2

6 Conclusions

There are an important number of questions that deserve additional research. One will be to find new information sources to mine about the use of these three languages and French language during all time of the Mars mission (520 days).

An area with great potential is the electronic usage of media, specifically, digital music [1]. In [6] is shown a system that learns of the user preferences based on the music listened, after songs are selected to be play on a shared physical environment, based on the preferences of the whole people present, this software has a narrative script to realize recommendations to another users in a free text.

Acknowledgements

We want to thank to ISTC-CNR for its economic support to purchase Social Data Mining books, and to permit use Databases related with Twitter users in Italian Language whom was in communication with the first Italian Cosmonaut Diego Urbina Vallessacchi during the emulation of this isolation experiment.

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Implementing mahalanobis distance to select element in a dyoram gift card

Jesús Rodríguez [1], Cecilia Morales[2] & Raúl Holguín [2]

Instituto de Ciencias Sociales y Administración, UACJ; México, Scholarships MCs Planning and Urban Development at Autonomous University of Ciudad Juarez
(Paper received on September 09, 2010, accepted on October 20, 2010)

Abstract. The paper discusses the importance of Social Modelling in the build of a Dyioram Gift Card selecting a specific number of societies based on their features from a repository of 1077 Societies, Mahalanobis Distance determine the correct classification of societies to approach the cultural diversity in the social system described in Memory Alpha, using at formal methodology regarding to the construction of analysis based on social data mining analysis. A case of study is presented regarding to the construction of a Dyoram Gift Card using data obtained from the diversity of cultural patterns described in Memory Alpha. Some futures conjectures and open future analytical works in the Social Modeling studies are described.
The intention of the present research is to apply the computational properties; in this case of corroborating them by means of mining of data to propose the solution to a specific problem, adapted from the modeled Literature about of Societies. Combined to this, we analyzed the selection and location of diverse societies with respect to their social similarity of its neighbors, in a novel & popular representation denominated Dyoram Gift Card. The set of study allowed to analyze the individual characteristics without affecting the resultant Dyoram (what represents the adequate matching), and emulate the distances that separate each one of them and as a set matching characteristic social, linguistics & cultural which specify a position in the Dyoram. By means of this is possible to predict the best position in the Dyoram, redistributing to the individuals that conform it, this article tries to explain this representation of the social behavior.

Keywords: Cultural Algorithms, Pattern Recognition and Social Modelling.

1 Introduction

The Cultural Algorithms (CAs) are an approach of Evolutionary Compute[1], which uses the culture like a vehicle to store excellent and accessible information to all the members of the population during many generations. Like in a human society, the cultural changes act as advances the time, this one provides a line bases for the interpretation and documentation of individual behaviors within a society [2]. CAs were developed to model the evolution of the cultural component on the time and to

demonstrate how this one learns and acquires knowledge. In agreement with this conception, the cultural algorithms can be used to lead the process of the self-adaptation within evolutionary systems in a variety of diverse social & cultural areas of application to analyze Textile Heritage, Commerce, Social Networking, Languages, Architecture and Dioramas in different representation [9].

The cultural algorithm base can be described by means of the following pseudo code.

```
Begin
t=0;
Initialize POP(t); /* Initialization of population */
Initialize BLF(t); /* Initialization of believing space */
Repeat
Evaluate POP(t);
Vote (BLF (t), Accept (POP(t))));
Adjust (BLF (t));
Evolve(POP(t), Influence(BLF(t)));
t = t +1;
Select POP(t) from POP(t-1);
Until (Term condition is reached)
End
```

Figure 1. - Pseudo code base of Cultural Algorithms.

Initially a population of individuals that represents the solution space, which is represented like a set of solutions within the space search, is generated randomly to create the first generation. In our example, the solution space contains a list of the attributes that can be used in the classification procedure. The space of beliefs is emptiness. For each generation, CAs will be able to involve a population of individuals using "frame" Vote-Inherit-Promote (VIP). During the phase of Vote of this process, the members of the population are evaluated to identify their contribution to the space of beliefs being used the acceptance function. These beliefs allow contributing in most of the solution of the problem and are selected or put to voting to contribute to the present space of beliefs. The belief space is modified when the inherited beliefs are combined with the beliefs that have been added by the present generation, this is made using a reasoning process that allows updating the space of beliefs. Next, the space of beliefs updated is used to influence in the evolution of the population. The belief space is used to influence on the rest of the population and the acceptance of its beliefs is modified. During the last phase a new population is reproduced using a basic set of evolutionary operators. This new population could be evaluated and the cycle continues successively, until all the population has the same space of beliefs [6]. Cycle VIP finishes when a condition of completion is introduced. The condition of term usually is reached when only a small change or no is detected in the population through several generations or when certain knowledge in the space has emerged from beliefs, as it is possible to be appreciated in Figure 2.

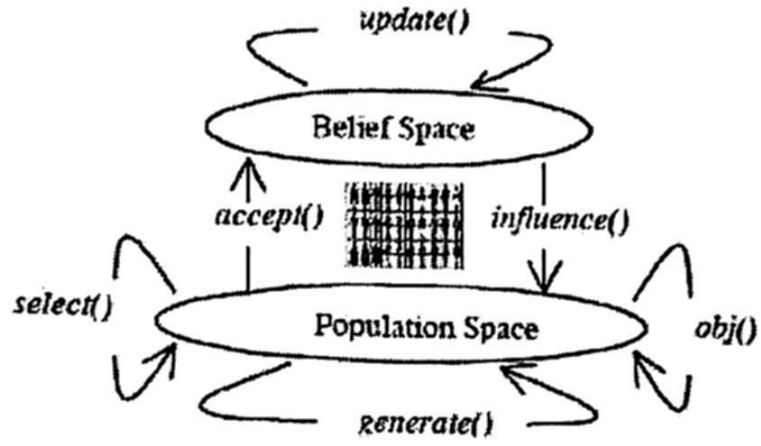

Figure 2. - Conceptual diagram of Cultural Algorithms.

2 Dyoram: the social net representation.

A social network is a social structure that can be represented making use of different types from diagrams. Both more common types are the graph and Dyoram. The graph is a collection of called objects vertices or nodes that are connected by called lines edges or arcs. The nodes represent individuals which sometimes are denominated actors and the edges represent the relations that exist between these actors. The social networks can be classified in: Dyadic, Valued, Transitive &. Directed. The representation of a social network can consist of one or more graphs where these graphs conceptualize the network, that is to say, the representation is made mainly on the basis of the relations that exist between the actors who conform the network. In this article, we focused our attention in a practical problem of the Literature related to the Modeled one of Societies, the select of elements to organize a Dyoram, which allows to include the location that keeps a society with respect to others, the capacity to establish the locations in the Dyoram, allows to establish "the adequate matching with the resultant card gift" for the given set of societies. The solution to this problem could be given by a sequence of generations of agents, denoted like "community". The agents, first realize a matching with the profile of person who was selected to bring this gift, the profile has different attributes with ranges of intensity and magnitude associated with her or his personality, after using Mahalanobis distance is determinate the elements (societies) selected to represent the components of personality associated with the person whom receive the Dyoram Gif card, finally is write a "Narrative Script" which justify the selection of a society according a ons specific behavior in the profile, for example "You are very kin as the Kelemane Society" and the representation show in the Dyoram is kept in a Repository for future new gifts [3]. A Dyoram characterizes a social networking, where the actors conforms the network according to their roll and to the location that each one have within the same. The development of a social networking requires on the one hand, of the conceptual development, and by another one, development of measures of mathematical discreet that allow ontological support to explore the human systems from the data. But it is necessary to prioritize the conceptual development and categories of the system in the social networking, and parallel think about the mathematical model.

3 Distributing elements within a Dyoram Gift Card.

From the point of view of the agents, this problem of optimization is very complex, on account that select a specific number of elements and a location of each one, with respect to the other elements selected. In the algorithm proposed for the cultural change, the individuals in the space of beliefs (beliefscape) through their better paradigm (BestParadigm) are put to zero to represent the fact that the culture increases the amount of expectations associated with the location of a society with respect to the others, giving an incentive to the behavior associated with the best paradigm (BestParadigm). For it we selected 1077 societies described in [4] and characterized their social behavior with base in seven attributes: emotional control, ability to fight, intelligence, agility, force, resistance, and speed, these characteristics allow to describe so much to the society as to the individual. The development of the tool this based on our desire to share the intuitive understanding about the treatment of a new class of systems, individuals able to have empathy, a reserved characteristic in alive people, which will be reactive with its decisions [5].

Formally, the Mahalanobis distance of a multivariate vector $x = (x_1, x_2, x_3, \ldots, x_N)^T$ from a group of values in this case the attributes of each society with mean $\mu = (\mu_1, \mu_2, \mu_3, \ldots, \mu_N)^T$ and covariance matrix S is defined as:

$$D_M(x) = \sqrt{(x-\mu)^T S^{-1}(x-\mu)} \qquad (1)$$

Mahalanobis distance (or "generalized squared interpoint distance" for its squared value) can also be defined as a dissimilarity measure between two random vectors and of the same distribution with the covariance matrix S:

$$d(\vec{x},\vec{y}) = \sqrt{(\vec{x}-\vec{y})^T S^{-1}(\vec{x}-\vec{y})} \qquad (2)$$

If the covariance matrix is the identity matrix, the Mahalanobis distance reduces to the Euclidean distance. If the covariance matrix is diagonal, then the resulting distance measure is called the *normalized Euclidean distance*:

$$d(\vec{x},\vec{y}) = \sqrt{\sum_{i=1}^{N} \frac{(x_i - y_i)^2}{\sigma_i^2}} \qquad (3)$$

where σ_i is the standard deviation of the x_i over the sample set. The Dyoram Gift Card resulting after to apply Mahalanobis Distance is presented in Figure 3 which included 33 Societies and its Narrative Script justify the selection of each one from the Repository with 1077 Societies.

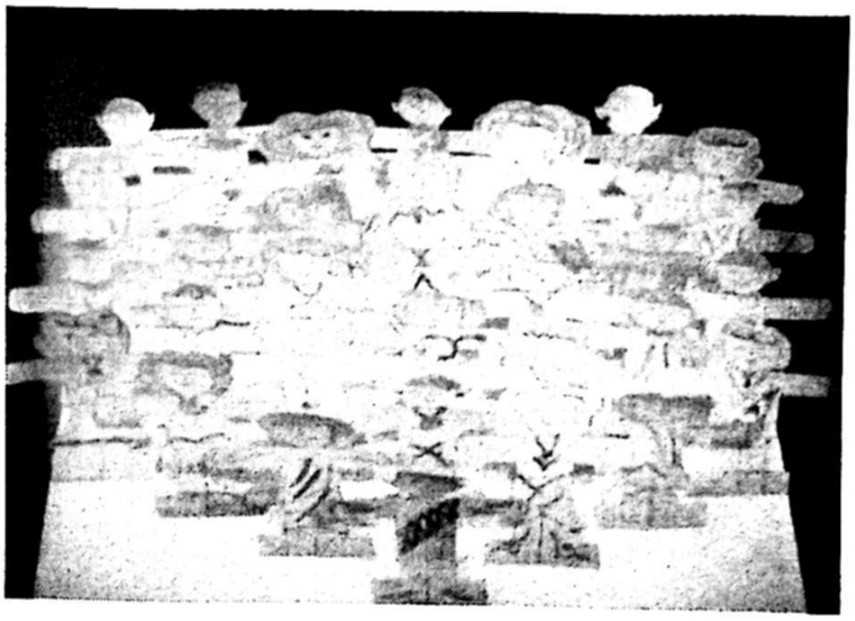

Figure 3. *Dyoram Card Gift resultant using Mahalanobis Distance [10].*

4 Experiments.

In order to be able similar the most efficient arrangement of individuals in a social network conformed a Dyoram Gift Card, we developed an atmosphere able to store the data of each one of the representing individuals of each society, this with the purpose of distributing of an optimal form to each one of the evaluated societies. One of the most interesting characteristics observed in this experiment was the diversity of the cultural patterns established by each community. The scenes structured associated with the agents cannot be reproduced in general, since they only represent a little while dice in the space and time of the different societies. These represent a unique form and innovating of adaptive behavior which solves a computational problem that it does not try to clustering the societies only with a factor associated with his external appearance (genotype), trying to solve a computational problem that involves a complex change between the existing relations. The generated configurations can be metaphorically related to the knowledge of the behavior of the community with respect to an optimization problem (to conform to cluster culturally with other similar societies, without being of the same quadrant [4]).

The main experiment consisted of detailing each one of the 87 communities, with 500 agents, and one condition of unemployment of 50 generations, this allowed us to generate different scenes from best dyoram possible, which was obtained after comparing different cultural and social similarities in each community, and to determine the existing relations between each one in relation with the Mahalanobis Distance (the colors indicated a cluster with specific intensity, the size of cluster determine the magnitude of societies) from the profile of person whom receive the gift. The developed tool classified each one in a different location according to the cluster more closely at profile used (To see Figure 4).

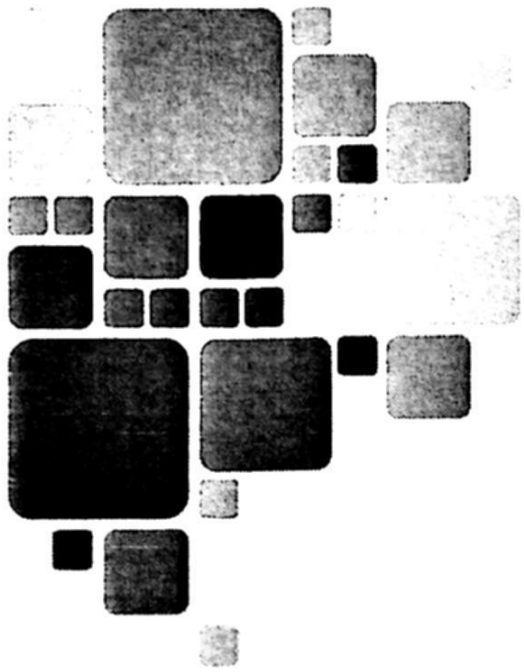

Figure 4.*Clusters constructed by means of the use of Cultural Algorithms and Mahalanobis Distance [10].*

5 Conclusions

Using Cultural Algorithms we improved the understanding substantially to obtain the change of "best paradigm", because we appropriately classified the agent communities basing to us on an approach to the relation that keep their attributes, this allowed us to understand that the concept of "selection and matching" exists with base in the determination of the function of acceptance on the part of the rest from the communities to the propose location for the rest of same ones. The Cultural Algorithms offer a powerful alternative for optimization problems and redistribution of clustering. For that reason, this technique provides a quite comprehensible panorama with the cultural phenomenon represented [8]. This technique allowed us to include the possibility of generating experimental knowledge created by the community of agents for a given dominion of application.

The analysis of the level and degree of cognitive knowledge of each community is an aspect that is desired to evaluate for the future work. The answer can reside between the similarity that exists in the communication between two different cultures and as these are perceived. On the other hand to understand the true similarities that have different societies with base in the characteristics that make them contributor of cluster and it as well allows him to keep his own identity, demonstrates that the small variations go beyond phenotypes characteristics, and are mainly associate to tastes and similar characteristics developed through the time [7].

Importantly, the cultural algorithm (CA) is a powerful tool, yet neglects various elements of cultural analysis, this being an opportunity to innovate new algorithms rescuing the complexity and the chaotic social and cultural relations.

A new Artificial Intelligence can take care to analyze retail these complexities that each society keeps, without forgetting that still they need to us methods to understand original and the particular thing of each society.

Also this experiment opens the possibility to analyze in future work, how to minimize to one society per quadrant to make a four societies bookmark and get a minimum unit form of visual representation of a diorama, using a grand prix model.

Acknowledges

We appreciate the permission of Alberto Ochoa Ortiz Zezzatti to use various published materials related with Cultural Algorithms.

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Towards a gesture selection model influenced by personality and emotional state for virtual characters

María Lucila Morales-Rodríguez, Patricia Alanis Maldonado, Claudia Guadalupe Goméz Santillán, Arturo Hernández Ramírez and Rodolfo A. Pazos Rangel

[1]Instituto Tecnológico de Cd. Madero, División de Estudios de Posgrado e Investigación, Ave. 1° de Mayo y Sor Juana Inés de la Cruz S/N
{lmoralesrdz,alanis.pam}@gmail.com, cggs71@hotmail.com, ahr@prodigy.net.mx, r_pazos_r@yahoo.com.mx

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Abstract. The virtual characters are being used increasingly in user interfaces to improve human-machine communication. For this reason, it is necessary to improve the interaction of these characters in a similar way like the communication between human beings. This paper presents a general model to characterize and select gestures influenced by personality and emotional state for virtual characters so they can communicate intentions, feelings and ideas.

Keywords: Non-verbal behavior, Virtual Characters, Gestures, Personality and Emotional States.

1 Introduction

The current approach in creating virtual characters and virtual environments is to endow them of credibility, associating to them a feeling, personality, an emotional state establishing a bond which avoids differentiate between reality and fiction.

Our aim is to create a gesture selection model for virtual characters that can express emotions and feelings associated with the context. The difficulty is inherent in the complexity of emulating the process of human communication and the variety of emotions that can be represented by a wide range of gestural expression, which in turn can be influenced by personality and the environment.

This paper aims to propose a model of the relationship between verbal and nonverbal expressions, since the second one function as a complement to verbal expressions in order to communicate feelings, intentions or goals, and thus create virtual characters to develop applications as presenters or tutors.

The paper is structured as follows: in section 2, the framework describes the main concepts related to believable virtual characters and their non verbal communication. In section 3, we show our background and propose our gesture selection model. The

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paper concludes in Section 4 with a brief summary of our main points and our current gesture approach.

2 Non verbal expression in virtual characters

2.1 Believable virtual characters

The nonverbal communication skills are specific of human beings, and for over a decade researchers have tried to transfer that richness to a virtual character, and thus facilitate human-machine communication. The creation of virtual characters involves several multidisciplinary concepts in order to represent them in virtual worlds; these characters try to improve human-machine interaction through verbal and nonverbal expressions.

A virtual character is a digital representation in a virtual environment [1]. The credibility of a virtual character is not linked to well-crafted animations and executed with precision. The reactions, verbal and nonverbal expressions and the decision-making inherent to context developed with naturally and consistency will facilitate the induction of immersion through a virtual character.

"The illusion of life" is an important objective of virtual agents research. The personality and emotions are key concepts for a credible agent and can be used to determine the expression and generation of verbal gestures [2].

2.2 Nonverbal Communication and influence of context

Nonverbal expressions have been an important part of the dynamics of communication as a means of support and in particular cases as a substitute for verbal expression. Integrating gestures, postures and facial expressions to verbal communication improve the communication of intentions, goals, feelings and ideas.
During the communication process there is an auxiliary element that can determine the true meaning of a message, this element is the context. The context can be defined as a set of elements that create a representation of the situation. It is said that the context takes a pragmatic dimension when refers to an element of the structure of the environment and a cognitive dimension when refers to the representation of an individual [3]. The context gives meaning to the different postures and different gestures that takes the human body in different social situations.

2.3 Gesture

The gestures are hand and arm movements executed when people speak. Such movements may be extensive or minimal, but present during the communication process and are highly synchronized with the flow of speech [4].

A gesture has three phases: preparation, stroke and retraction (see Fig. 1). The preparation phase is considered the rest phase and is where you start the development

of gestural expression. The stroke phase can be regarded as the top or "climax" of gestural expression (what the movement actually "does" or what was "intended") and is the main content of the gesture. In that phase, the synchrony with speech is maintained by the interlocutor. Retraction is the phase in which the gesture begins to decrease once the stroke phase finished [5].

Figure. 1. *Example of gesture phases on a presentation context. (Deictic gesture)*

Cadoz [6] divides gestural expressions into three groups, one that involves communication, a second one that integrates the handling and a third which includes movements of haptic[1] exploration. Since our goal is to create a virtual character that emulates nonverbal communication through arms and hands, we characterize the gestures which by their nature are closely related to acts of verbal communication. For this reason we will focus on defining *semiotic gestures*, which communicate meaningful information and results of the shared cultural experience that occur in parallel with verbal expressions. These gestures are intimately connected with verbal communication so as to complement the speech. McNeill [4] classifies semiotic gestures as follows:

Metaphoric: represents an abstract idea, the concept which represent has no physical form, the form of gesture comes from a common metaphor. An example can be found in the phrase "the talk was over and over again", accompanied by a hand that indicates movement of oscillation [8].

Deictic: are gestures that pointing to something or someone either concrete or abstract. These gestures locate something in the physical space in front of the narrator, can be discourse entities that have a physical existence or not. An example of this might be to point while we say "this dress" or "that gentleman over there" [4].

Iconic: these gestures representing a particular object or event. Having a close formal relationship to the semantic content of speech, illustrating what is said to describe any property relating to verbal expression [9].

Beat: are rhythmic movements that go along with speech, but the shape of the hand don't have relation with the content of speech. Such gestures have only two modes (up / down, in / out) [9].

---

[1] Haptic Exploration is defined as perceiving information of surfaces and textures by touch [7].

2.4 Emotional State and Personality

Gestures, postures and facial expressions not only strengthen the dialogue, they also convey emotions. Show our emotion has important implications in the act of communication, so it's important to know how to express and interpret them.

The personality of an individual largely determines the way they speak and behave during the act of communication. Personality refers to the characteristic through patterns that persist across time and situations, and that distinguish one person from another [10].

We think that the integration of nonverbal communication, emotional state and personality into a gesture selection model for virtual characters will allow us, to achieve a faithful simulation of reality, matching gestures developed in virtual worlds with gestures expressed in a real context. One way to validate the credibility of the virtual characters is through the degree of immersion that causes the interaction with them in the virtual world.

2.5 Immersion and presence

The focus of this work is to carry out a social and emotional immersion through a believable virtual character, which executes gestural expressions with personality and emotional connotations.

The immersion is carried out when the user forgets that he is interacting with a virtual character and associates to him a personality, a feeling, a goal or a particular behavior as you would with a human being. The experience of immersion is not conditioned on the exact reproduction of the physical aspect of reality but it is linked to the emulation of social interaction. Morales and Pavard consider the factors involved in improving social and emotional immersion through virtual characters are nonverbal expressions, social behaviors and empathy expressions [10]. This acts that involve the communication process must be accurately represented by the virtual character.

