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Implementation of an affective-motivational architecture tied to a teaching-learning process

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Abstract: This project implements an affective-motivational structure tied to a teaching-learning process. The implementation is accomplished through the artificial intelligence technique known as fuzzy cognitive maps. The theories on which the structure is based are the emotional theory of the authors, Ortony, Clore, and Collins, better known as the OCC theory; and motivational theory. The project's contribution is in the area of affective computing, a branch of artificial intelligence.

Keywords: Affective computing, affective-motivational architecture, OCC theory, fuzzy cognitive maps.

1. Introduction

Affective computing is one of the newer areas of artificial intelligence (AI) and explains the importance of emotions in human cognition, as decision-making, perception, human interaction, and intelligence; therefore, applying this approach to intelligent tutor agents is essential to maximize the agent's effectiveness.

The project's contribution to affective computing is the implementation of an affective-motivational structure tied to the model of a general teaching-learning process described in (Laureano-Cruces, Mora-Torres, Ramírez-Rodríguez & Gamboa-Rodríguez, 2009 and Laureano-Cruces, Ramírez-Rodríguez, de Arriaga & Escarela-Pérez, 2010) using the AI technique known as fuzzy cognitive maps. In our previous paper we left clear that a cognitive structure of emotions allows us: 1) to highlight the importance of emotions in education and 2) to create a representation of the distributed behavior which allows for the inclusion of emotions, using fuzzy cognitive maps, 3) to generate a dynamic interaction, 4) to choose the personalized, preventive didactic strategy, maximizing the learning status. This work is a continuation of this one (Laureano-Cruces, et al., 2009). The current work proposes the link between the perception of the cognitive process and the perception of the emotional state, in order to maximize the effectiveness of the agent when interacting with the user.

The development of the affective-motivational structure is based on the emotional theory known as OCC theory (*Section 2*) for the initials of its authors: Ortony, Clore, and Collins, who propose a cognitive structure of emotions based on personal and interpersonal descriptions of situations. Authors like Conati & Maclaren and Jaques & Vicari have performed works based on this emotional theory (*Section 3*). According to motivational theory

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(*Section 4*), emotions are one of the sources of energy for motivation, which is related to two essential elements of the model of the teaching-learning process: interest and desire. This explains the importance of motivational theory to tie the affective-motivational structure to the aforementioned model.

In *Section 5* we describe the affective-motivational structure, whose domain of application is structured programming. The implementation of the affective-motivational structure is developed in *Section 7* and is realized by means of the artificial intelligence technique known as fuzzy cognitive maps (*Section 6*). *Section 8* shows two test scenarios, to finish with our conclusions.

2. OCC Theory

The OCC theory (1996) proposes a *general structure*, which postulates the existence of three main classes of emotions, resulting from a focus on each of the three fundamental facets of the world:

- Events and their consequences
- Agents and their actions
- Pure and simple objects

For this purpose, it establishes as evaluation criteria:

- Goals to evaluate events.
- Standards to evaluate the action of agents.
- Attitudes to evaluate objects.

The three main classes of emotions postulated are:

- Emotions based on events: Goals related to events are specified.
- Emotions of attribution: Responsibility is attributed to agents for their actions as a function of standards.
- Emotions of attraction: based on attitudes in relation to objects.

The intensity of emotions can be affected by what are known as local variables (desirability, plausibility, and the ability to attract) and global variables (proximity, sense of reality, arousal, and unexpectedness). Thus, the cognitive representation of emotions is also modified.

3. Related work

Conati and Maclaren, (2005), present the empirical evaluation of a probabilistic model of student affect based on Dynamic Bayesian Networks and designed to detect multiple emotions (six). The part of the network above the nodes emotional states represents the relations between possible causes and emotional states, as they are described in the OCC theory of emotions. The probabilistic dependencies among goals, personalities, interaction patterns and student actions are established through correlation analysis between the test results, the questionnaire results and student actions logged during the interactions.

Our proposal makes explicit the emotions linked to model of teaching-learning process based on the OCC theory not only related to the goals, but also those related to standards and attitudes respect to events, agents and their actions, and pure and simple objects of teaching-learning process.

Jaques and Vicari, (2007), describe the BDI (believe, desire, intention) model, to implement the process of affective diagnosis in an educational environment; and use the psychological OCC model in order to infer the learner's emotions from his actions in the system interface. In their article, they are going just to focus on the inference of joy/distress and satisfaction/disappointment emotions.

Our proposal also infers the emotional reaction from an evaluation of user behavior on the interface but the implementation of the model is performed using fuzzy cognitive maps (causal network). This causal network is linked to the established for the teaching-learning process based on a general teaching tutor (Laureano-Cruces, et al, 2009 and Laureano-Cruces, et al, 2010).