3 Gesture Selection Model

3.1 Background

This work is an extension of the behavioral architecture for virtual characters proposed by Morales [11] (see Figure 2). In that research, Morales develops a kinesics model which includes a gesture, facial, postures and body expressions. In the internal structure of the kinesics model specifically in the gesture module of virtual character is where we tried to make a contribution in order to develop applications of virtual characters that interact through non-verbal expressions of arms and hands.

In the work of Morales the gestural expression module is implemented through an empirical weighting, for that reason we intend to implement a gesture selection model

with an emotional connotation associated to the personality using classification techniques with the aim of improving the gesture selection process.

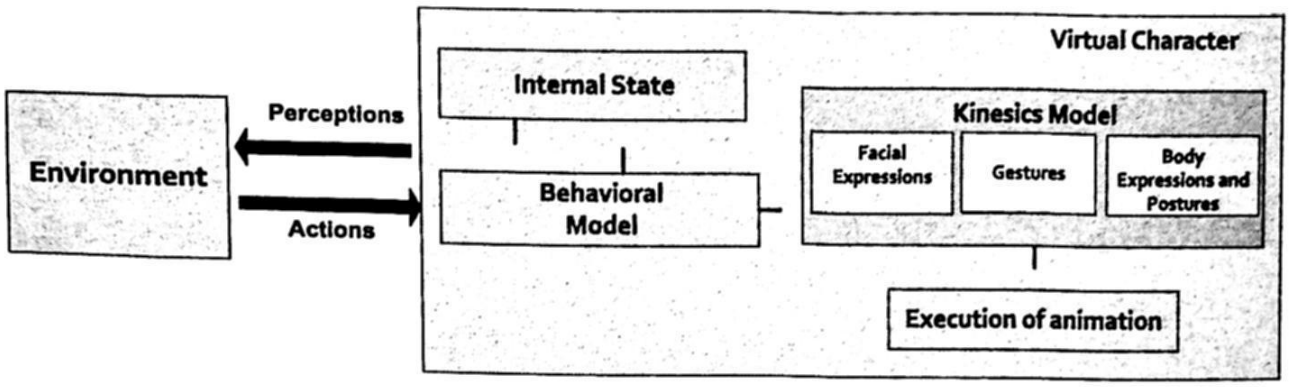

Figure. 2. *General view of the Behavioral Architecture for Virtual Characters proposed by Morales 2007 [11].*

3.2 Proposal of the Gesture Selection Model

Our proposal in this work is a gesture selection model that selects a gesture connected with a personality and emotional state associated with a context, and thus improves the way of human-machine interaction that currently lacks of this characteristic, producing an easy break of immersion. Our architecture consists of the following modules, which are integrated into the behavioral model proposed by Morales (see Figure 3):

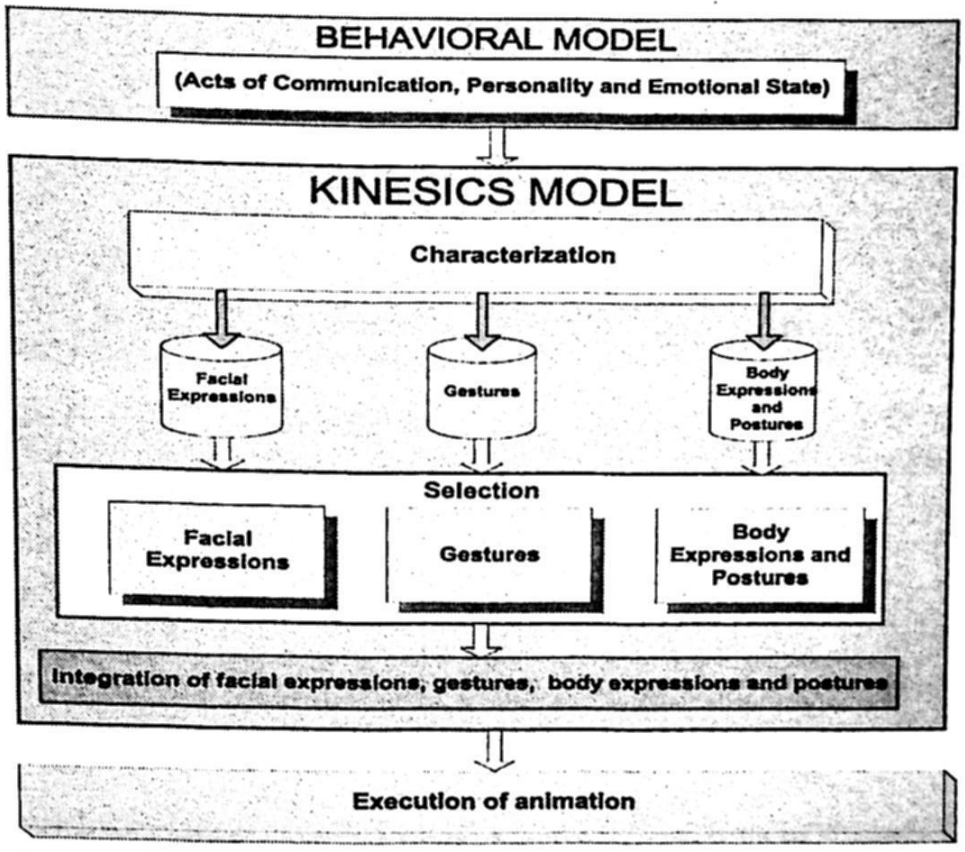

Figure. 3. *General architecture of virtual character animation.*

The architecture includes two main processes corresponding to the modules of *characterization* and *selection* of gestural expressions.

3.2.1 Characterization process

In this process we intend to characterize the attributes of gestural expression using causal models to reduce a dimensionality of the information and thus find the correlations between attributes to improve the selection of gesture.

On the characterization process, we identify the attributes that best characterize the gestural expression (see Table1). The gesture attributes are obtained through a video analysis with the ANVIL[2] tool developed by Kipp [9]. With the video analysis attributes we create a database with all gestural expressions that may be generated.

The characterization of nonverbal expressions allows us to identify the main characteristics of gestural expression to associate it to an emotion, intention or goal and thus, improve the quality of the gesture selection process. At this moment, we search the use of multivariate analysis and data mining techniques in order to solve characterization and selection problems.

Table 1. Composition of the attributes of the knowledge database used by the gesture characterization process.

ATRIBUTES	COMPOSITION
Image	
Gesture	Phase Type
Emotional State	Stress Arousal Valence Stance
Speech Acts	Locutionary Illocutionary Perlocutionary
Configuration	Right Hand Right Arm Left Hand Left Arm
Speed	

[2] Annotation of Video and Spoken Language

3.2.2 Selection process

After of the characterization process, we select the appropriate gestural expression that we call an expression triplet, because join the expressions of each of the gesture phases (see Figure 4). In that process we will use a classifier in order to predict the most appropriate gesture to express a particular feeling and personality.

The triplet of gestural expression is the output of the kinesics model, likewise is the input for the animation process that will generate the animations of virtual characters, which in this case consist of three continuous animations, one for each one of the gesture phase that will represent the gestural expression.

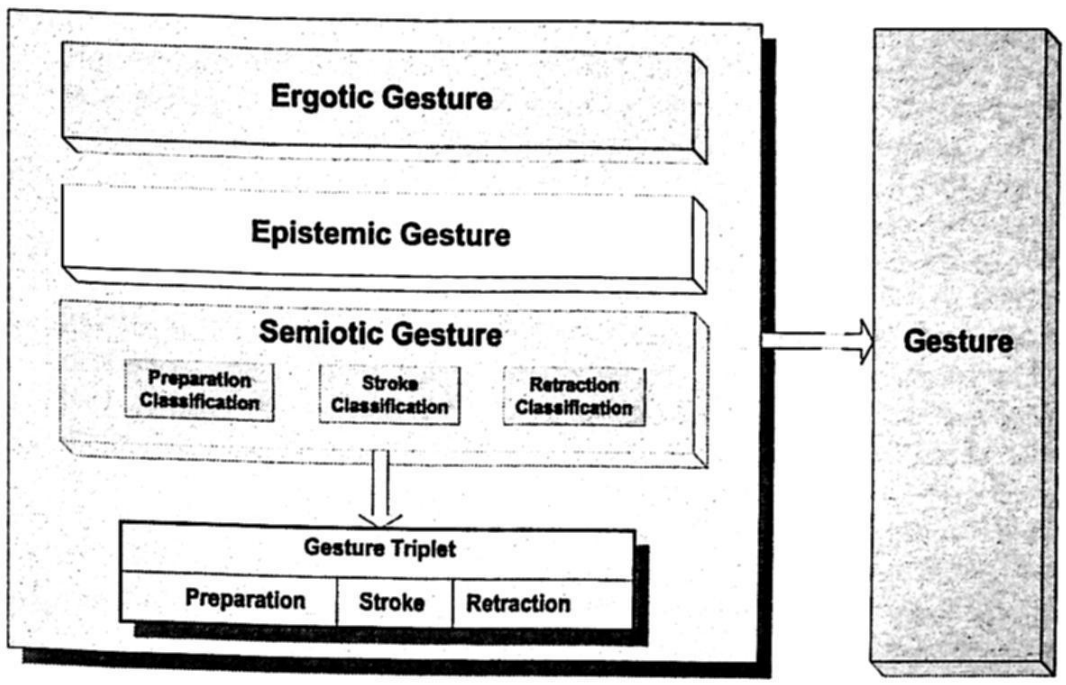

Figure. 4. *Gesture selection model proposed*

4 Conclusions

This paper puts forward a gesture selection model for virtual characters which focuses on semiotic gestural expressions associated to the personality and emotional state of the virtual character.

Our gesture selection model is based on the combination of a behavioral model for virtual characters that expresses emotional and social behaviors and a qualitative gesture model; their combinations allow us to create gestures with different qualities and characteristics which improve the credibility of gestural expressions for a virtual character.

We believe that gesture is an important element of communication process which can support or replace verbal expressions. We think that there are a relationship between gesture characteristics, personality, and emotional state when a gesture is executed. We propose the division of the gesture process selection using the phases of

gesture like in the face to face interaction. We think that if these features are provided to a virtual character could endow the virtual characters of credibility and increase the sense of immersion.

Acknowledgement.

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Water on the water: A hybrid approach using Intelligent water drops algorithm and cultural algorithm to improve a shoal in fishville

Alberto Ochoa[1], Arturo Hernández[2], Sandra Bustillos[1], Antonio Zamarrón[3], Rubén Jaramillo[4], Paula Hernández[5] & Ikkadh Dagheranis[6]

[1] Instituto de Ciencias Sociales y Administración, Universidad Autónoma de Ciudad Juárez [2] CIMAT; Guanajuato, México.[3] , Instituto Tecnológico de León; Guanajuato, México. [4] CIATEC (Centro Conacyt); León, México. [5] IT de Ciudad Madero (Maestría en Inteligencia Artificial) Tampico, México. [6]Bakú Technical University, Azerbaiyán.
megamax8@hotmail.com

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Abstract. Many problems involve not structured environments which can be solved from the perspective of Cultural Algorithms (CAs) and Intelligent Water Drops Algorithm (IWD). In this research analyze a prototype of hybrid algorithm validated with improve optimization of a virtual shoal playing in the Facebook's social network game named FishVille. This prototype takes as input data a set of fish in FishVille (7000 different issues –but only 6750 issues available on 70 level- to combine in a shoal) and returns an organized the maximum shoals of 40 fishes each of different species. Using a generate and test method, guided by a set of construction heuristics obtained from the possibility of arrive at this ideal shoal, the prototype can operate in two modes: either generating an unrestricted set of fishes, or generating a shoal according to one of three predefined shoal structure. Seven different construction heuristics are tested over different combinations of two sets of initial data, one obtained from a classic and popular combination used in ichthyology to decoration and other using a Ichthyology Habitat patterns. A set of numerical parameters are extracted from each test, and evaluated in search of significant correlations. The aim is to ascertain the relative importance of size of initial shoal and construction heuristics with respect to the general acceptability of resulting shoal which are validated using Cultural Algorithms.

Keywords: Social Network Game, Intelligent Water Drops Algorithm and Cultural Algorithms.

1 Introduction

The Social Network Game are very popular in Internet (Used by a 2% of World Population); supported with Social Networking especially Facebook is recurring dream within the AI community, but it has always been assigned a very low priority. Practical applications in the area of analysis of Multiplayer game online, such as

understand the behavior of the game and the way to provide more immediate rewards [1]. On one hand the automatic generation of Ichthyology composition involves advanced Biology and Environmental sense. On the other hand it involves an important amount of creativity and sensibility. These ingredients are very difficult to characterize formally, and very little is known about how they might be treated algorithmically. On the positive organize a shoal with different species not requiring exaggerate precision. If one accepts that the main aim of a shoal is the esthetic presentation, the general problem becomes tractable. The present paper considers how the different parameters that can be controlled by a hybrid algorithm affect the acceptability of the result. The set of parameters to be monitored are: size of shoal, species including, decoration, and enough feed. The elusive concept of acceptability of a shoal is determined by resorting to hand evaluation by a team of volunteers which has an account in Facebook. By searching for correlations between the strategy and initial data used to generate a shoal and the positive or negative evaluation of the resulting of it which is obtained about the relative relevance of these parameters to the end result.

The paper is organized as follows: in section 2 we analyze the Ichthyology Compositional Analysis. In section 3 we described the proposed prototype, in section 4, the results are evaluated, the paper concludes with section 5 explain the conclusions obtained.

2 Ichthyology compositional analysis.

Formal analysis of Ichthyology composition considers the position of a fish in a specific habitat. The period required to food is different in each specie and the time to arrive at adult age will be have a range from 3 minutes to 4.5 days, when a fish is bought is registered its specie, if you bought enough fishes is possible liberate new species of similar family. It is enough for certain strategic related with the organization of a shoal. The literature of multiagent system [3] describes a set of skills to obtain advantages when is bought an issue in this kind of games, in the figure 2 is shown the behavior of the game during 320 days of game using our proposal algorithm and the randomly of actions,

A shoal may be an unstructured sequence of fishes, but this paper is concerned specifically with shoals that make use of known compound-multi strategy (issues from different species supported similar at biological symbiosis). In such cases, the formal rules that govern the chosen Ichthyology form can be used to guide the generation process. A shoal may consist of single specie or several species together (in which case the different species are usually organized by their behavior). For the present purposes, only three of the simplest patterns be considered: Specie, Time to be adult, and quantity of food required.

3 Description of the System.

The prototype requires a set of initial data to start the generation process: a repository of fishes and a set of patterns associated with a shoal. The choice of buy a fish determines improve to realize and the topic of the shoal. The set of Ichthyology patterns can be considered as a set of descriptions of best shoal in the nature, in the sense that it encodes information about important parameters (time of life, quantity of food...) while allowing a certain leeway in terms of specific content (particular fishes species) of the present solution. The set of initial data is obtained as follows. Given a set of fishes, it is split into value of each one according the velocity of increase their size. All the issues in the repository will be included in the proposal shoal. The resulting values of the original issues are used to produce the reference patterns. In order to compare the effect of the choice of a fish from an Aquarium Repository, two distinct set of data are used to test the programs. The first set of data is obtained from a set of Ichthyology patterns. The second set of data is taken randomly from an academic work in the field of Ichthyology Habitat. A certain shoal [4] of equivalent size is chosen, all the fishes in this are included, and a set of reference patterns is built by splitting the shoal into triplets (a mini combinatorial shoal) with a required size and encoding the necessary information.

3.1 Hybrid Algorithm

This algorithm is composed by Intelligent Water Drop and Cultural Algorithms which permit organize the best strategies to reach the best shoal using the different ways to buy and sell fishes and other things related with an Aquarium. The IWD Algorithm work together to find the optimal solution to a given problem and the Cultural Algorithms to analyze each bought and sell.

Generation starts with the selection of appropriated Ichthyology patterns, based on criteria designed to ensure that there is a minimum of coherence across the issues in the shoal. From this pattern an empty draft of the current shoal is generated.

The elementary generation cycle can be described as follows:

1. Randomly choose from the given fishes in the repository that matches the first category of the current shoal according the level in the game
2. Append it to the draft of the current segment
3. Eliminate (bought) the corresponding fishes from the current segment pattern
4. Test whether the resulting shoal draft satisfies the conditions of the strategy being used – and the required size of segment in number of different species
5. If the conditions are satisfied, iterate from 1.
6. Shoal's issues that either violate the conditions to improve, or overshoot or fall short of the given number of value of bought are rejected

The generation of a shoal requires two additional features to be solved, both related to the restrictions imposed on each Ichthyology patterns. One concerns the choice of best fish to use for the next strategy related with the shoal. This issue is independent

of the particular goal. The other concerns the different value of each fish, and is governed by the particular rules of each shoal.

4 Evaluation of Results.

Three different sets of experiments were carried out. In each experiment of the first set, the versions of the system corresponding to different strategies for the build to best shoal with more different species using Cultural Algorithms for buying thus technique can simulate the recommendation of an artificial society. The experiments of the second set were designed to evaluate which of the strategies for validating the current draft to a proposal shoal gave better results using IWD. For both the first and the second sets of experiments, each competing issue was evaluated attempted to generate diverse scenarios, operating in standard style mode. A set of 150 fishes from FishVille was used to provide initial data, and Ichthyology patterns were respected. The third set of experiments was carried out using only a version of the system that combined the strategies that had obtained better results over the previous sets. Comparisons were established between results obtained for different combinations of initial data. In this set, each proposal shoal generates fifteen issues for each one of the possible scenario's tank.

Figure 1. *FishVille User'environment with all the information about the performance on the time in this Multiplayer Game Online.*

4.1 Shoals Generation and Initial Data

Different sources for initial data (fishes in three different repositories) extensions of the Ichthyology patterns search in an Aquarium, two possible ways of improve the shoal is determine which fishes is better bought and the time to will be adults to sell and obtain more resources. A total of 504 trials were carried out (14 combinations, and 116 different possible species to buy, and 12 combinations to organize). Many of the resulting shoals were either economically incorrect. For this reason, evaluation

took place in two stages. During the first stage every resulting shoal was assigned three numbers: (1) number of issues of the shoal, (2) a value for its economical correctness, and (3) a value for its esthetical rating. These values are used as a first stage of filtering to avoid wasting evaluation effort on shoals that are too short or without economic value. Values were assigned on first inspection by one sample of users (11 players).

A shoal is considered weakly connected itself, if it can be parsed in some way as a set of independent fishes. A shoal is considered strongly connected if at least some of the issues join together into a variety of species that make Ichthyology sense.

Esthetical rating was subjectively evaluated on the following scale:
1. ugly
2. mediocre
3. acceptable
4. pleasing
5. very pretty

4.2 Discussion of the Results

The results contain an enormous amount of information, only part of which has been mined at this stage. However, some very interesting conclusions can be drawn from the resulting facts. Since it had been assumed from the start that if the choice of a fish and/or the choice of Ichthyology patterns (for example the quantity of food in a day) play an important role in determining the quality of a shoal. This hypothesis is validated by the fact that only seven of the 45 acceptable shoals were generated using the set of initial data (the best Shoal is reach in the level 57 after 147 days playing the game). Overall, only nine of the combinations that were tried managed to produce a shoal that went into the final selection. Of these, only one of them was not using an extended version of the original repository (obtaining issues from gifts of another player). However, that very one did produce the top scoring shoal according to the evaluators. This suggests that in general terms the system performs better with a wider choice of options of fishes, unless the random factor in the generation process actually comes up with a shoal that closely mirrors the first randomly (which is what happened in this case). While it is clear that recovering the first shoal organized to give an acceptable result, this is hardly a desirable solution.

Two of the combinations that produced most top scoring shoals were working with repositories that had been extended with extra issues (fishes available in top levels and limited edition issues). These fishes tend to appear more often than others in the shoals. However, it produces very interesting results from an aesthetic point of view. While no way has been found yet to evaluate this fact numerically, it has been observed informally by many of the evaluators and it should be taken into account for further analysis.

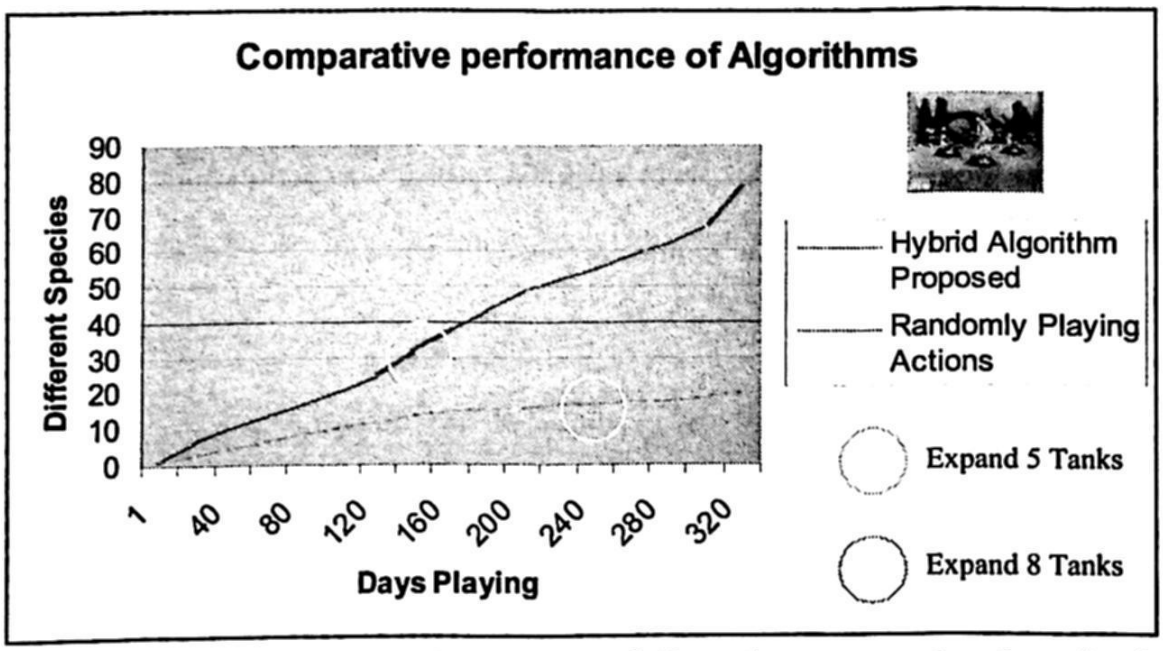

***Figure 2** Comparative Analysis of Hybrid Algorithm proposed and randomly selection actions in the game.*

5 Conclusions.

The present experiment is intended as preliminary work in a project in developing Ichthyology knowledge based on Evolving Compute. The results obtained will help to discriminate between the different possible strategies and stratagems in the game. Additional knowledge and heuristics governing the selection of appropriate selection of patterns to follow a given group of issues might be used either to guide shoal construction or to eliminate poor results. Several interesting insights have been obtained from the analysis of the results presented here. Better heuristics must be developed for the selection of appropriate pattern for the next shoal. Ichthyology patterns should be distinguished in some way according to whether they are beginning, middle or end sections of a game. The evaluation procedures are still subject to a great deal of improvement. In a matter where subjective opinion of the player, special effort must be made to devise an evaluation procedure that provides a rigorous rating without interfering with the natural attitude of the evaluator as user of this kind of Social Network Game, in another of this games is possible improve the selection of actions as Evony, Dygredis. Social City, Birland, Restaurant City or My Tribe. A future research is analyzed the Virtual Social Networking (27 people at level 57) organized in My Tribe to reach level 100 in the less time and the Social organization developed by this.

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Artificial Intelligence Computer Security Applications

Authoring tool architecture for edutainment systems

Gilberto Huesca[1] and Julieta Noguez[1],

[1] Tecnológico de Monterrey, Campus Cd. de México, Calle del Puente 222, Col. Ejidos de Huipulco, Tlalpan 14380 México, D. F., México
{ghjuarez, jnoguez}@itesm.mx
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Abstract. Pedagogical theories have embraced games in the past years as a teaching tool. This is because games have an intrinsic entertainment characteristic that can be used as a vehicle to deliver educational concepts and to engage students in the teaching-learning process. Edutainment, as a special type of serious games, is nowadays used as a way to engage students and improve education delivery. But, building an edutainment system is a complex task because it is needed a hybrid work team. Design, art, developers and pedagogical experts are required to work together to create the serious game. Also, professors, that will apply this tool into the class, must have an active role in the design process to adapt the game to their specific needs. Authoring tools can help in this process by providing professors with instruments that require less computer expertise in order to create a serious game of this kind.

Keywords: Authoring tools, Edutainment, Serious Games, System Architectures

1 Introduction

Engaging capabilities of games can be used as a medium to expose educational concepts so students can learn with less resistance. Computational research over years has made available new developments so new platforms can be used to build more entertaining and funnier games. Also, large companies have worked to distribute these systems to consumers directly to their home.

From another point of view, new generations are more used to use this kind of technologies. Nowadays, young people are not afraid of using cell phones as an entertainment tool rather than only a communication device for example. Also, these systems are more and more popular and have a great acceptation between people.

Serious games have emerged as a computational application that takes profit from these elements and combines serious aspects (teaching, learning, communication or information) with the playful characteristics of video games [1]. As an educative tool, edutainment (contraction of education and entertainment) is a specific serious game that combines education and entertainment. Edutainment is a methodology that combines teaching methods and games characteristics to engage students in order to make easier their learning process [2]. It tries to increase the educational value of games by adding pedagogical techniques to display educational content. A main objective is to present education in a less stressful way as it can be in traditional ways.

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But creating such an educational tool is not an easy task. Edutainment systems development needs a hybrid development team. A design team is required to work over the story line. Also, an art team must get involved to create all game images and sounds. A software development team will put all this together to have a final product. But, as an educational tool, a pedagogical expert is necessary too. The professor that will use it must have an active role in this process. But not always these professors have the computational expertise to compose the system.

Authoring systems are a framework that allows virtual learning environments' production with a lower material (money and time) cost and that reduce the abilities or training needed to create them [3]. These tools can be used in order to help professors to get involved in the development process for edutainment systems.

In this work, we propose an authoring tool architecture that will help such a hybrid team to design and implement an edutainment system and that will aid the professor to get involved into it.

2 Related work

As stated before, the construction of an authoring tool requires integrating different components that require different knowledge to be developed. There are some works that try to solve the task of developing some components like learning environments or to compose multimedia applications. These tools, put together, can be useful to create an edutainment system. Next, we will describe some of these tools.

2.1 Adaptive Lecture Authoring Module

This architecture describes four components [4]: Teacher profiler, Student profiler, Lecture profiler and Notification manager. This four components work together in order to create profiles that will be cross referenced to give the student a notification of a new lecture that is available in the system and that fulfill the students' learning needs. The Teacher profiler allows the teacher to define properties such as name and assigned courses. Through the Lecture profiler, the teachers can create learning content in the formats they need for their courses. They may also assign metadata to the lectures (such as the level of difficulty) to help the adaptation to the students needs. The Student profiler allows the definition of student general information (name or enrolled courses) and the results of quizzes taken in the system. The Notification manager will analyze this students' information and the characteristics of the lessons to find the best material that specifically help students in their learning process.

This architecture highlights the need for two aspects within authoring tools' architecture. One of them is the existence of components that help the teacher to define the data that will characterize the courses, lectures and students. This information will help the system to give students a specific learning content to help their learning process. On the other hand, components that help the professors to design and create these learning contents are needed. In an edutainment system, this component must help the professor to create the digital components that will compose the serious game like animations or sounds.

2.2 Architecture for authoring tools based on interactive television services

Kuo-Shu Hsu et al [5] argue that traditional authoring tools for sequencing of events are based on a linear representation of the content sequence. They propose a hierarchical model composition of scenes. The scenes sequence is represented by a tree. Each node represents a scene and each path, a sequence of scenes that responds to the player's interactions with the components of each scene. The root of the tree is the initial stage of the system. Each scene is a container for artifacts. An artifact is a digital item which can be static or that can allow interaction. Under this idea, the authors present the architecture for authoring tools based on interactive television services. The main component of this architecture is the Author controller. Its job is to coordinate the other components interactions. Through a graphical user interface (GUI) editor component, professors can create the structure of the scene to define the layout and the artifacts in it. This information is stored in a repository in an XML format. When a component is requested to deploy, the XML[1] is retrieved from the repository and this is translated into code to deploy the artifacts to the student.

This architecture focuses to two aspects. The first one is the presence of components that help to manage the creation and persistence of scenes and artifacts. The other one is the existence of components that help the use and deployment of these artifacts. This is very important for edutainment environments because professors must be provided with simple GUI tools to manipulate digital content to compose the game. Also, the definition of formats to store these digital contents, so to be displayed after, is required in order to facilitate its management.

2.3 Authoring tool for the composition of 3D audiovisual scenes

The main contribution of this architecture [6] is the management of objects created by the authoring tool. The architecture components are dedicated to the persistence and recovery of material. This architecture is intended to help video makers to open, save or play them inside a learning context. Despite being a simple architecture, it highlights again the need of internal formats that will help to manage and display the learning contents and other components that will manage the author interactions.

3 Edutainment architecture

As a semi open learning system[2], edutainment requires a high interaction from students. These interactions must be assessed to infer the students' cognitive state and to give them specific tasks to do in the game to give support to their specific learning

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[1] XML stands for Extensible Markup Language. It is a text format originally designed to meet the challenges of large-scale electronic publishing, XML is also used as a language for exchange data.

[2] An open learning system is an environment that helps students to interact and explore learning environment resources by a subset of parameters in order to obtain a better comprehension of the experiments and concepts that are exposed [7]. In a semi open learning environment an educative goal is added in order to infer students knowledge[8]

needs. [9] proposes a generic architecture for this kind of environments. This architecture proposes three components: A User Interface component, an Intelligent Tutoring System and a Virtual environment component (Fig. 1). By means of the User interface, students interact with the Virtual environment. These interactions are collected and sent to the Intelligent Tutoring System to be analyzed and to give back, to the students, lessons or quizzes to help them in their learning process.

Based on this architecture, we propose an edutainment systems architecture. Fig. 2 presents the RchEd architecture.

The User Interface component will display the multimedia content and will capture students' interactions. The Edutainment System component will manage the game mechanics and will contain a simulation module to construct multimedia models. This component will also gather information from students' interactions. These interactions will be useful to apply an inference process to track the students' cognitive state. The Intelligent Tutoring System will apply this inference process to the data collected by the Edutainment System. The results obtained by this procedure will be fed back to the Edutainment System component in order to modify the story line. This modification will present the students with new challenges where they will be able to continue the learning process or rectify their answers. It is important to see that these results are presented by means of the simulation and not directly to the student as a test or lesson to learn like in the semi open learning environment architecture of [8].

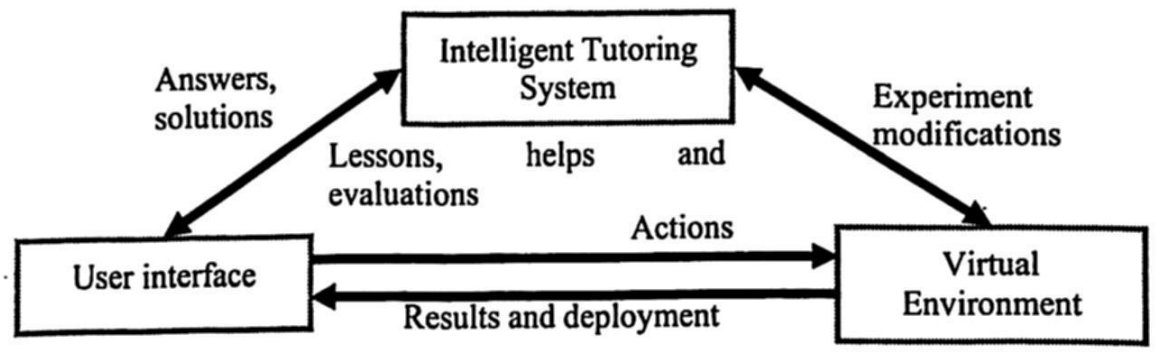

Fig. 1. High level view for a semi open learning environment architecture [8]

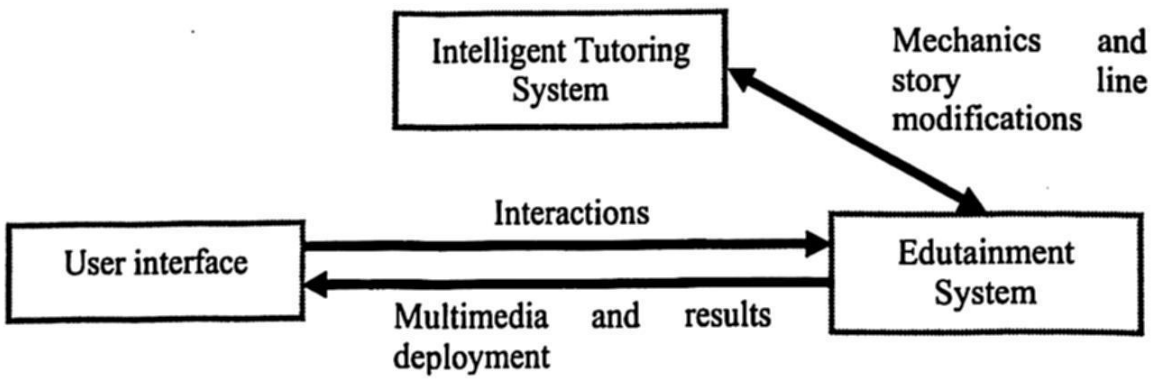

Figure. 2. *High level view for the RchEd architecture for edutainment semi open learning systems*

This is because in edutainment systems, education is presented within an entertainment goal. By not communicating directly the Intelligent Tutoring System

decisions to the students, the entertainment goal is not affected and the students enjoy more the interaction with the system. This is helpful because the more the student interacts with the system the more the student can acquire the knowledge and abilities exposed in the learning environment. Also, by modifying the storyline components according to the Intelligent Tutoring System, the entertainment goal can be enriched with hard challenges or more appealing plots.

4 Authoring tool architecture

Edutainment systems focus their attention into two elements: education and entertainment. This can be seen in the RchEd architecture that defines a component to manage education (Intelligent Tutoring System along with the collaboration of the other components) and another component to manage entertainment (Edutainment System along with the collaboration of the other components). Like it has been seen in the authoring tools described, it is very important that authoring system architectures define components to help professors by defining elements for these to aspects. The Archaud authoring tool architecture proposed in this work (Fig. 3) has two components that will help professors to center into these two features and combine them to secure the educational and entertainment aspects in the final game.

The Knowledge Arguments component focuses its capabilities to provide authors with tools to define the domain structure to be taught. Within this component, professors can define which educational components will be displayed, when and where to be displayed. Also, the professor is able to define the inference structure that will be used by the intelligent tutoring system to evaluate the students' interactions to know the actual students' cognitive state. This component also allows the definition of the pedagogical actions that will be performed after this process is done. These pedagogical actions can be the repetition of the same or a similar challenge with less or more difficulty as reinforcement, or to present a challenge where the student needs to use the last knowledge obtained to solve a puzzle. These pedagogical actions must be aligned with the main storyline in order to show progress in the game.

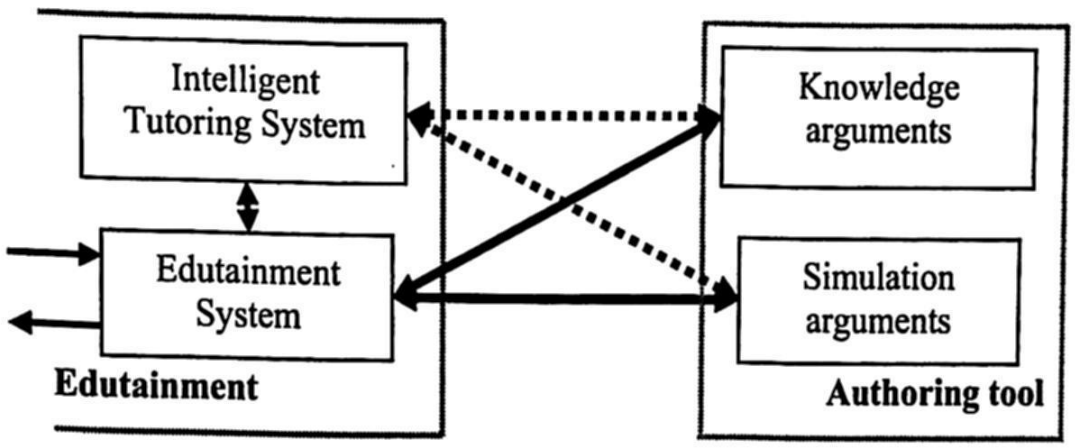

Figure. 3. *High level view of the Archaud architecture for authoring tools for edutainment systems*

All these definitions need information from the game multimedia objects configurations because these actions will affect the multimedia deployment of the

game. Due to this situation, this component must communicate with the Intelligent Tutoring System component from the Edutainment Environment and also with the Simulation Arguments component from the Authoring Tool.

On the other hand, the Simulation Arguments component helps with the definition of the entertainment characteristics of the serious game. This component helps to define the multimedia objects that compose the game. Also, the professor can define which multimedia objects will be displayed, when and where. Professors can also define which parameters, from multimedia objects, will be used as information to be fed to the inference model. That is what students' actions will be stored, how this information is collected, when the inference process will be started and how results will be displayed to the students.

Fig. 4 shows a specification view of the Archaud architecture and the relationships with the RchEd architecture.

The Knowledge items relationships module will hel top define the model used to represent the domain model for the Intelligent Tutoring System. By means of it, the professors can define the knowledge items that they want to teach and their relationships. This model should be closely related to the topics in which the edutainment system will be applied. This representation may be a concept map showing where the components of knowledge and its hierarchy. This module should provide the necessary tools for the author to describe each of these elements and to relate them.

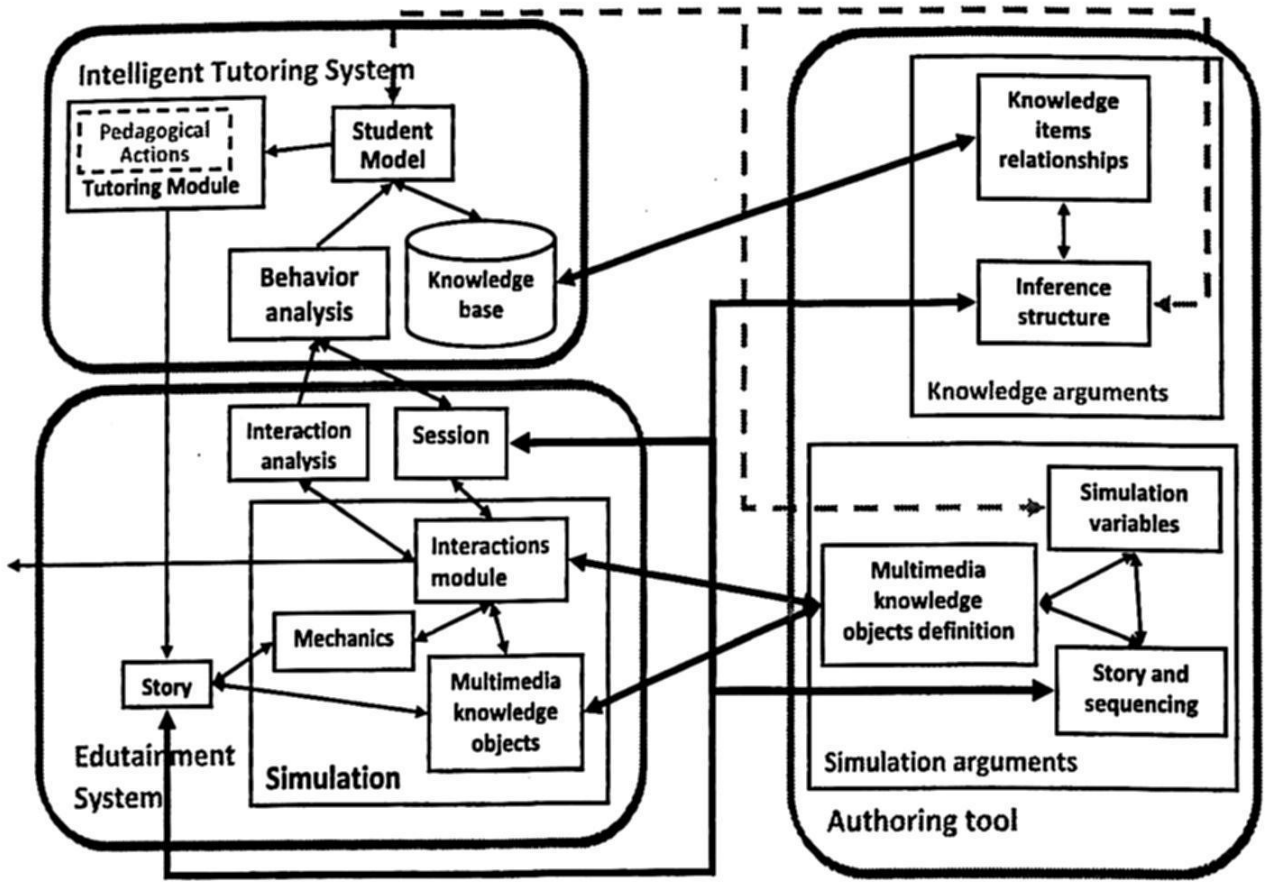

Figure 4. *Archaud architecture (right side) for authoring tools for edutainment systems and interactions with RchEd architecture modules (left side)*

The Inference structure module works over the structures de defined in the previous module to define a student model structure for the Intelligent Tutoring System. This means that the professor should be able to indicate which components of the global domain model affect each of the scenes or events in the game that require a process of inference. Based on these models, the module will enable the professors to define the way in which they perform the inference of the new cognitive state. For example, the author may indicate the weights of the relations between knowledge items to focus the inference to a specific aspect. To have all the information required for this inference process, the module will allow the identification of elements that affect the student model, such as students' interactions.

The Multimedia knowledge objects definition module allows the authoring for the digital components to be deployed in the serious game. Professors can allow individual modification and customization of the elements to be used. This customization would include the modification of state and behavior of the objects. This module can also allow the composition of objects.

The Story and sequencing module helps to define the main plot of the game. By means of this module, professors should be able to define the sequence of events in the game and how these events start or end. Also, the module can help the professors to define the relationships between digital objects used in the learning environment and their sequence of deployment in the simulation (i.e. if one object can start or stop another object action).

The Simulation variables module is primarily responsible for defining the simulation variables that will affect the inference structure. This means that the professor can define variables in the simulation (object state, student interactions, timing, etc.) that may be used in the structure used to infer the new student cognitive states. Some information needed in the inference process is obtained from the simulation models and objects, and vice versa, the results of this inference process will affect directly the digital deployment and the storyline of the game. Due to this, these two components of the Archaud architecture must work together.

5 Conclusions and future Work

Based on the RchEd architecture, we are working in a framework that will help in the implementation and configuration of edutainment environments (Fig. 5). The framework shows the composition of a scene by events and a game by scenes. Scenes and Events implement the interface Connectable in order to allow professors to connect the same event or scene to different ones in different games. An event could also implement the interface Scorable to score students interactions. An Intelligent Tutoring System could be useful in this process. This framework will be also the foundation for a further implementation of an authoring tool for edutainment systems based on the Archaud architecture. This will help to implement some events that will be used to compose a Physics RPG (Role Playing Game) game. The authoring tool will allow professors to define the game events, the configuration for these events and the event and scene sequences in the game. Once finished this work, the game will be tested in a pretest-posttest process that employs leaning gains in order to know if such a game and architectures help in the learning-teaching process. This process will be applied to an undergraduate group in a Physics course.