4. Theory of motivation

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The theory of motivation helps to explain the reasons for a behavior, and therein lays its importance for our work, because it helps explain the relationship between the model of the teaching-learning process and the affective-motivational architecture. Emotional behavior is directly related to motivation, because emotions are one of its sources. Motivation in turn is one of the essential elements of the teaching-learning model, because learning can only occur in motivated students (Castañeda y Martínez, 1999 and Castañeda, García & González 2006).

The study of motivation concerns those processes that give behavior its energy and direction. Energy implies that behavior is relative and strong, intense, and persistent. Direction implies that behavior is guided toward achieving some particular goal or outcome. There are seven aspects of conduct that reveal the presence and intensity of motivation, to wit: effort, latency, persistence, choice, probability of response, facial expressions, and bodily expression (Reeve, 2001).

5. Affective-motivational structure

The affective-motivational structure is constituted by goals, desirable and undesirable events, and affective reactions (cognitive representations of emotions). The structure has as its higher (general) goal to acquire the skill proposed by the system, in other words to understand the elements of structured programming: (1) types of data, variables and constants 2) procedural and functional abstractions, 3) the use of parameters by value and by reference; (Laureano-Cruces, Sánchez-Guerrero, Mora-Torres and Ramírez-Rodríguez, 2008). Desirable events are represented by understand the content, and learning from errors committed. Examples of undesirable events are: quitting or repeatedly committing the same errors. The latter constituting a divergence from the higher goal. To achieve this higher goal it is necessary to establish sub-goals, known as instrumental (more specific goals). Such goals are related among them, the links could be: necessary, sufficient, facilitating, or inhibitive, in order to achieve different goals.

The cognitive representation of emotions is shown in Figure 1 (Laureano-Cruces, et al., 2009 and Mora-Torres, Laureano-Cruces and Velasco-Santos, 2010).

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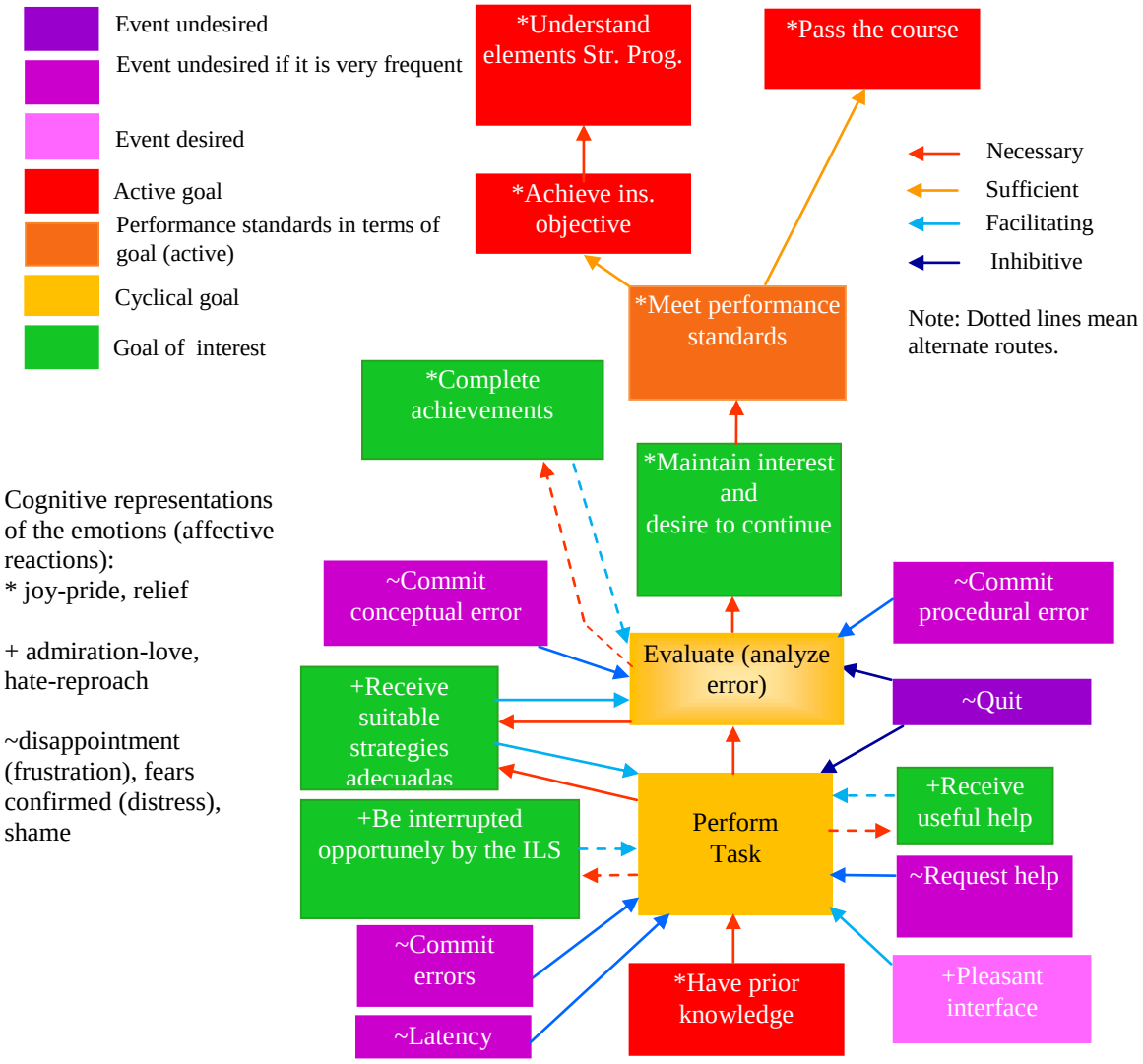