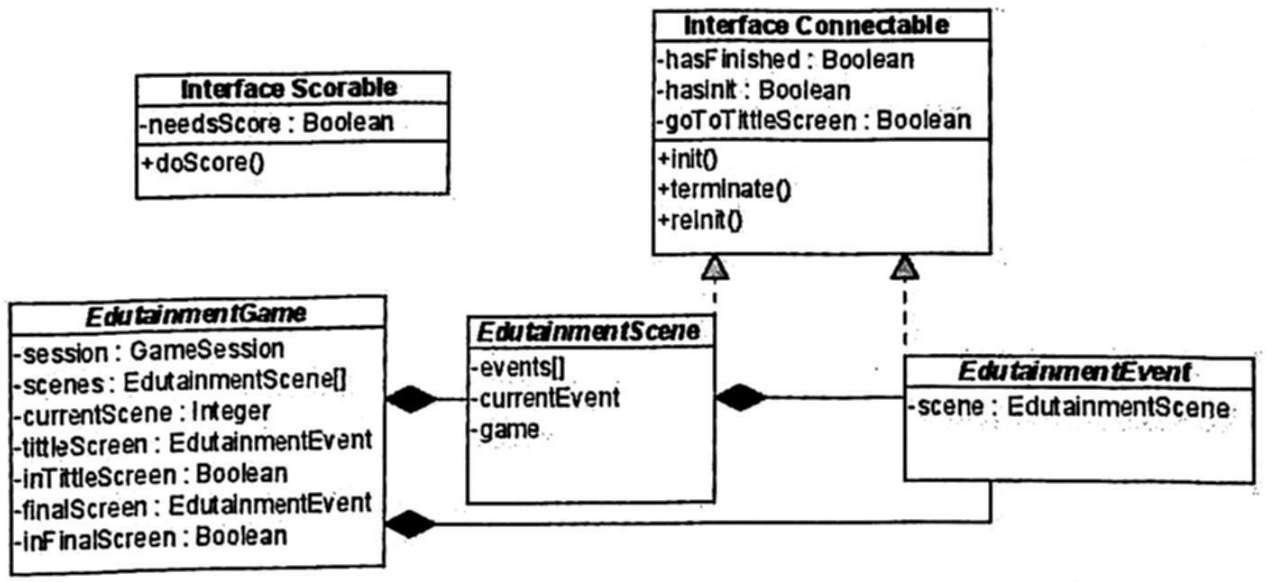

Figure. 5. Framework to build edutainment environments designed under RchEd and Archaud architectures.

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Design of mobile collaborative environments using smartphones to support learning

Arturo Serrano Santoyo[1], Gerardo Tovar Ramos[2], Efrain Kantel Escobedo[2], Javier Organista Sandoval[3],

[1]CICESE Research Center, Innovation and Development, [2]Autonomous University of Baja California, Information and Communications Technology Graduate Program, [3]Autonomous University of Baja California, Institute of Educational Research and Development, IIDE.
serrano@cicese.mx, {tovarg, ekantel, javor}@uabc.edu.mx
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Abstract. The availability of 3G mobile technology provides broadband internet and voice connectivity allowing the access to content and tools in an immediate and ubiquitous fashion with the use of smartphones and handheld devices. This paper describes the development of a mobile collaborative space that integrates the capabilities of 3G mobile devices for educational purposes. We discuss the elements of design and an associated case study involving the use of smartphones in conjunction with a server denoted as mobile collaborative space, MCS. We are interested in identifying requirements, constraints and capabilities of smartphones for collaborative work in learning environments. Our findings suggest that it is crucial to focus on the mobility and interactivity of the user more than on the device itself to create relevant and pertinent applications to support education.

Keywords: Educational technology, collaborative work, mobile communications.

1 Introduction

The availability of highly converging and multifunctional portable devices, denoted in this article as smartphones [1], [2] and the deployment of wireless Internet connectivity (3G and beyond) along with the understanding of the interactivity, cognitive and ergonomic issues involved in mobile learning (m-learning) constitute key factors in the development and integration of collaborative tools to support educational tasks in remote and ubiquitous fashion.

There are many contributions describing experiences of mobile technology applications in educational environments [3], [4], [5]. However, in many cases the projects include mobile devices of the same brand and model provided by the schools' administration or teachers to test the effectiveness of a particular educational application or tools centered in the technology features of the device. Our approach considers the application of a practical and real environment involving the use of smartphones with different brands, models, technology features and even operating systems and Internet browsers. Furthermore, in our view, a real environment must include students using their own smartphone with wireless Internet connectivity plans

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offered by their local providers to evaluate the limitations, advantages and cost constraints affecting the interactivity patterns of the users.

We describe in this paper the key factors involved in the design and development of a Mobile Collaborative Space (MCS) using the advantages of emerging wireless Internet connectivity (such as 3G and 4G) in conjunction with pedagogical and social interaction aspects involved in m-learning scenarios [6], [7], [8]. In section II we describe briefly the frame of reference considered for the definition and deployment of the applications located in the MCS. In section III we discuss the client-server architecture issues involved in the development of the collaborative applications selected. Section IV presents preliminary results and evaluation of the design concept of our MCS in base of a collaborative case study. Finally, section V provides our conclusions regarding the application of mobile technology to support learning.

2 MCS Design Elements

The design of our MCS is based on the FRAME model (Framework for the Rational Analysis of Mobile Education) [9]. One of the main characteristics of this model is that mobile technology, human learning capacities as well as social interaction aspects converge to provide a very useful and cohesive frame of reference focused on the main elements involved in m-learning (see Fig. 1).

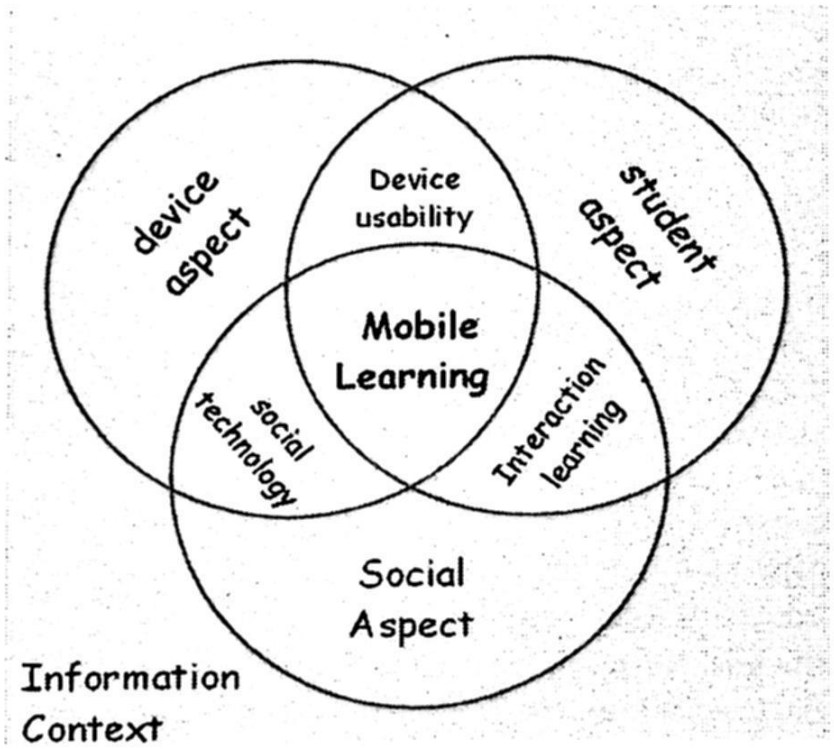

Figure. 1. *The FRAME Model.*

The MCS described in this paper constitutes a collaboration tool that takes into account cultural and social interaction issues arising from the confluence of mobile technology and ubiquitous computing in learning environments. In this scenario, university students show a tendency and natural disposition to adopt and integrate

mobile and portable equipment such as laptops and smartphones in their educational endeavors. With this in mind, our design is focused on the advantages of such natural inclination and familiarization of the so called *digital natives* with the use of social networking platforms for interaction and information exchange [10].

The objective of the MCS is to provide college students with a space or platform for collaborative work that requires a high level of communication and interactivity. Our design supports collaborative work of small working groups or tasks forces established to comply with assignments or projects with clear and specific deliverables in a very short term. Two aspects regarding the collaborative space deployment are important: the definition, scope and characteristics of the applications (collaborative modules) residing in the MCS and the student working-group structure and dynamics of operation.

Our design considers the accommodation of different student groups working independently and simultaneously in their own collaborative space inside the MCS. In order to ease the information display and flow during the operation of the collaborative sessions, we decided to conform the student working groups with no more than 6 participants. These working groups are structured during classroom sessions where the teacher or course facilitator, in conjunction with the participants, establish the individual roles and responsibilities as well as deadlines, goals and scope of the particular assignment. Group leaders are appointed to coordinate and monitor the individual contributions and team performance to meet the goals in a timely manner.

The students access the MCS installed in a web server through their smartphone browser or mini-browser. In order to access the MCS, a student creates an account using his or her phone number. Personal data are recorded to facilitate the location of individual members for urgent tasks. Fig. 2 shows the MCS modules considered in our design. The specific modules were defined based on common habits of Mexican Internet users [11]. The first module is called "Progress" which provides data about the project such as theme, objectives and a list of key activities and their associated deadlines. The module "Notices" displays relevant information for the development of the assignment. This information can be addressed to one or more team members with messages to indicate immediate or urgent action. The "Repository" module hosts information for research and analysis regarding the central theme of the project. The information stored in this repository includes images, text, video and may include voice or other formats required to comply with the assignment. Each working group creates its own repository with content available to registered individual members only. The "Chat" module provides real time access to collaborators to support their interactivity and communication needs. We included a module called "Convergence" which is a w*iki* where individual and group contributions are documented in a collaborative fashion. The module "Contact" contains brief resumes that highlight the skills of the working group participants to identify capacities required to successfully accomplish the project goals. The "Help" module contains the MCS user manual and a group of frequently asked questions.

Figure. 2. *The MCS collaborative modules.*

3 Development of the MCS

The development of the MCS takes into consideration three main factors: Smartphone characteristics and functions (client), 3G or 4G network capacity and limitations (connectivity) and the web architecture (server). These three factors provide the platform that allows student-device-student interaction for seamless and ubiquitous collaboration as the FRAME model suggests [9].

The first factor in our development approach for the MCS must allow the interaction and communication among team members using any smartphone available in the market. (See Fig. 3).

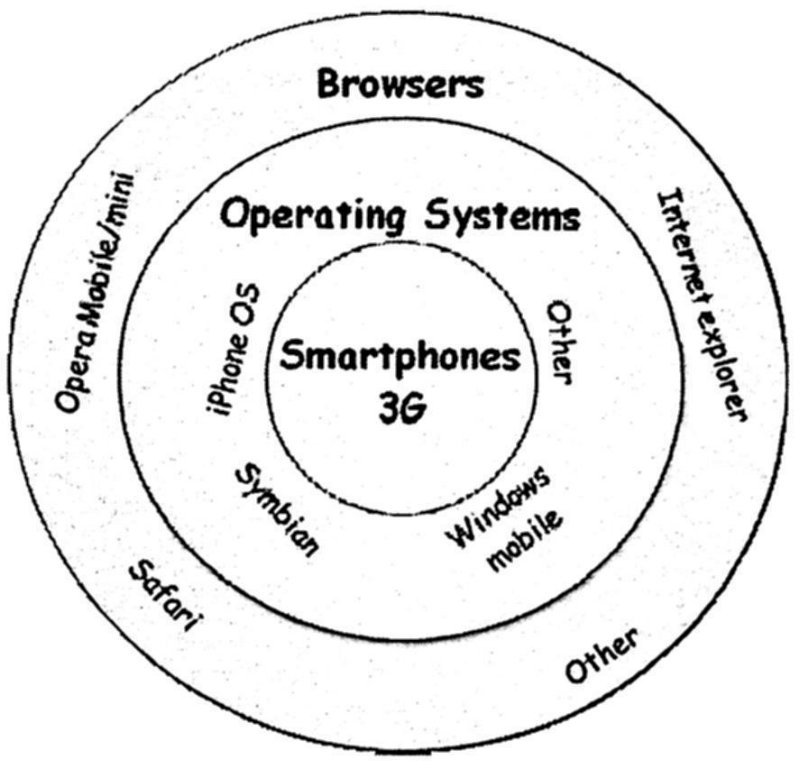

Figure. 3. *Smartphone features with 3G connectivity.*

The second key aspect is that the available wireless Internet connectivity must provide the smartphones with fast and efficient access to the MCS resources to optimize the interactivity and user experience. This task was accomplished using a 3G open layer architecture with transport, control and application components shown in Fig. 4 [12]. The transport layer manages the user information and the signaling flow, the control layer deals with the services and domain storage and management, while the application layer provides access to platforms and services such as Internet access.

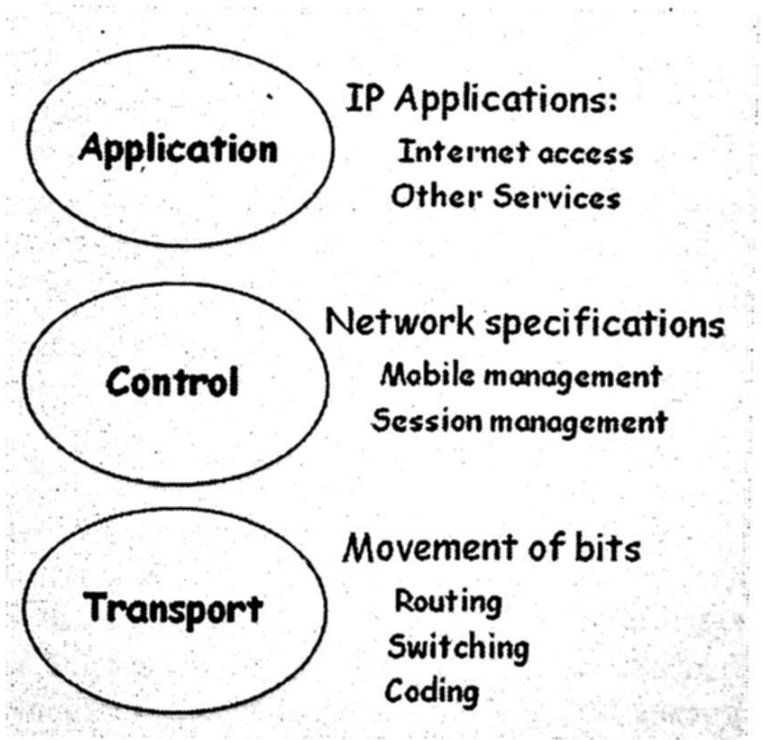

Figure 4. *3G open layer architecture.*

The third aspect to consider in the MCS development involves a web server architecture design that integrates the educational materials' storage services with the corresponding databases. This architecture (shown in Fig. 5) allows the MCS operation and access without the need of using specific applications for each type of smartphone [13]. Fig. 5 depicts the data flow and subsystems interaction to respond and process the smartphone (client) information requests, providing in this manner, seamless access to the MCS resources.

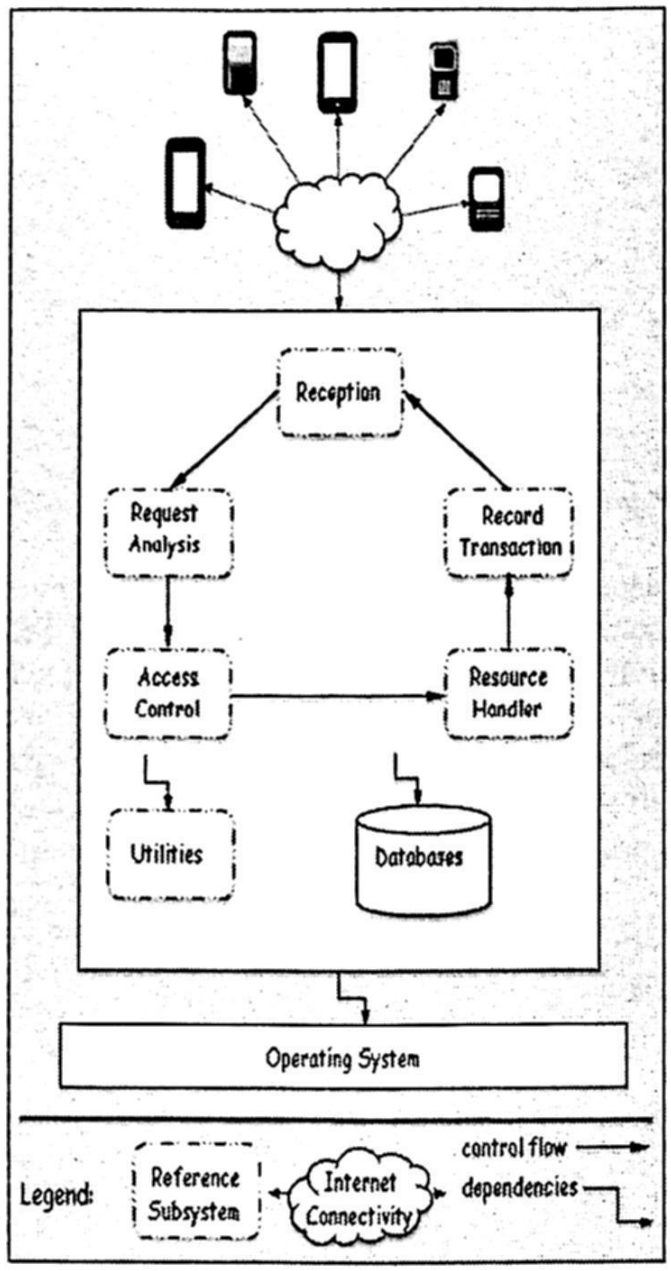

Figure. 5. *Web server reference architecture.*

The implementation of a web server architecture allows the flexibility of using both open source and other market available technologies. Our approach considers the use of open source resources to configure the server with a LAMP (Linux, Apache, MySQL, and PHP) architecture. In this scenario, the student interacts only with the client, i.e. the smartphone. Fig. 6 shows the collaboration environment with students accessing the MCS by means of smartphones with 3G connectivity. The aspects

involving the interaction between the student and the smartphone are fundamental for the design of the screen displays of the MCS modules. Simplicity and functionality become important when considering the limitations of screen size and processing power of the currently available smartphones.

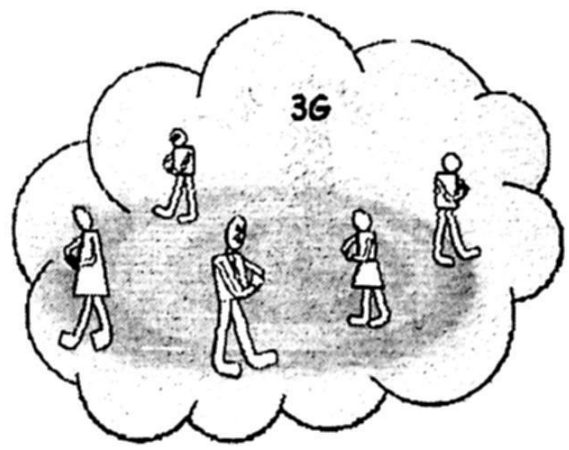

Figure. 6. *Remote collaboration among working group members.*

Other elements to consider in the development of the MCS are the selection of pertinent and relevant educational content suited to both the learning needs of the student working groups and the smartphone technical, physical and power consumption limitations. Furthermore, the availability of adequate wireless coverage and of cost efficient data plans for Internet access are crucial for the required level of interactivity and communication to accomplish the working group goals. We considered a minimalist design for the smartphone screens. Fig. 7 shows the start page, Fig. 8 shows the session initiation page and Fig. 9 shows the display of the MCS modules. We used six smartphones with a variety of operational systems, browsers and ergonomic designs and features.

4 Case Study

The operational features of the MCS were preliminary evaluated through the development of a task that involved writing an essay in a collaborative manner. The title of the essay was "An approach to educational applications of mobile devices with 3G connectivity". The essay was written in a remote and ubiquitous fashion in a period of 7 days. The working group consisted of six participants with a combination of pedagogical and computing skills.

Figure. 7. *The MCS start screen.*

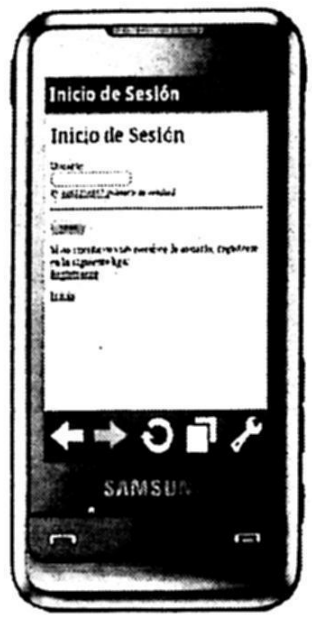

Figure. 8. *The MCS session initiation screen.*

Figure. 9. *Structure of the MCS modules.*

The MCS assessment had two main purposes; the first one was the use of this tool to understand the challenges of supporting collaboration through smartphones in a remote and ubiquitous manner, the second purpose considered the analysis of technical and operational factors involved in the client-server wireless communications link to provide a seamless user experience. A summary of our assessment is presented as follows:

1) In order to comply with the task deliverables in a short period, it was necessary to make use of other mobile devices such as laptops and notebooks to overcome the smartphone limitations. This was particularly important in activities regarding text editing, reading and compiling educational content.
2) We observed important limitations in relation to 3G connectivity, mainly coverage and signal power. Furthermore, the relative high cost of wireless Internet access, *vis-a-vis* the purchasing power and economic limitations of college students, seriously affects the intensity and frequency of the interactions and communication between group members.
3) The currently available mini-browsers and full-browsers do not display the information in the same way on all the smartphones. We noticed changes in font size and shape as well as in structure and topology of the screen elements. In this case, the individual user selected the best combination of browser and operational system that better fit his or her ergonomic preferences and type of smartphone.
4) The fluidity of interaction was affected when all the participants were accessing the "Chat" module. The reduced dimensions of the smartphone screens limit the number and proper visualization of simultaneous chat messages.
5) Seamless connectivity, close proximity and immediate access of smartphones were key factors for successful interaction and communication. Other two aspects that require further analysis are motivation, collaboration skills and participant training about the MCS functions and attributes before the start of the task.
6) In summary, according to the participants perception, the use of smartphones in conjunction with our proposed MCS architecture contributed to interaction and communication among the team members that was crucial to meet the assignment goals in a timely manner.

5 Conclusions

The preliminary results of our case study show that smartphones constitute versatile devices that allow interactivity and communication in a remote and ubiquitous fashion. The MCS architecture and the smartphone attributes contributed to finish the working group assignment in a timely and satisfactory manner. We identified challenges and limitations of smartphones to support collaborative work using a design approach for our MCS that, in spite of its simple structure, provided a flexible and useful platform for the interactivity and communication requirements of the college working group.

In order to increase the adoption and diffusion of m-learning, it is necessary to develop cohesive and sound research frameworks to harness its full potential. In the

authors' view, it is important to emphasize that smartphones are only tools to support collaboration and learning, the most important issues regarding their use in educational contexts are related to the understanding of the mobility and interactivity patterns of the users, the development of relevant and pertinent content taking into consideration the mobile devices' limitations and more importantly, the cost constraints of data plans for wireless Internet access.

Our design approach provides a flexible and integrated collaboration tool with potential application in other social contexts such as health, manufacturing and security.

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Interpreter for the deployment of intelligent tutoring systems in mobile devices

Ramón Zatarain-Cabada, M. L. Barrón-Estrada, Jesus E. Urías Barrientos

Instituto Tecnológico de Culiacán, Juan de Dios Bátiz s/n, Col. Guadalupe, Culiacán Sinaloa, 80220, México.

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Abstract. The main objective of this paper is to propose an application to display educational content in mobile devices, adaptable to the way that each user learns, with the added value of allowing students to carry out the learning process at any time and any place. The educational content is tailored to the student's learning style according to the model of Felder-Silverman. The identification of the student's learning style is performed using self-organizing maps. The operation of the tool presented, is based on techniques such as parsing XML files and deployment of user interfaces on mobile devices. It also makes use of neuron networks, specifically, self-organizing maps or Kohonen maps to perform detection of learning style of students.

Keywords: Adaptive mobile learning, Authoring tools, Learning Styles.

1 Introduction

Shaping the study materials, according to the characteristics of the student, on mobile devices is a topic of current research. However, most research on mobile intelligent tutoring systems (MITS, for its acronym in English) is more suited to systems that do not support artificial intelligence techniques to develop the adaptive implementation [1, 2, 3]. This is largely because mobile devices have many limitations, such as its low processing power, small memory and low speed at which access it. In addition, we also found that the user interface is rather limited (the screens are small and the keyboards have only a few keys). This causes that the information displayed to the user, is limited to some few lines of text and perhaps some images at once. Because of these limitations, any application designed to run on mobile devices should make a wise use of available resources. For example, the size of the files of the application must be as short as possible, as space is quite limited. In addition, processes should not be too demanding of the processor (should not take many clock cycles), the memory used should be the minimum possible, and the information that must be displayed to the user must be brief and concise.

Here we propose a visualization tool for intelligent tutoring systems, built on the platform EDUCA [4], which lets you create Intelligent Tutoring Systems (ITS) using the theory of learning styles of Richard Felder and Linda Silverman [5]. These ITS are stored using XML files, which allows the interpretation to be performed easily

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and keeps the cost of processing and memory usage at a low level. To make the adaptation to the student's learning style, the tool uses a self organizing map, which was designed with the goal of requiring few resources, without compromising its effectiveness, making it ideal to run on mobile devices.

The paper's organization is as follows: In Section 2, we present the layer architecture of the interpreter. In Section 3, we explain how an ITS is built. Section 4 gives a short introduction of the Predictive Engine. Results and Discussions are given in Section 5. Conclusions and future work are discussed in Section 6.

2 Interpreter Layer Architecture

The architecture of the interpreter is shown in Figure 1. We have placed only the most significant components of the whole application.

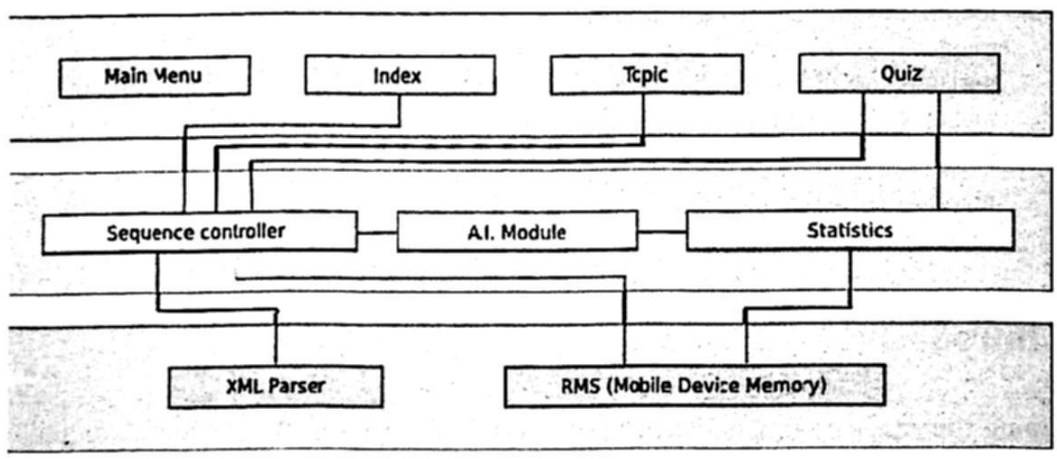

Figure 1. *Mobile interpreter architecture*

From all the components, **MainMenu** allows the first contact with the user since it is connected with **Sequence Controller**, which selects and shows the contents to the user.

In addition, **Quiz** is related with **Statistics** (business layer) which in turn is related with **RMS** (the data persistence module) in the data layer, to store the results of the evaluation.

On the other hand, component **AI module** has a link to **Sequence controller** and to **Statistics**; both of them provide the intelligent module with information about the user interaction with the course; with that information the AI module performs several actions (using the neural network) to determine which information is shown and how it is going to be shown to the user according to the learning style.

The interpreter was implemented using Java MicroEdition and XML since both technologies are platform independent. Java has been chosen as the language for the mobile application to take advantage of the multiplatform support, which helps the application to work on a wide range of mobiles without requiring neither complete nor partial reprogramming.

3 Building the ITS

The process of constructing an intelligent system consists of three main steps (figure 2). During Step 1 a tree structure of the adaptive or intelligent tutoring system is designed by the main instructor(s) of the learning material. On the tree structure, the designer also inserts quizzes (multiple selection and choice). Quizzes are an important element to provide adaptation capabilities to the produced tutors.

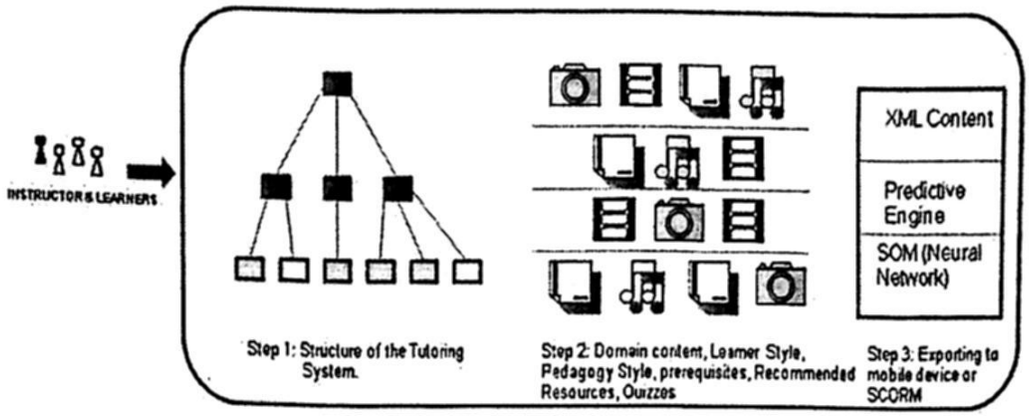

***Figure 2.** Building a Tutoring System*

In step 2 the tree structure is filled with domain contents (a knowledge base), and some other learning resources. At the beginning of the creation the instructor or teacher authors the tutoring system by inserting different learning objects like text fragments, images, audio/video clips, and by defining learning styles, prerequisites, tags and quizzes. At a later time, learning resources are added to the tutoring system by learners, who recommend resources they find commonly on the web. The third step consists of saving/exporting a package with the learning resources or contents (an XML file), a predictive engine for navigation purposes, and a SOM Neural Network for learning style classification.

3.1 Creating the Knowledge Base

In order to design and implement a course knowledge representation, we apply some of the concepts related to Knowledge Space Theory [6]. This theory provides a sound foundation for structuring and representing the knowledge domain for personalized or adaptive learning. An adaptive assessment based upon knowledge spaces and student prerequisites (and employing a Kohonen neural network [7] for identifying learning styles), will derive a particular or personalized path of learning objects. For each topic a set of prerequisites and quizzes are set. Figure 3 shows the knowledge domain of the topic *parsing* or syntactic analysis for a compiler construction course. Dashed lines represent those paths. We can also see the prerequisites for studying the topic (Lecture 2 – Lexical Analysis).

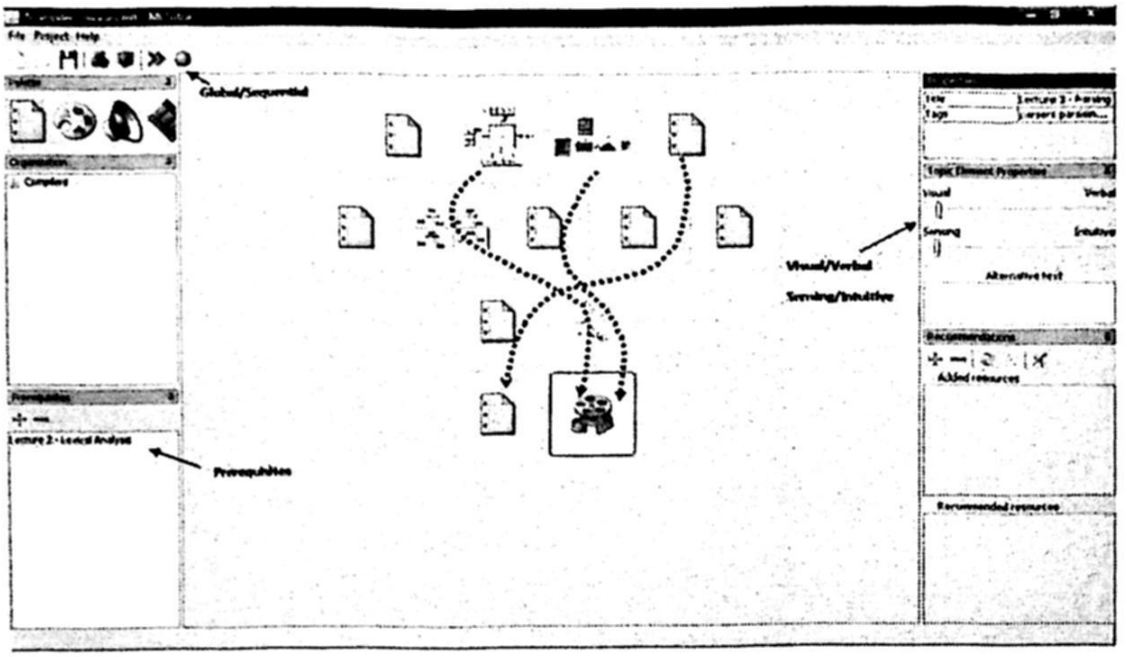

Figure 3. Knowledge Domain for the parsing topic

3.2 Implementing the ITS

The storage of the contents of the course is done using XML files. To reduce the workload of the mobile device, the information is divided into multiple files, that when the course is exported, this is inserted into the mobile application. Next, part of an xml file for a tutoring system is shown.

```
<?xml version="1.0" encoding="UTF-8"?>
  <topic>
        <title>Graficas</title>
        <resources>
              <resource>http://www.cucei.udg.mx/.../histograma.html</resource>
              <resource>http://www.hrc.es/bioest/Ejemplos_histo.html</resource>
        </resources>
        <prerequisites />
        <row rank="0">
              <component>
                    <sensing_intuitive>20</sensing_intuitive>
                    <visual_verbal>100</visual_verbal>
                    <alt></alt>
                    <sequential type="text">
                          <source>text0.xml</source>
                    </sequential>
                    ...
                    <global type="image">
                          <source>-832547520.png</source>
                    </global>
              </component>
              ...
        </row>
        ...
  </topic>
```

Each of the themes of an ITS is represented with file *topic#.xml* where # is the identifier of the item. The elements of the file are:

- Topic. File root element which has components *title, resources, prerequisites* and *row* as children.
    - Title: The name of the topic.
    - Resources: the description and URL of a resource.
    - Prerequisites: Topics the students need to know to understand the current topic.
    - Row: Within each file *topic#.xml*, it must be one or more row elements, which represent a learning unit. Each *row* element contains one or more *component* elements. *Component* is part of the learning unit. It contains elements that define the degree of belonging to this component, to Felder-Silverman dimensions "visual / verbal", "sensitive / intuitive", and "sequential / global".

4 The Predictive Engine

The main goal of the predictive engine is to dynamically identify the student's learning style whenever he/she is running the tutoring system. At the beginning, an interpreter selects content (learning objects) based upon the student's learning style, obtained from a student profile created since the first session of the student. The learning style can be modified according to evaluations applied to the student.

4.1 The Self-Organizing Map

The selection of a neural network model for solving a problem depends on its nature of it. The choice of using self-organizing maps was motivated mainly by three factors: the unsupervised type of learning of such networks, the network performance and the training speed. In supervised learning, we assume the existence of an expert on the problem that we are trying to solve with the neural network. In unsupervised learning, neural networks keep relationships between the input signals independently. Identifying learning styles of students is a complex task which falls in the discipline of pedagogy. The proper training of a neural network with supervised learning requires, in most cases, a pedagogue. With self-organizing maps we do not need a specialist in the training process.

5 Results and Discussions

The interpreter was implemented first in desktop environments and mobile devices. The desktop environment was used to edit the intelligent tutoring systems while the mobiles were used for deployment of them. Currently the interpreter has been implemented also in a Web 2.0 social network. This learning social network has the

name of Zamná [8]. Figure 4 shows a deployment of an ITS for a compiler course in both environments (The web and Mobile devices). One of the advantages of using a social learning networking is the exchanging and sharing of learning objects among community members.

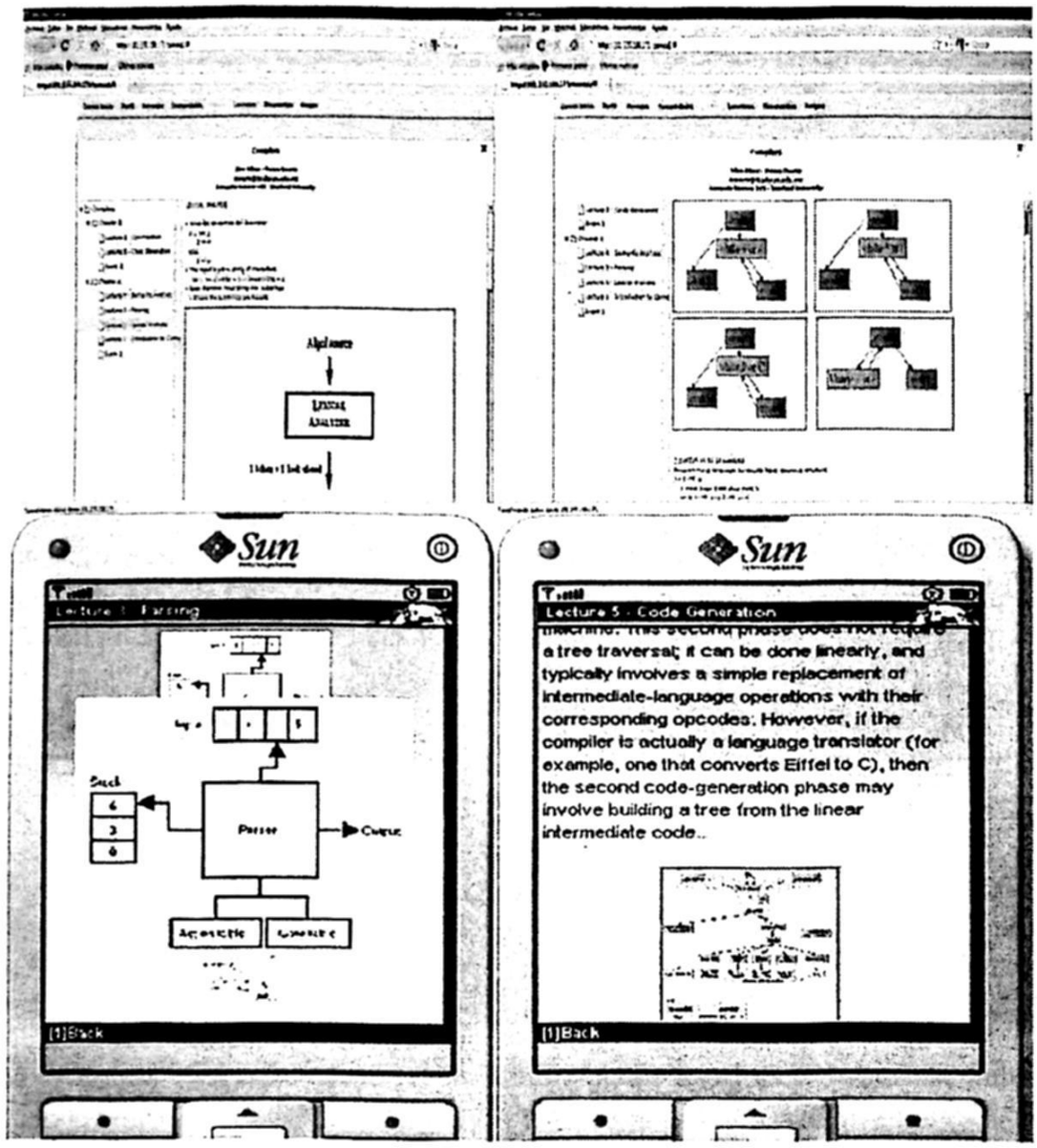

Figure. 4. *The Compiler Course on the Web and Mobile Devices*

6 Conclusions and Future Work

The interpreter for mobile devices is a good tool to support education "anywhere, anytime", because it allows to carry out the learning task using a device that most people have, and carries almost any moment, this, without sacrificing quality of content and also adding the ability to tailor the information displayed to the way each student learns.

Currently, the interpreter is totally being migrated to the Web 2.0 environment of Zamna. For future work, we want to export tutoring systems to other mobile platforms like Microsoft .NET Compact Framework [9], and the iPhone OS [10].

Acknowledgments.

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Lupita: Software architecture for virtual characters on the internet and mobile devices

José Gildo de Araújo-Júnior, Patricia Alanis-Maldonado, Ma. Lucila Morales-Rodríguez, Claudia Gpe. Gómez-Santillán, Juan Javier González B. and Héctor J. Fraire Huacuja.

Instituto Tecnológico de Ciudad Madero, División de Estudios de Posgrado e Investigación, Ave. 1° de Mayo y Sor Juana Inés de la Cruz S/N Col. Los Mangos, Ciudad Madero, Tamaulipas, México
{zegildo,alanis.pam,lmoralesrdz}@gmail.com,hfraire@prodigy.net.mx,
{cggs71,jjgonzalezbarbosa}@hotmail.com
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Abstract. This paper presents educational software based on a math tutor for elementary school children. This software teaches the basics operations of mathematics through a virtual tutor endowed with personality. The virtual tutor is a cognitive agent that integrates a behavioral model, verbal and nonverbal expressions. This architecture was based on the concepts of computing Clouding and RIA (Rich Internet Application) for easy access through Internet and mobile devices.

Keywords: Virtual Character, Intelligent Tutor, Educational Software, Software Architecture, Internet.

1 Introduction

Nowadays the inclusion of mobile devices and Internet in the daily life has a rapid growth and opens a window for developing software with educational purposes.

Educational software can be defined as "*computer programs created with the specific purpose of being used as a teaching tool, to facilitate the teaching and learning*" [1].

Educational software has evolved to providing more facilities and interactivity to the educational process. Simulators, tutors, hypermedia, multimedia and intelligence features are some of the attributes that have been developed in different generations of educational software. The wide incorporation of Internet in the daily life is one of the most revolutionary characteristic that allows the extension of educational applications on mobile devices [2].

The virtual characters seen as an applicative example of educational software for children are having huge boom [3], for this reason it is important a software architecture that provides support for the creation of portable and flexible applications for their inclusion on the Web and mobile devices.

This article describes the software architecture for the intelligent tutor called *Lupita*. This paper is organized as follows. Section 2 discusses the software architecture under the concept of Clouding Computing. Section 3 details the software architecture for intelligent tutor *Lupita*, associated with the concept RIA (Rich Internet Application) for their incorporation on Internet and mobile devices and describes the logic. Then, Section 4 describes the Intelligent Tutor. The paper concludes in Section 5 with a brief summary of our main points.

2 Integrating the concept "Clouding Computing" in an Intelligent Tutor

The concept of *cloud computing* is a new paradigm for software development, which offers the ability to use the infrastructure and platforms that are managed and provided by third parties in order to provide services through Internet.

That is, the user has access to a number of files and programs stored in a place indefinitely, hence the term cloud, which are permanently available independent of where we are. The documents are not physically hosted on a computer and can dispose of them from anywhere with just an Internet connection [4]. There are three types of cloud services [5]:

- **Software as a Service** (SAAS), which delivers applications such as office applications.
- **The platform as a service** (PAAS), which provides environments and tools to develop applications, in this case the supplier is responsible for operating the infrastructure (servers, networks, operating systems, the storage media).
- **The infrastructure as a service**, (IAAS), provides infrastructure for processing, storage, networking and other elements on which customers run their operating systems and applications, and are able to control things such as firewalls or load balancers.

In the cloud, the service platform for Lupita's architecture is provided by Google App Engine also known as GAE, which provides the cloud computing service allowing to create Web applications using Google technology and servers (see Figure 1).

GAE is a platform to develop and host Web applications in data processing centers operated by Google itself. This system has some restrictions, among them that developers have access only to read the file system of App Engine, which runs only with HTTP calls, the storage is limited and Java applications cannot create threads [6].

Figure. 1. *General architecture of system performance under the concept Clouding*

The application development in GAE is supported by the Python programming language.

3 Implementation and Rich Internet Application in the Intelligent Tutor

The Lupita's interface has been created based on the concept of RIA (Rich Internet Applications). RIA is a new type of Web application whose aim is to increase and improve the options and capabilities of traditional Web applications. This new type of applications in most cases are developed using their own markup languages and is performed using a presentation server also own [7].

RIA is highly interactive and with a remarkable visual richness, providing an unprecedented ease of use to web users.

Inside available RIA technologies we found Flash RIA, which is a technology that allows the development of Web applications, these are compiled as SWF files to be executed by the plugin of Macromedia Flash Player. Such applications provide a more attractive and dynamic view [7]. Lupita's interface was developed as a Flash RIA using objects and advanced features accessible through any web application and mobile devices.

Python was the main language used to develop the logic of the intelligent tutor (Lupita), this is an object-oriented programming language [8] and this characteristic has been essential to provide a decentralized and modular implementation of the components.

Lupita is composed of the following modules that interact in order to select math's exercise and give feedback to the student:

- **Cognitive module:** this module allows the selection of the student questions which are influenced by the previous performance of the student.

- **Behavioral Module:** this module endows the virtual character of a personality that will influence their verbal and non verbal behavior during the interactions.
- **Expressive Module** allows communication with AIML[1] enabling verbal and nonverbal expressions of virtual tutor.
- **Game Module**: enables integration of all modules and begins the system execution.

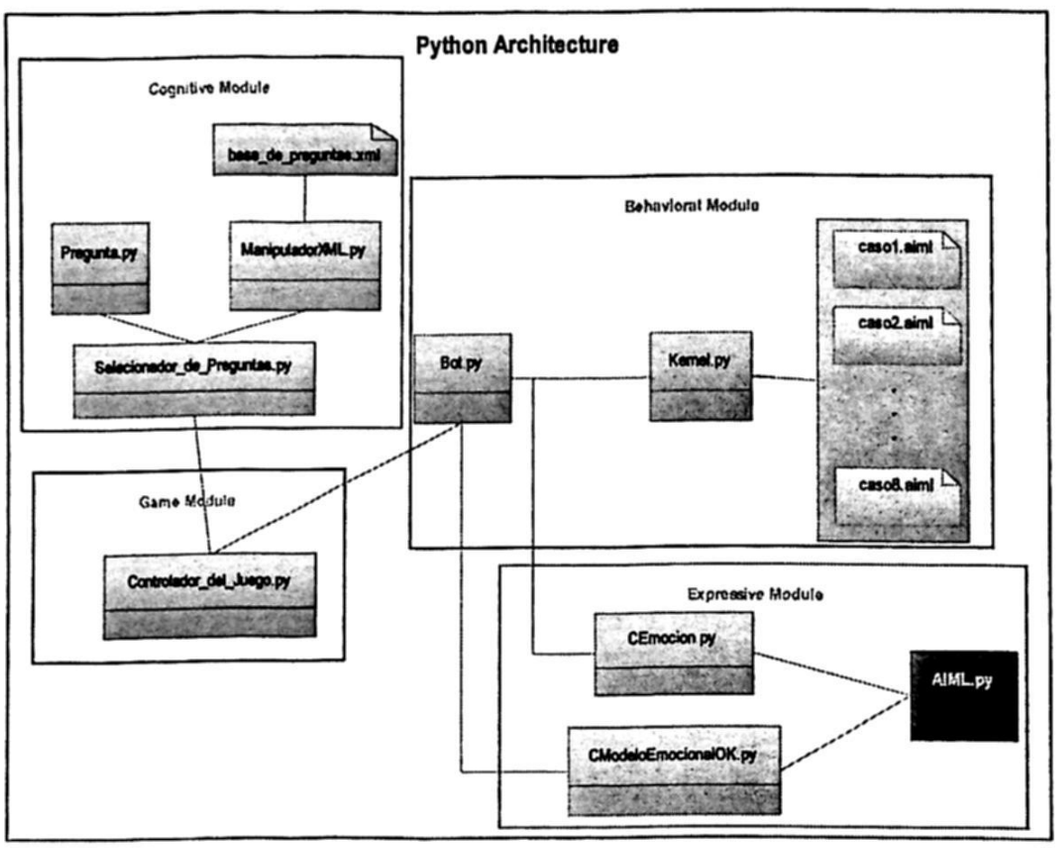

***Figure 2.** System Architecture*

4 Intelligent Tutor Lupita

Lupita is an Intelligent Virtual Agent (IVA) endowed with personality that guide an online test related to the basics operations of mathematics. This virtual tutor is a cognitive agent based on the behavioral model proposed by Morales [10], and able to use verbal and nonverbal expressions [11].

The interaction between a user (student) and the Virtual Agent begins when a math's exercise and their possible answers are showed to the student. After this, the behavioral model updates the emotional state of the virtual tutor according to the evaluation of the solution submitted and the time taken to answer it. In order to give a feedback to the student and select a new exercise, these values are processed by the AIML database and

[1] Artificial Intelligence Markup Language [9].

produce the selection of the next utterance and the non verbal expression. Next, the application interface displays the animation appropriate to the current emotional state of the agent (see fig. 3).

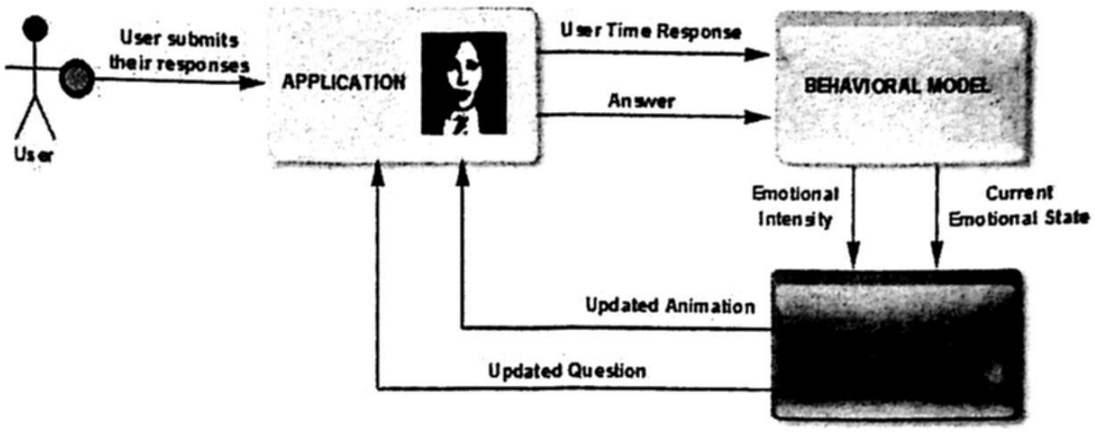

Figure 3. *Interactions in Lupita's architecture*

In the virtual environment Lupita interact as a tutor that aids, assists, encourages and supports the efforts of users to learn.

4.1 Expressions of Nonverbal Interaction on the Virtual Character

Usually the nonverbal expressions in a tutor-student interaction are shown in several stages of the interaction, for example:

- Explain how to solve problems.
- Discuss the nature of the concepts and strategies that are being learned.
- Teaching knowledge.
- Explain the connections between the learning in the present and what is learned in the past.

In our work we modeled and implemented three types of nonverbal expressions which are influenced by the personality profile of the virtual character and the performance of the student:

- Related to the context of the Activity: they are expressions that support, replace or complement messages involved in the educative activities in order to motivate the learning, to hold the attention of the student and to stimulate the good performance.
- Related to the behavior: they imply physical actions or involuntary acts.
- Related to the Social Interaction: they express courtesy protocols, like greetings.

4.2 Prototype of the Math Tutor

Our prototype is educational software based on a tutor for elementary school children, which is available on the Internet at http://www.patylupita.appspot.com/.

The software developed evaluates the basics operations of mathematics through a virtual tutor endowed with personality. In fact, in this prototype the student could chose between two different characters and personalities, Lupita that is a calm person and Paty that is an annoying person (see Fig. 4)

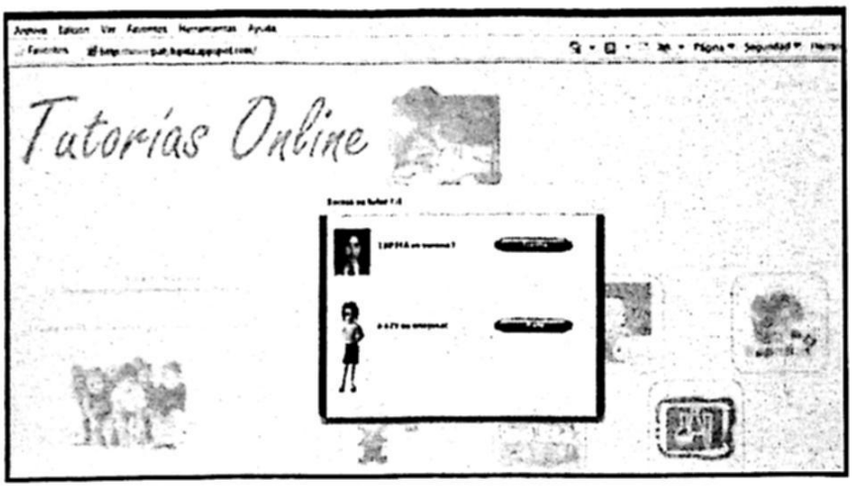

Figure 4. *Tutor selection*

After selecting the tutor, the evaluation interface is displayed (see Fig. 5). This interface is divided between the virtual character and the question-answer area.

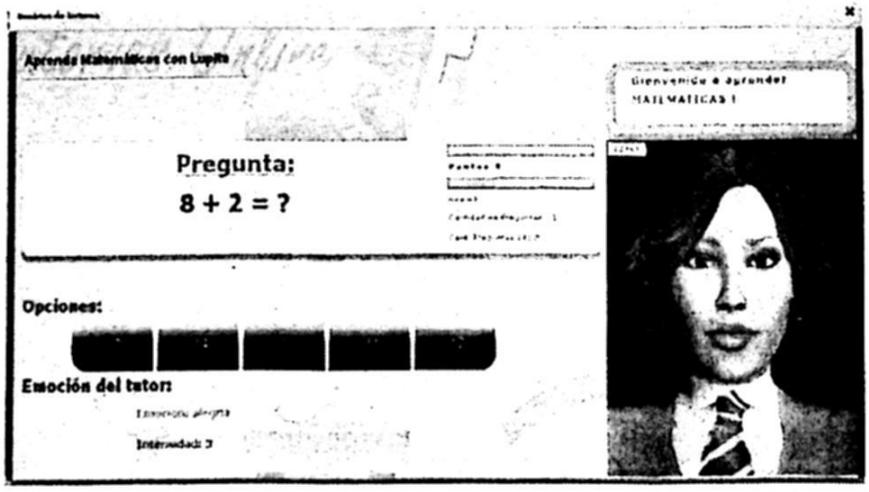

Figure 5. *Example of an interaction with Lupita*

The question-answer area shows additional information related to the level, and the points obtained. The virtual character interacts with the student by text message and nonverbal expression related to its emotional state result of the performance of the student.

5 Conclusions

This work show a new line of educational applications involving virtual characters oriented to teach children. We think that the dynamic interaction with this emotional and social character caught the interest of the student in practice and thus improve their scholar performance.

The present architecture shows the possibility of using the services of the Google infrastructure and RIA technologies for development of educational software that could be easy access through the Internet and mobile devices that support Flash technology.

The main contribution of this work is the development of general software architecture for the creation of applications on Internet and mobile devices that integrates a virtual character endowed by an emotional and social behavioral model.

As future work we want to improve the prototype applying data mining to the performance historic record of the student and thus guide the selection of the next group of exercises that he needs to practice. This new improvement will allow that Lupita will be adaptable to the particular needs of each student.

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Integrating learning styles and affective behavior into an intelligent environment for learning

Yasmín Hernández, Guillermo Rodríguez, G. Arroyo-Figueroa

[1] Instituto de Investigaciones Eléctricas, Gerencia de Sistemas Informáticos
Reforma 113, Col. Palmira, 62490, Cuernavaca, Morelos, México
{myhp, gro, garroyo}@iie.org.mx
(Paper received on September 07, 2010, accepted on October 20, 2010)

Abstract. It is well known that personalized tutoring helps to improve the learning process and to obtain better results. With this aim we have developed an affective behavior model to provide students with an instruction according to their affect state besides the knowledge state. Now we are developing a model including the learning styles of the students. We based our model on the Felder-Silverman Learning Styles Model. According to the student learning style, the instruction is establishing by a proposed set of rules. To prove our model we propose to use an LMS in compliance with SCORM. In this paper we present our general proposal.

Keywords: affective model, learning styles, LMS, intelligent learning environments, learning objects.

1 Introduction

Up to the present time, most of the intelligent learning environments personalize learning basically by following what the student knows and selecting the next learning object according to the student's current knowledge. This is usually implemented with a student model where his knowledge state is compared with the knowledge of an expert, teacher or instructor in the domain of the course. On the other hand, while several models of affect have been proposed, few proposals of personalization of the tutorial actions based on affective models are reported in the literature [1] and the same happens with personalization using learning styles [2].

We are developing a model including knowledge, affect and learning styles of students. Next, we describe the affective model followed by a section presenting the learning style model. In section 4, an introduction to the learning management system (LMS) Moodle is provided. In section 5, we present our integration proposal to implement intelligent tutors at IIE. Finally, conclusions are presented.

Before to proceeding, we want to clarify two terms: affect and emotion. Although literature offers several definitions of emotion, there is not an accepted definition. According to [3, 4] emotion is a reaction to events which are supposed to be important for the needs, goals, and interests of an individual. Generally, affect is use

in a broader sense than emotion; as a term to comprise emotion, sentiments, feelings, moods. Consistent with [5], in this paper these terms are used interchangeably.

2 Affective Behavior Model

Emotions have been recognized as an important component in motivation and learning. There is evidence that experienced human tutors monitor and react to the emotional state of the students in order to motivate them and to improve their learning process [6]. If we want to consider the student affective state in the tutorial actions, an important problem is to identify the best tutorial action given both the students' affective and knowledge state. We have developed an affective behavior model (ABM) [1] that takes affect into account when interacting with a student by i) inferring the affective state of the student (affective student model); and ii) by establishing the optimal tutorial action based on the student's current affective and knowledge state (affective tutor model). A flow diagram of the ABM is presented in Fig. 1.

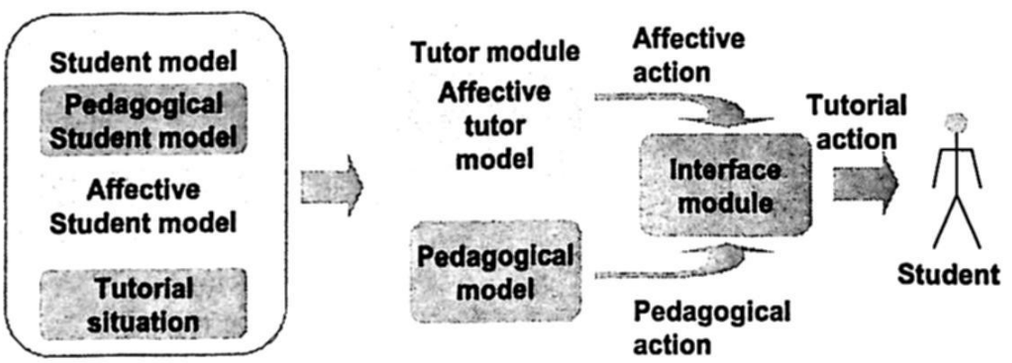

Figure. 1. *General diagram of the affective behavior model. The model is composed by an affective student model and an affective tutor model. The tutor model produces an affective action considering the affective and pedagogical student models and the tutorial situation. The affective action is a component of the tutorial action to be presented to the student*

To generate a tutorial action, the ABM considers the affective and knowledge state of the student (as assessed by the corresponding student models), as well as the tutorial situation. The tutorial action is viewed as consisting of two components. The first component targets mainly the student's affective state (affective component) and, the second component (pedagogical component) targets mainly the student's knowledge and consists of verbal hints. Thus selecting a tutorial action involves selecting these two components. Finally, the interface module establishes the physical realization of the tutorial action.

Our affective student model uses the OCC model [4] to provide a causal assessment of student's emotions based on contextual information. The OCC model defines emotional state as the outcome of the cognitive appraisal of the current situation with respect to one's goals. The student model consists of a dynamic

Bayesian network (DBN) that probabilistically relates student personality, goals and interaction events with student's affective states, based on the theory defined by the OCC model. Fig. 2 shows a high level representation of the model, where each node in the network is actually a set of nodes in the actual model. The model is based on the proposal by [7, 8].

The DBN models the dynamic nature of the student's emotions. To infer the affective state at t_n, it considers the student's knowledge, personality, and the tutorial situation at that time, as well as the student affective state at t_{n-1}. The tutorial situation is defined based on the results of the student actions.

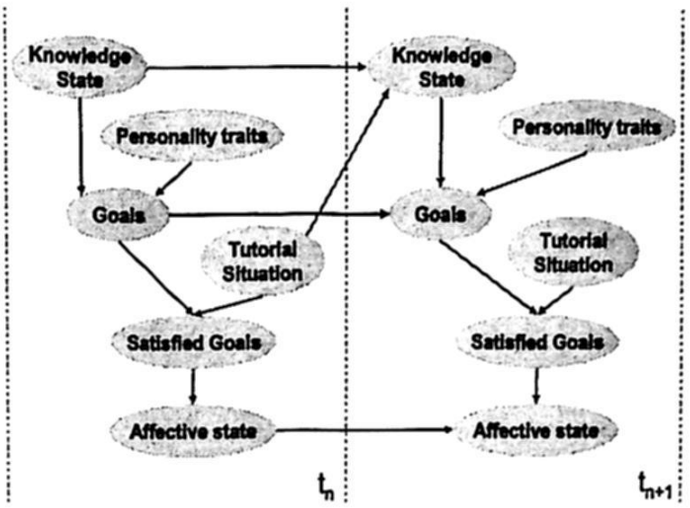

Figure 2. *High level DBN for the affective student model. We include two time slice to represent the dynamic behavior of affect and its impact in the next state.*

The student's appraisal of the current situation given her goal is represented by the relation between the goals and tutorial situation nodes through the satisfied goals node. The influence of the appraisal process on the student's affect is represented by the link between the satisfied goals node and the affective state node. From the complete set of emotions proposed by the OCC model, the affective model only includes six emotions: joy, distress, pride, shame, admiration and reproach.

According to the OCC model, one's the goals are fundamental to determine one's affective state, but asking the students to express these goals during game playing would be too intrusive. Consequently, the goals in our network are inferred from indirect sources of evidence. We use personality traits as a predictor of the student's goals, but we also include the student's factorization knowledge.

The personality traits we included in the model are based on the five-factor model [9], which considers 5 dimensions for personality: openness, conscientiousness, extraversion, agreeableness, and neuroticism. We include only 2 factors, conscientiousness and neuroticism, to establish goals, because these are the ones for which a stronger relationship was found with learning [10]. The information on the student's knowledge state and tutorial situation nodes comes from the model of student's knowledge and from the outcome of student's actions.

The dependency relations in the DBN have been established based on the literature [8, 9] and on insights from teachers.

Once the affective student state has been determined, the tutor has to respond accordingly. To do that, the tutor needs a model which establishes parameters that enable a mapping from the affective and knowledge student state to tutorial actions. The tutorial actions are composed by an affective and a pedagogical component.

Because we want that tutorial actions both help students learn and foster a good affective state, we use decision theory to achieve the best balance between these two objectives. The decision process is represented as a dynamic decision network (DDN), shown in Fig. 3. The DBN included in the DDN model is used to predict how the available tutorial actions influence a student's knowledge and affect given her current state. This prediction is used to establish the utility of each tutorial action for the current state.

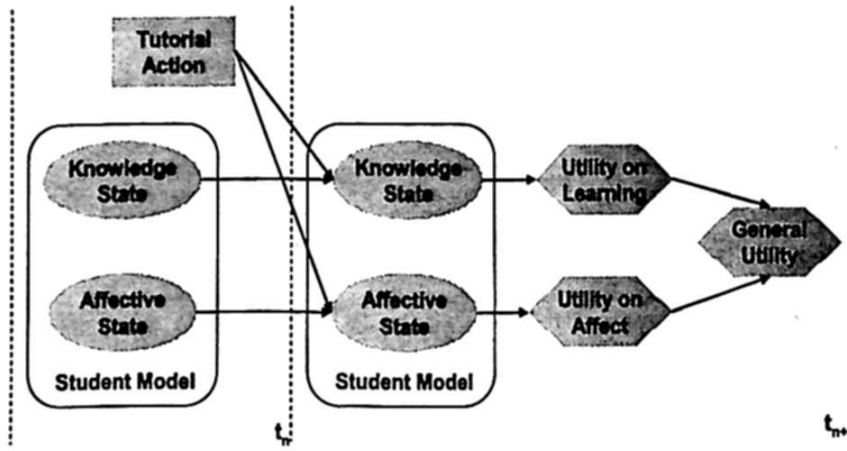

Figure 3. *High level DDN for the affective tutor model. This network is used to establish the tutorial action to be presented to the student.*

Our model uses multi-attribute utility theory to define the necessary utilities [12]. That is, the DDN establishes the tutorial action considering two utility measures, one on learning and one on affect, which are combined to obtain the global utility by a weighted linear combination. These utility functions are the means that allow educators adopting the system to express their preferences towards learning and affect.

After the student performs an action, i.e. after the student model is updated (time t_n), a new time slice is added (time t_{n+1}). At time t_n we have the current student state and the possible tutorial actions; at time t_{n+1} we have the prediction of how the tutor action influences the student's affect and knowledge, from which we estimate the individual and global utilities. The influence of each tutorial action on student's knowledge and affect, and the corresponding utility, are based on the teachers' expertise.

The utility for learning is measured in terms of how much the student's knowledge is improved by the tutorial action given her current knowledge. Similarly, the utility for affect is measured in terms of how much the student affect improves as a result of the action. Finally, the overall utility is computed as a weighted sum of these two utilities Thus, the tutor calculates the utility for each tutorial action considering the current state, and it selects the tutorial action with the maximum expected utility.

When the tutorial action has been selected, the decision network has finished its work and the time slice t_{n+1} is discharged. This is because the tutorial action is not used to update the student model but only to predict the impact of the tutorial action. At this point, the tutor delivers the selected action to the student and then uses the resulting student's response to update the student models. This cycle is repeated for each student action.

This model have been evaluated in two domains with good and encouraging results; the evaluations of the affective model can be found in [1, 13].

3 Learning Styles Model

To incorporate learning styles in the adaptation logic of tutorial systems it is required an approach to identify the best tutorial action given the students' learning style. First, we present the Felder-Silverman Index of Learning Styles model [2, 14, 15], a well-known and used learning styles theory and model is presented. Then the model is used in a rule-based proposal to incorporate learning styles in intelligent tutors. We use rules since they are conceptually easy to implement and integrate into adaptive tutors.

The Felder-Silverman categorizations of learning styles are: Sensing-intuitive, Visual-verbal, Active-reflective, Sequential-global.

Active and Reflective Learners. The Active style learner understands information best by doing something with it and likes group work. The Reflective style learner understand information best by thinking about it quietly first and prefers to work alone.

Sensing and Intuitive Learners. The Sensing learner likes learning facts and solves problems by well-established methods and dislike complications. The Intuitive learner prefers discovering possibilities and relationships and likes innovation and dislikes repetition.

Visual and Verbal Learners. The Visual remembers best what they see—pictures, diagrams, flow charts, time lines, films, and demonstrations. The Verbal gets more out of words—written and spoken explanations

Sequential and Global Learners. The sequential gains understanding in linear steps and follows logical stepwise paths in finding solutions. The Global learns in large jumps and solves complex problems quickly once they have grasped the big picture.

To identify the learning style of a person, the Felder-Silverman assessment instrument is used, which is a Soloman and Felder questionnaire, consisting of 44 questions [16].

The rule-base is a collection of rules and each rule proposes a set of teaching instructions for one learning style. Table 1 shows the rules.

Rules are conceptually easy to implement in tutorial systems. However, to apply these rules, every lesson of a course has to be converted into 8 different lessons according to the teaching instructions. This effort is justified if there are many potential students classified in each of the learning styles so that they can benefit of the personalized learning objects. As opposed to the Affective Behavior Model, the learning style of a person is assessed once at the beginning of the course.

4 Learning Management System

The use of programs to manage the activities around training and education is rapidly growing; universities and other institutions are using them to support the education/training programs. The simplest definition of learning management system (LMS) is software application for the administration, documentation, tracking, and reporting of training/education programs for e-learning and b-learning; however, an LMS is also concerned with centralize and automate administration, provide self-service and self-guided services, assemble and deliver learning content rapidly, consolidate training initiatives on a scalable web-based platform, support portability and standards and personalize content and enable knowledge reuse [17]. The functions of an LMS vary from systems for managing training and educational records, to software for distributing courses over the WWW with features for online collaboration.

An LMS should provide the following elements: The syllabus for the course, administrative information, a notice board for up-to-date course information, student registration and tracking facilities, basic teaching materials (These may be the complete content of the course, or copies of visual aids used in lectures), additional resources (including reading materials, and links to outside resources in libraries and on the Internet), self-assessment quizzes which can be scored automatically, formal assessment procedures, electronic communication support including e-mail, threaded discussions and a chat room, with or without a moderator, differential access rights for instructors and students, production of documentation and statistics on the course, easy authoring tools for creating the necessary documents including the insertion of hyperlinks [17].

Table 1. Rules of teaching instructions for each learning style for Felder-Silverman model.

Learning style	Teaching instructions
Active	Show exercises at the beginning of the chapter because they like challenges and problem solving Show less examples. They are not interested in the way others have done something, because they want to solve a problem by themselves
Reflective	Show exercises at the end of a chapter Show examples after explanation content, but before exercises Show less exercises, because they learn better by thinking about a topic instead of solving problems actively.
Sensing	Show examples at the beginning of a chapter (before explanation content) because they like concrete content. Show exercises after explanation content, because they solve problems by already learned approaches

Intuitive	Show less examples, because they like to discover topic application by themselves Show examples after explanation content, because they like abstract content more than concrete Show exercises before explanation content, because they like challenges Show less exercises with a similar teaching goal because they don't like repetition
Visual	If possible, show resources as a picture or a video
Verbal	Show resources as a text or an audio
Sequential	Show learning content in a standard sequence – explanation content, examples, exercises and summary, because they like linear approach
Global	They are less interested in details, because they need to create a global picture of the topic. Therefore, add an overview of each chapter at the beginning of the lesson Show summary before examples and exercises, because summary helps you to create a global picture

In addition, the LMS should be capable of supporting numerous courses, so that students and instructors in a given institution experience a consistent interface when moving from one course to another [18]. An important feature of LMS is the adherence to standards, such as SCORM [17], it means that the LMS can share content complying with standards regardless of the authoring system that produced it.

There are many commercial and open source LMS. Some of popular commercial LMS are: Blackboard [19], WebCT [20] and the leading open source LMS is Moodle [21]. For our proposal we decided to use Moodle.

Moodle is a software package for producing Internet-based courses and web sites. It is a global development project designed to support a social constructionist framework of education. The word Moodle was originally an acronym for Modular Object-Oriented Dynamic Learning Environment. Moodle allows providing documents, graded assignments, quizzes, discussion forums, etc. to students with an easy to learn and use interface. We are assembling a Moodle site to develop our proposal for the Institute for Electrical Research (Instituto de Investigaciones Eléctricas) at México.

To develop dynamic courses or intelligent tutors that are SCORM compliant, a method to obtain a SCORM activity tree from a graph (AND/OR graph or a tree) that represents a tutor plan is presented in [22]. This will allow running SCORM compliant intelligent tutors in Moodle.

5 Integration Approach

An integration approach is proposed that allows building intelligent tutors that are adaptive in response to the knowledge state, the affective state and the learning style of the students.

At the beginning of a course, the learning style assessment instrument (Felder-Silverman) is applied to the student. Using the rules from Table 1, the learning style determines the type of explanations to be presented to the student when taking the

course. Additionally, during the course, the tutor monitors and reacts to the knowledge and emotional states of the student, using tutorial actions as described above in section 2, in order to motivate and improve the learning process of the student.

6 Conclusions and Future Work

In this paper we presented two models that will allow us to integrate affective behavior and learning styles of the students into intelligent environments to complement the current approach in intelligent tutors that only follow what the student knows using a model that tracks the knowledge state of the student. The affective behavior and learning styles models increase the degree of personalization of the intelligent environments.

In the future, we plan: to incorporate the affective and learning styles models in dynamic courses for power generation and electric distribution operators and evaluate the effectiveness of these models.

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Integrating videogames into learning object using multiagent approach

Edgar A. Calvillo Moreno [1], Jaime Muñoz-Arteaga [1], Alberto Ochoa Zezzatti[2], Fco. Alvarez Rgz[1], Joaquín Pérez[3], Alejandro Padilla Díaz [1]

[1]Universidad Autónoma de Aguascalientes, Av.Universidad #940. C.P. 20131, Ags. México. [2] Universidad Autónoma de Cd. Juárez, Cd. Juárez, México, [3]CENIDET, Interior Internado Palmira S/N, Col. Palmira Cuernavaca, Morelos
alancalvillo@yahoo.com, jmunoz@gmail.com, fjalvar@correo.uaa.mx, apadilla@correo.uaa.mx, alberto.ochoa@uacj.mx,jperez@cenidet.edu.mx
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Abstract. How is possible to take the advantages of videogames inside of learning objects?. This work tries to answer this question proposing a model in order to integrate the videogames into learning objects coming from several distributed repositories located in different educative institutions. This could be possible using a multiagent system that is designed and implemented, this system is presented here by a case study.

1 Introduction

A videogame is an interactive computer program proposed for entertainment; it can run on various devices such as personal computer, consoles, cell phones, audio allowing users learn in a ludic manner. The videogame market is constantly growing; new developments occur almost every month, increasingly sophisticated and offer more possibilities to the player. Nowadays the videogames are using in multiple platforms creating a lot of mobile consoles. Then, the user could use the videogames consoles exploring academic resources in those devices. However, in the e-learning area, there are several works that offer few options for access educational resources with videogames. [1,14,15].

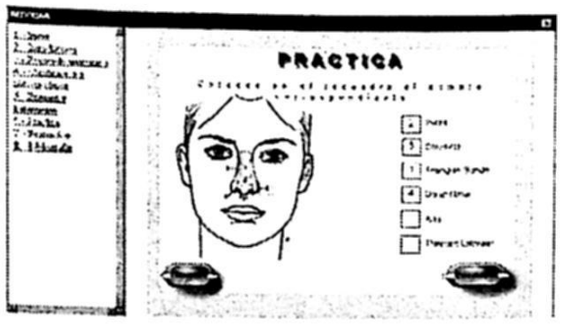

***Figure 1** A learning object from morphology domain.*

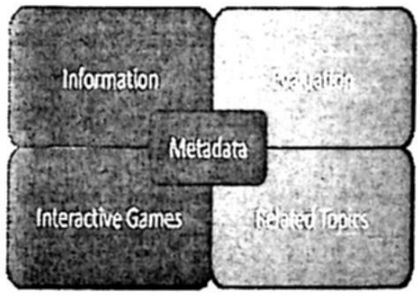

***Figure 2.** Model of Learning object with videogames.*

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The learning objects are considered as educational resources that can be employed in technology support learning. They are a digital pieces of knowledge to put together in order to form online courses; an example is presented by figure 1 of a learning object coming from morphology domain [2]. In figure 2, a model is proposed of learning object (modified from [7]) composed by five components as follow: Information of theory, evaluation, related topic, metadata and the practices in terms of interactive videogames. With this model, the students could learn easier and put in practices the theoretical knowledge playing with the interactive videogames embedded in every learning object. The students can learn and put in practices the theoretical knowledge playing interactive games, or a videogame provided inside of a learning object. The metadata save features of object and the videogames; in addition with the metadata is possible to identify learning objects. The use of learning objects has led several educative institutions to encourage the creation of digital materials for implementation in various devices such as desktop computers, mobile devices, laptops and other devices [8].

Current work is structured in four sections; some common problems using videogames as educational resource are presented in next section. In the contribution section is proposed the use of mobile devices in order to access the educative resources coming from a federation of repositories. Next, a case study presents the feasibility of current proposal. Finally, related work and conclusion sections are described for this work.

2 Problem Outline

The learning objects are generally saved and accessed in repositories which offer a series of services such as display, search, and update. Then a teacher can develop a course in a transparent way searching and selecting learning objects from different repositories. Several institutions use LMS (Learning Management System) to develop course their courses with learning objects on various topics such as: data structure, programming, software engineering, morphology, etc. [7,3]. The creation of heterogeneous learning objects require the compatibility between LMS platforms, OS platforms and content of learning object, but the compatibility isn't a guaranty with portable devices such as mobile devices, handheld, videogame consoles in another. It is possible to identify several difficulties when learning objects are composed with videogame, these difficulties are as follows:

- The learning objects needs to be portable and reusable across multiple platforms, including mobile devices and portable game consoles.
- It is necessary the use of a learning object with videogame.
- It is necessary a better performance searching learning objects.
- The searches of learning objects require to be applying in local and distributed repositories.
- It is important to have a visualization of a learning object as a game.
- It is necessary a high interactivity in the content of learning objects.
- The evaluation methods to measure the quality of learning of object.

3 Contribution

Nowadays, a large number of universities are producing online courses in terms of learning objects and saving these objects in their own repositories, these repositories in general support several local queries with different criteria thanks to the information in the metadata. The universities could connect their repositories in order to reuse the academic contents and offer online course in terms of learning objects. Then, the final user could use videogames accessing different repositories (see figure 3). In addition all the learning objects in the federation should be filter by multiple agents asking and getting learning objects with videogames.

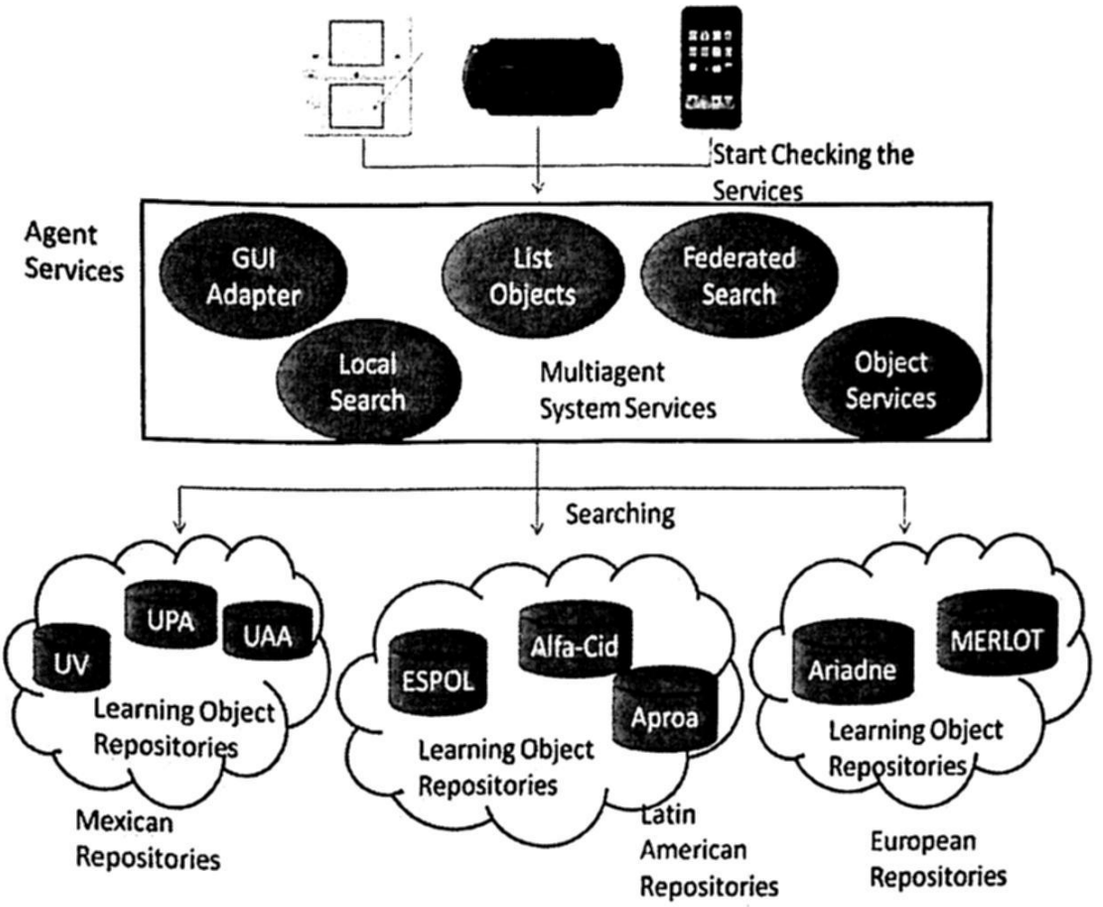

Figure 3.*Access of learning objects with videogames coming from different repositories.*

Figure 3 shows the architectural model where the game console could access and display different learning objects with videogame from different repositories [2,3,5], The user interface of videogame consoles (psp, itouch, pc) allows a direct access of a learning. This multiagent system could access to a large collections of learning objects from different repositories located in different institutions (as an example Mexican repositories, Latin-American repositories and European repositories) which they can share their academic resources. In the multiagent system proposed here each agent is specified in terms of classes with attributes and functions and the interactivity between the agents; these framework give us the opportunity to launch

each agent, with this performance is incremented of a local search and a federated search.

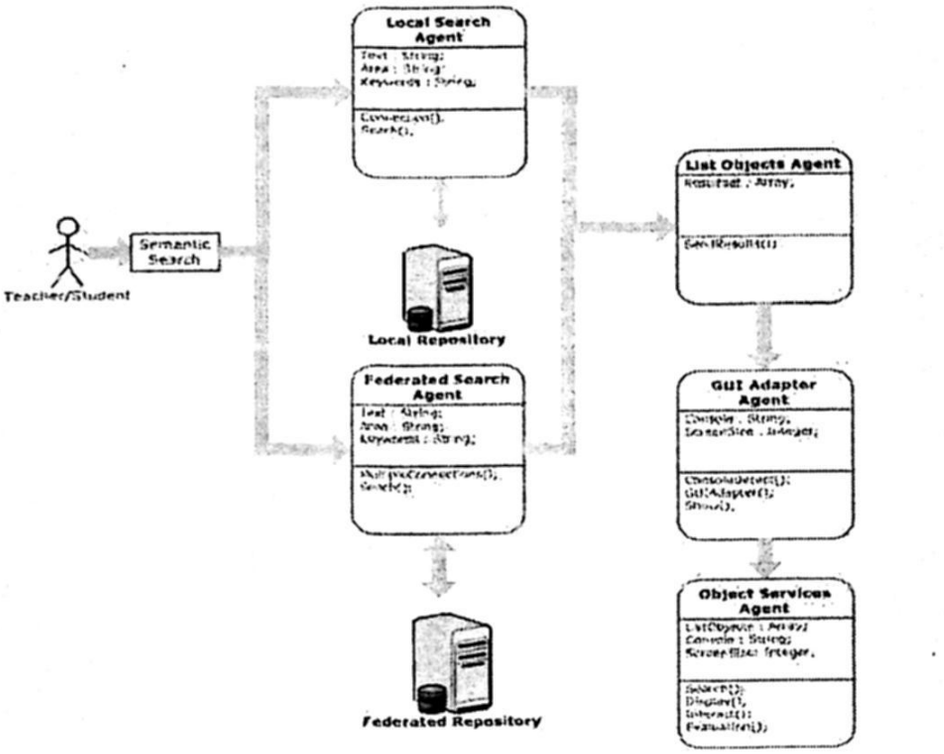

Figure 4. *Components of multiagent system.*

The figure 4 presents the components of system with multiple agents in each activity. The *Local-Search Agent* work only in the local repository creating queries, the *Federated-Search Agent* this agent work in the federation of learning objects, when this two agents finish their work then the list objects agent get all the results and send to the GUI-Adapter Agent, this agents try to detect the final dispositive to adapt the information generated by the previous agents. Finally, we have the *Object Services Agent*, this agent works with the main functions of a learning object such as the visualization, accessing, interaction (in this space we have the interactivity of a videogame) and evaluation. This community of agents is called "social network games".

```
import jade.core.Agent; import jade.core.behaviours.*;
public class MultiAgent extends Agent{
  protected void setup(){
  addBehaviour(new LocalSearch());
  addBehaviour(new FederatedSearch());
  addBehaviour(new ListAgent()); }
private class FederatedSearch extends Behaviour{
  public void action(){
  try {
        java.sql.Connection conn = null;
        java.sql.Statement s = conn.createStatement();
        java.sql.ResultSet   r   =   s.executeQuery("SELECT   *   FROM
Federated_Learning_Object where description like '+word+'");        }
        catch (Exception e)
      {
```

```
    System.out.println(e);
    System.exit(0);
}}
```

Figure 5. *An excerpt of internal process of multiagent system*

The code of figure 5 shows how the multiagent system works with different classes communicating between them, all the agent functions are launched using the behavior, this event permits launch multiple agents working like threads, but the difference between threads and agents is the performance and stability of the agents. The multiagent system has been implemented with Jade a Framework[10], it use the RMI Interface of Jade in order to create agents, and at the begging start with two agents, one is for the search of local objects and the other for the search into multiple repositories, the result is sent to the *list agent* who receive all the information for send to the GUI adapter agent all these agents communicate with the search and the graphical user interface adapter, finally we have the agent services who offer services like search, display and evaluation.. In the literature of Intelligent Games [9], is commonly the interaction with many community agents to negotiate for reach the best situation to survive, for this reason the principal behavior is the survive of this communities maximize the cooperation with the rest of agents, for example in a FishVille with shoals of fifteen fishes at same time of different species, this one of most popular game in Facebook[9].

4 Case Study

This section presents a case of study using a playstation portable to learn about the human cell in terms of a learning object with videogames (see figure 6). First, the user goes directly to a graphical user interface where he/she could create some quests using words and creating filters to the information. The second step, two agents start the search one is searching in the local repository and another in a federated repository, then an agent take all the results and prepare all the information in an unique list of learning objects. In this step the user doesn't know the platform, then an agent detect the platform where is the client, once is identify send all the aspects to run in this platform to the final agent who gives all the services like search, display, interact and evaluation [13].

Figure 6. *A human cell as a learning object with videogames.*

The figure 6 shows a human cell as a content of a learning object inside a course of *morphology*. This object is the result of research service notably using two agents, one searching in the local repository and the federated repository, then all identified information by the two process are taken by the agents, creating an uniform list of learning objects, this list of objects are taken by the *GUI adapter Agent*, who detect a play station portable, sending all the display sizes and list of objects at the last object services agent finally we have the game in the form of exercise with a theme of human cell, allowing the user to drag the elements that are relevant to each of the boxes in white, this is done interactively allowing the user to learn based on practices and games.

An example of a metadata of a learning object.

```
<imsmd:general>
 <imsmd:identifier>001 ED</imsmd:identifier>
 <imsmd:title>
 <imsmd:langstring xml:lang="en">Morfologia</imsmd:langstring>
 </imsmd:title>
 <imsmd:catalogentry>
 <imsmd:description>
 <imsmd:langstring    xml:lang="en”>Ejercicio    sobre    ambiente
interactivo en multiples consolas de OA's</imsmd:langstring>
 </imsmd:coverage>
```

The information of metadata used by the agents for the local search and the federate search; all this information is send to only one server in order to have a better performance. This information of the metadata is sent to the web service to form a group of key information related to the learning objects inside the federation. Once created the global index, the multiagent list is used to show the information, and then the graphical user interface agent adapts the interface to the videogame console [10], he searches to federated level inside the federated learning objects repositories are performed; take several searches outline at semantic level.

5 Related Work

In this section our proposal is compared with another related work.

Table 1. Some related works of learning object repositories.

	UAA	Ariadne [11]	ESPOL [13]	APROA [12]
Web Service	X	X	X	X
Multiagent approach	X			
Videgame	X			
Federated Repository	X	X	X	

There are a large variety of repositories in the literature of learning objects. According to the repositories of table 1, they offer basic functions in the searches, carrying out queries of learning objects without taking advantages of any artificial intelligence technique. Current work proposed here presents a major number of characteristic for the use of learning objects with videogames throughout multiagent approach.

6 Conclusions

This paper proposes the use of a multiagent system is composed by learning objects with videogame. In order to assure the portability is proposed a multiagent system to make a portable graphical user Interface and make easy the use of several services, all these service in particular the search of learning objects in several repositories. The proposed model of learning is composed of five components such as: theoretical knowledge, evaluation, related subjects, metadata and practical knowledge in terms of interactive videogames. In this model the students can learn and put in practices the theoretical knowledge playing with the interactive videogames embedded in every learning object.

The proposed multiagent system presents the results with good performance in the connection between different repositories institutions and a good compatibility between different kinds of mobiles devices. As future work, it is necessary a virtual environment of education using all the learning object resources in the different institutions and it is necessary portable devices to communicate all the students, it could be possible to create an online community of videogames to interact between them [15].

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LMSPlan: An architecture to integrate adapted learning objects sequences within a LMS

Lluvia Morales and Jesús Miguel García Gorrostieta

Universidad de Granada, España.
Universidad de la Sierra, Moctezuma, Sonora, México
lluviamorales@decsai.ugr.es, jesusmiguelgarcia@gmail.com
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Abstract. E-learning process is customizable thanks to the great development of systems of learning management and their standardization, united to the advances on artificial intelligence techniques that complement them. This article presents LMSPlan, an innovative architecture that integrates learning management systems (LMS), e-learning standards and intelligent planning & scheduling technologies in order to customize a sequence of learning objects and display them effectively to students in any LMS that supports standards.

Keywords: Adapted Learning Objects Sequences, Student Modeling, Continual Planning.

1 Introduction

The use of intelligent technologies for planning and scheduling applied to the adaptation of learning paths is not new, since 1986 Peachy and Mcalla [1] innovated with a rudimentary approach of this proposal applied to intelligent tutorial systems (ITS).

These systems evolved to accommodate the huge amount of information that brought with it the use of the internet for educational purposes and, therefore, the emergence of standards for definition, management and exchange of educational material for the web, better known as learning objects (LO).

At the same time, various planners used in this kind of systems have evolved over the years and according to Ullrich [2], we can see that planners as SHOP2 and SIADEX, based on hierarchical task network, are the best suited to represent the tree structure of the courses and/or books: title, chapters, subchapters, objectives, and finally activities at the lowest level of the tree hierarchy.

However, for organizations in charge of providing online courses to the masses of students around the world, it is clear that ITS's are not the first choice to manage all their courses because the majority are limited to a certain area of knowledge or to a specific course, also many of them require the installation of special software on the computer where to be used.

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These and many other reasons are leading administrators of online courses to use the ITS's as an external educational tool to complement the facilities of the platform of traditional courses, and not as an integrated tool within the platform. This platform is usually a learning management system (LMS) such as dotLRN Claroline or Moodle.

On the other hand, developers of the LMS's have chosen to integrate within the courses structure various content management standards, in order to adapt to new needs for knowledge exchange. Among the most important standards are SCORM and IMS-CP.

Given the above considerations, it's clear that if we want a real and extended use of intelligent technologies originally proposed for ITS's, they should be adapted and generalized to be used by any LMS in the market taking advantage of the facilities that allow integration with e-learning standards, as demonstrated in the example shown in [3].

In this article we present an innovative architecture that integrates LMS's, e-learning standards and intelligent planning & scheduling technologies, we use a common interpretation of the e-learning standards proposed in [4] for the automatic generation of domains and problems for planning in HPDL language; we establish a protocol for communication between the LMS and the planning server and a set of rules to determine if it requires a continual process planning or replanning to adapt the sequence of learning objects and finally we conducted an experiment to determine the feasibility of implementing our architecture in MOODLE, one of the LMS most used worldwide, and the student's satisfaction using this kind of technology tools.

2 General Architecture

LMSPlan is a communication architecture via web services that allows to any LMS to contact with a planning server in order to adapt the learning sequences of the topics in an e-course to every student profile related with the course. The LMS and learning objects must meet the next criteria:

1. LO's must be related and labeled under the IMS-MD or LOM standard, following the instructions described in [4].
2. The LMS must support the SCORM or IMS-CP standards, and it owe use them to store and display the learning objects sequences.

The architecture shown in Fig. 1 describes the above criteria, in addition to the planning client that must be integrated into the LMS, and the planning web server used to interpret and adapt the information given by the client. These modules are described in the next subsections.

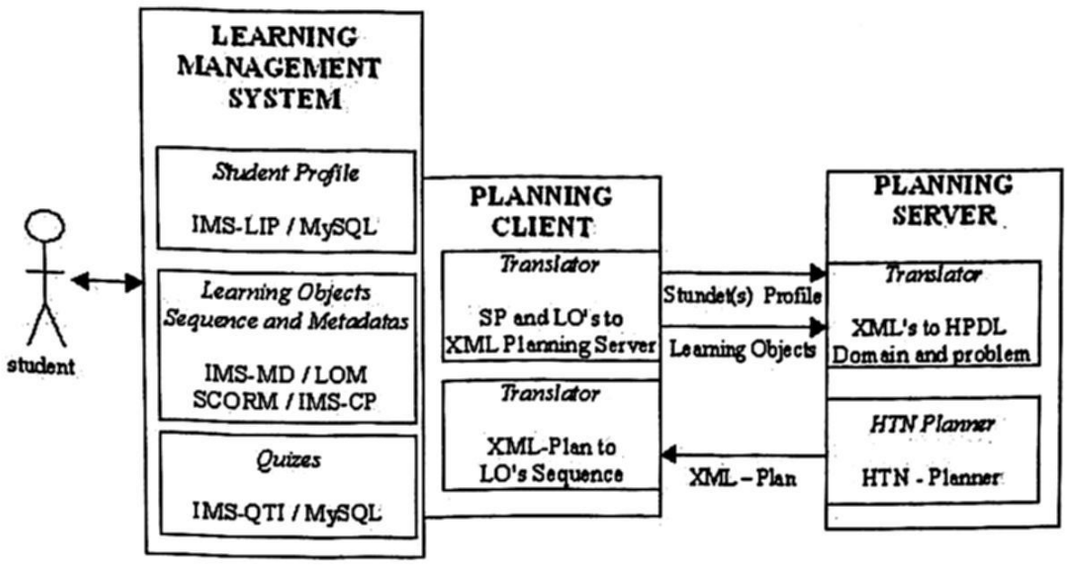

***Figure 1.** LMSPlan Architecture*

2.1 Planning Client

The LMSPlan planning client is the intermediary between the LMS and the planning server. It is responsible for obtaining all the information it needs from:

- The SCORM package content that is requested to adapt to the students of the e-course. That is the LOs and metadatas that describe and relate them.
- The student profile. Preferably in the IMS-LIP standard.
- The score obtained by each student in the quiz applied before the item you want to adapt. This information should be, preferably, within the IMS-QTI XML manifest which describes the quiz.

In most of the used LMSs, the two last standards above mentioned, are not yet integrated; therefore the client has the option to obtain information from the LMS' databases.

Once the information is obtained, the students' profiles and the quiz score for each one are combined in an XML file called `students_profile` that must be dispatched to the learning server through an xml-rpc call. The XML manifest containing all the data from the LO's will be dispatched using this sort of calls too.

The planning client interface shown in Fig. 2 allows to the professor or system administrator specify the e-course where is located the SCORM that wants to customize, the SCORM itself, and the previous quiz if exist, besides the objective of the subject. The objective is needed because the SCORM can contain several objectives as part of it.

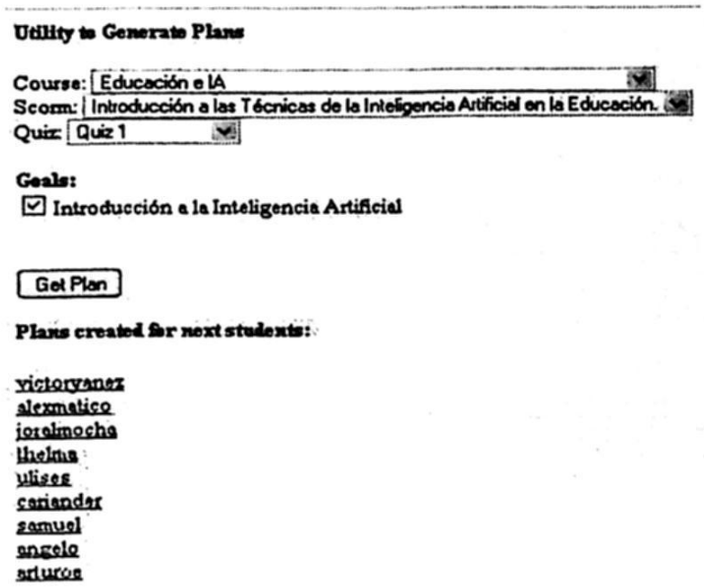

Figure 2. Planner Client

Once each parameter is select, the user can press the getPlan button and leave the rest to the planning server that will return a hyperlinked list with the course's students which allows checking the adapted SCORM contents in plain text for each of them. These contents would be displayed to each student inside the LMS platform.

2.2 Planning Server

When you press the getPlan button, the planning server receives the XML files containing the students' profiles and the LOs information. Then, according to the information given by these files, the server decides if a planning, continual planning or re-planning processes will be held. This decision process is described in the next paragraphs.

First of all, if the planning history of the received SCORM does not exist, and also the previous quizzes' scores of the students' profiles neither exist, then the server performs the translation process from the LOs to the HPDL planning domain and from the students' profiles to the HPDL planning problem as described in [4] as a simple *planning* process.

Otherwise, if the SCORM has not been planned previously, but the students' profiles file contains the scores of the previous quiz. Then, the server recognizes that the user is requesting a continual planning process, where the subject contents customization is based on the previous subject knowledge. Therefore, the planning domain and problem will be generated as in the previous point, but the information about the student's profiles must be modified before the translation according to the score obtained in the previous quiz, and given rules as e.g.:

- If the score of the previous quiz is greater than 90/100, then the student' performance will be increased to the maximum.

- If the score of the previous quiz is less than 50/100, then the student' performance will be reduced to the minimum and a high availability will be reassigned, so he/she could take optional activities for reinforcement.
- It is expected that in a short future the above rules could be adapted, through a web interface, to the preferences of each professor, and according to different e-courses. This will allow a mixed initiative process much more sophisticated than the current.

The last case occurs when the two previous cases are not met and the SCORM has a planning history, in this case the re-planning process must take place. It means that students' profiles have changed or a new version of the SCORM has been received. As this process requires a real-time adaptation, just the file where a change is detected (students' profiles or LOs), will be translated into a planning domain or problem, allowing the subject to be re-planned in a few seconds.

Finally, the planning server returns to the planning client the customized plan for each of the students in a predefined XML file format. This file will be processed by the planning client and integrated into the database tables that contain the SCORM information for each student.

3 Experiments

In this section we describe the design of the experiment conducted to demonstrate the feasibility of implementing the proposed architecture and the qualitative results we have obtained through a satisfaction survey applied to the students which have used the adapted sequence of LO's.

Quantitative evaluation of the paths obtained from the process of Continual planning or replanning, and the comparison of paths is not an issue to be addressed in these experiments because it involves deep-level detail of planning and scheduling and it will be covered in another paper.

3.1 Experiments Design

The experiment was conducted on a sample of 20 Mexican students and teachers aged between 18 and 43 years old and with a minimum of Bachelor and maximum of Doctoral degree. These students were enrolled in an elearning seminar with duration of four weeks with four different topics and four quizzes.

Training materials for each subject was converted to the format of LO's and labeled under the IMS-MD standard according to [4], then we create a SCORM package supported by the Moodle LMS hosted in the sepia server (http://sepia.ugr.es/moodle) from University of Granada (UGR). Moodle communication is made through a planning client integrated to a planning server hosted on SIADEX (http://siadex.ugr.es/planner_server), another server of UGR.

Seminar participants fill in the fields of their user profile within the platform the "fields of adaptation", English level, learning style based on Honey-Alonso quiz, time

availability to attend the seminar and the performance level associated with previous academic experience. In order to know their ages, expectations and motivation level, an initial survey was applied to them.

Once this preliminary step was completed, we proceeded to begin the process of adapting the first topic and then apply the first quiz; and so on culminating with the applying of the fourth quiz. It is possible to observe the outcome of the process of adaptation that is visible to any student within Moodle accessing the sepia server using a provisional user which can be ask to the authors.

Sometimes during the experiment it was necessary to use the web service of re-planning because some students increased their English level or changed their learning style in the course. This process was also necessary when the teacher decided to change the note of one or more students, when the next topic had already started.

It is important to highlight that, given the limited experience of students with these kind of course, was necessary to support the adapted SCORM material with weekly videoconferences.

At the end of the experiment we applied an electronic survey to measure the degree of acceptance of students with the online course and in particular the adaptation given by the program.

In the next section we will discuss the values of the fields of adaptation and contrast the results obtained from the initial survey and final to determine the degree of student satisfaction regarding with the adjustment provided by the tool.

3.2 Results

In Table 1 we can see how the student profile is very diverse. Notably, being a course of engineering, the number of students with theoretical learning style turned out to be zero and the rest of the styles were well-balanced, as well as the rest of the results for the other three variables taken into account for this experiment.

	Amount	*Percent*		*Amount*	*Percent*
Learning Style			*Availability*		
Active	7	35,0%	Many	13	65,0%
Reflexive	8	40,0%	Little	7	35,0%
Theoretical	0	0,0%			
Pragmatic	5	25,0%			
English Level			*Performance*		
Excellent		0,0%	High	11	55,0%
Acceptable	13	65,0%	Medium	8	40,0%
Low	7	35,0%	Low	1	5,0%
Very Low		0,0%			

Table 1. Students' Profiles Summary

In the initial satisfaction survey was 97% of students with good or high motivation to use e-learning platform, plus 55% hoped to learn better, 44% expected to learn with a more fun way and 26% organize their own study time, among others.

The results of the final satisfaction survey shown in Table 2 indicate that 85% of the group agreed that the seminar topics were interesting or very interesting, more than 53% have agreed with the timing that have been given according to their needs and, finally, it's worth noting that 75% of students would be willing to use the system in other subjects and they feel that have learned enough or more using our proposal.

4 Conclusions

In our country the LMS have begun to be used to support the students learning but not with a high impact due to the complexity of adapting the contents to each student' profile. The proposed model tries to solve this by using an architecture called LMSPlan that integrates the LMS capabilities and a planning server to provide a continuous customization of e-course contents that are shown to the student through e-learning standards. This architecture takes in to account the uncertainty associated to the results of interim quizzes and continuous changes the student profile.

When testing the model into a real e-course, there was a wide variation in learning styles, English level, previous performance and temporal availability of the students. A traditional course does not take in to account these issues due to the large effort that implies the adaptation process for the professor and because the previous performance of the students is usually static. It should also be noted that a 75% of the students are willing to use this e-course model again.

We have also concluded that more training is needed in order to use LMSs in which autonomous participation of the student is needed, and intensify the use of this kind of courses in order to improve the student performance on them.

5 Future Work

In the future it aims to improve the planning client interface, so as to have an automatic interaction with the planning server.

Question	**Do you think the contents of the topics were interesting?**		**Do you think the time to do exercises and understand all the subjects has adapted to your needs?**				**How much do you think yo have learned?**	
Value	*Amount*	*Percent*	*Little Time*		*Much Time*		*Amount*	*Percent*
			Amount	*Percent*	*Amount*	*Percent*		
Much	13	65%	5	71%	7	53%	4	20%
Quite	5	25%	1	14%	5	38%	9	45%
Average	2	10%	1	14%	1	7%	6	30%
Little							1	5%
Nothing								

Table 2. Final Survey summary

It would be either interesting to carry out a mixed initiative process where the professor could change the rules to customize the course quickly, considering the

information about the students performance that the system could provide. This information could be obtained using data mining techniques over the LMS databases and the adapted standards.

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Developing linguistic resources for the nahuatl indigenous language

Carmen C. Martínez-Gil[1], Alejandro Zempoalteca-Pérez[1],
Venustiano Soancatl-Aguilar[2], Rosa M. Ortega-Mendoza[3],
[1] Universidad de la Cañada, [2]Universidad del Istmo, [3] Instituto
Tecnológico Superior del Oriente del Estado de Hidalgo,
{cmartinez, alejandro}@naxoloxa.unca.edu.mx,venus@bianni.unistmo.edu.mx
rosy_om@hotmail.com
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Abstract. In this paper we present the development of linguistic resources with the purpose of studying and analyzing the Nahuatl indigenous language. Nahuatl is currently spoken in countries such as: Mexico, El Salvador, United States, Guatemala and Nicaragua. The linguistic resources developed are: a Nahuatl-Spanish corpus of unstructured text and dictionaries. The dictionaries are three, the first having terms in Nahuatl and Spanish, the second containing words in Nahuatl which are translated into Spanish phrases, and the latter having specific Nahuatl terms from the northern region of Oaxaca, Mexico

Keywords: Corpus, Linguistic resources, Nahuatl indigenous language.

1 Introduction

Nahuatl is an indigenous language currently spoken in many countries such as Mexico, El Salvador, United States, Guatemala and Nicaragua. Nahuatl is one of the most studied and documented American languages [1, 4, 6, 7, 10, 11, 14]. Nowadays we can still find manuscripts and documents written in Nahuatl and we can extract useful, valuable and important information from those documents which benefits current and future generations.

Our interest in developing linguistic resources for the Nahuatl language is mainly focused on: a) Due to ignorance and mismanagement of terms of this language, we are losing much of our culture. It is therefore important to recognize and extract the information contained in documents written in Nahuatl, b) To preserve and disseminate a language with historical roots, in order to keep the language alive, because if we lose it, we lose our essence and identity as Mexicans; c) To comprehend and understand cultures that use this language including speakers whose first and only language is Nahuatl.

On the other hand, the research area of Natural Language Processing (NLP) is a sub-discipline of Computer Science and Linguistics [2, 3], which is responsible for producing computer systems that enable man-man or man-machine communication using natural language. The aim of NLP is to study the problems derived from automatic generation and understanding of natural language. Some relevant applications of NLP are: Automatic translation, Speech recognition, speech synthesis,

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information extraction, information retrieval, automatic summarization, handwriting recognition, text mining, question answering, text classification [8], and Automatic Identification of Languages [9]. To strengthen these NLP applications, NLP uses linguistic resources. Linguistic resources are sets of language data in computer readable form and are used in the construction, improvement and evaluation of natural language systems, although the term also includes software tools aimed for separating, collecting, and managing other resources. Language resources are classified into three categories: body, tools and lexical resources. A corpus [12] is a collection of natural language texts, chosen to characterize a state or variety of a language. There are corpuses of written language and spoken language, in both cases the body acts as a repository of information which can be manipulated to extract knowledge. The tools help to analyze the texts, among the most common tools are: parts of speech labelers, morphological analyzers and parsers. The lexical resources [5] provide a set of valid words in the language, and may also contain language properties, the meaning of words and relationships between words or group of words. Some examples of lexical items are: word lists, dictionaries, thesauri, anthologies, glossaries, and others.

However, the texts that form the corpus can be classified [13] broadly into three categories: structured text, semi-structured text and unstructured text. Structured text is stored in a rigorous format that allows differentiation of relevant parts of the text. Semi-structured text contains some kind of structure, but not enough to be considered as structured text. And unstructured text that does not have a definite structure, it is free text format and extracting information from these texts is not easy and usually includes a pre-processing stage.

In the following section we describe the process to develop linguistic resources, the corpus and dictionaries. Then, in the section 3 we show the significant results obtained to the moment. Finally in the section 4 and 5, the conclusions and future word are present.

2 Developing Linguistic Resources

With the purpose of developing tools and applications for the Nahuatl language, we are currently developing the following linguistic resources:

a) a corpus of Nahuatl-Spanish texts
b) some lexical resources that consist of three Nahuatl-Spanish dictionaries

While it is true that nahuatl is one of the America's most studied and documented languages, it is also true that much of this documentation is in electronic PDF or hard copies. So, to build our corpus we need unstructured texts in a txt format in order to manipulate its contents to extract knowledge and in a later stage structure the texts according to our requirements. On the other hand, because there are different variants of Nahuatl, we have focused on Nahuatl from Northern Oaxaca mainly for three reasons:

a) Our geographic location
b) The viability of documents in this region
c) The participation of students whose native language is Nahuatl and their ability to collaborate on the development of the project

At the moment we are working with this variant of Nahuatl, although we have considered extending our linguistic resources to analyze any kind of text in Nahuatl. To form our corpus of texts, we have obtained Nahuatl-Spanish texts from various sources [4, 6, 7, 10, 11].

Regarding lexical resources we have developed a dictionary of terms in Nahuatl and its translation into Spanish. Because the Nahuatl is an agglutinative language, ie, adds prefixes and / or suffixes to roots to form very long words. The first version of the dictionary is divided into two parts, the first one containing terms Nahuatl-Spanish and the second containing Nahuatl words whose meanings are sentences. Finally we are working on a dictionary of terms and Nahuatl words from the northern state of Oaxaca. This latter resource will help us to analyze the native texts in the region.

3 Results

The corpus that we are building is made up of texts in Nahuatl and their correspondent text in Spanish, so we have two files in txt format for each text. The texts are classified into four categories: Poetry, Stories, Religion, and Miscellaneous. Table 1 shows the number of texts that form the corpus.

Table 1. Number of texts by category.

Category	Náhuatl	Spanish
Poetry	125	125
Stories	68	68
Religion	550	550
Miscellaneous	93	93

Poetry texts were primarily obtained from the poems written by Nezahualcoyotl, Nahuatl stories were written in the state of Guerrero (state of Mexico) and translated into Northern Oaxaca Nahuatl, religious texts were obtained from the Bible and some others from prayers, finally the miscellaneous contains several texts such as legends, tales, stories, thoughts, wills, among others. Table 2 shows on average how many text words are contained in each category.

Table 2. Word average contained in each text by category.

Category	Average
Poetry	143
Stories	345
Religion	258
Miscellaneous	933

Three dictionaries have been built, one of Nahuatl words and their correspondent word in Spanish, the second provides he words in Nahuatl and their translation in sentence form and finally the third dictionary contains specific Nahuatl words from the upstate region of Oaxaca, Mexico. Table 3 shows the number of words for each dictionary.

Table 3. Number of words for each dictionary.

Dictionary	Number of words
Nahuatl-Spanish word-word.	9765
Nahuatl-Spanish word-phrase.	3288
Nahuatl words from the northern region of Oaxaca, Mexico.	560

4 Conclusions

In this paper we have introduced the development of language resources for studying and analyzing the native Nahuatl language with great historical, linguistic, literary and nationalist significance.

We have presented the development of a corpus of unstructured texts in Nahuatl and their correspondent text in Spanish, as well as the construction of three dictionaries: one with Nahuatl-Spanish terms, the other with Nahuatl words whose translation into Spanish is a phrase, and a final dictionary of Nahuatl specific terms from the northern region of Oaxaca, Mexico.

The results obtained so far are very significant because we have a high quality corpus that is, varied and large enough for getting significant results. The dictionaries contain information representative for the Nahuatl language and are useful for future applications. For the moment to obtain and use the resources you can contact the authors, soon we open a URL to obtain them.

5 Future Work

As immediate future work we will add semantic information to the terms of the dictionary, we will implement a system for suffixes or prefixes of a word in Nahuatl

and we will continue increasing the amount of texts of the corpus and the terms of the dictionaries. As long-term future work we will consider building a Nahuatl speech tagger of parts of sentences as well as a stemmer.

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