Fig. 1. Motivational-affective macro-structure

There are goals like: *have prior knowledge* (inferior goal), *achieve the instructional objective* and *pass the course*. This kind of goals is active pursuit because they depend on the user. There are cyclical goals like: *perform tasks suggested by the tutor* and *Evaluate (analyze error)*. These goals permit accomplish the active goal: *achieve instructional objective*.

Also, there is a goal of interest referred to as *completing achievements* based on *errors committed* (because the user wants that to occur to preserve the state of ongoing progress when the tutor applies the strategies). *Errors* and *requesting help* constitute desirable events, to a certain degree, given that committing errors or requesting help often ends by causing *frustration* instead of *facilitating* progress toward the higher goal. *Quitting* is considered an undesirable event because it prevents achieving the higher goal. There is an active goal on the part of the tutor: *apply the proper strategies*.

Cognitive representation of the structure of evaluation

The process of evaluating desirable or undesirable events, the actions of the user or the tutor, and content (tasks, texts seen as objects) occurs in function of goals, including the goals of compliance with standards of

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performance and attitude. This process in turn gives rise to the respective emotions: based on events, attribution and attraction. Each of which has as its reaction the so-called affections or cognitive representation of emotions, which are described below.

Emotions based on events are presented depending on the performance of tasks and expectations, and are represented cognitively with joy if an expectation is met or relief if a fear is not realized, or otherwise, would cause disappointment if the expectation is not met, and distress or confirmation of fears. Emotions of attribution are represented cognitively with reproach, admiration, pride, or shame and are experienced on evaluating the actions of the tutor (strategies used) or of the user in performing the tasks set in accomplishing or not the goal of complying with the standards of performance (covering a percentage of material in a given time). Emotions of attraction are represented with love or hate when evaluating tasks with reference to the goal of satisfying the preference (attitude to tasks seen as objects).

6. Fuzzy cognitive maps

Fuzzy cognitive maps (FCM's) are an artificial intelligence technique for knowledge representation with uncertainty and are used to model the behavior and operation of complex systems. Bart Kosko (1986) introduced the FCM to describe the behavior of a system in terms of concepts and causal relationships between these concepts.

FCMs are represented by a digraph, in which nodes are concepts describing the main characteristics of the process, and the edges between the nodes establish causal relations (positive or negative) between the concepts. This graphical representation illustrates the influence that each one of the concepts has on the rest (Laureano-Cruces, Ramírez-Rodríguez, Mora-Torres, and Espinosa-Paredes, 2006; Mora-Torres, 2007; Mora-Torres, Laureano-Cruces, Ramírez-Rodríguez and Espinosa-Paredes, 2009). The FCM is represented by a relations matrix (E) whose elements (eij) are the effect of each causal relation, ie the weight from one (Ci) and another (Cj) concept. A value of 1 and -1 signify a relationship wholly positive and wholly negative, respectively, while a 0 means there is no causal effect between them. The remaining values in the range [-1, 1] correspond to different levels fuzzy causal effect (causality diffuse) (Khan, Chong & Quaddus, 1987).

The causal relationships between nodes can be defined as:

- *Positive*: Ci to Cj causally increases iff $Qi \subset Qj$ and $\neg Qi \subset \neg Qj$,
- *Negative*: Ci to Cj causally decreases iff $Qi \subset \neg Qj$ and $\neg Qi \subset Qj$

where, Ci is a concept, Qi = a set of linguistic labels (much, more or less, etc.) for Ci
Cj is an another concept, Qj = a set of linguistic labels (much, more or less, etc.) for Cj

Threshold function

The qualitative approach allows observing the general behavior of the system. However, quantification must be taking into account the causal relation in the fuzzy cognitive map.

The state of a given node is derived from all nodes that affect it. These states are multiplied by the weight of the edge between the two nodes, and summed. The sum is taken as the input of a threshold function, transmitting a non bound input in a bound signal. (Kosko, 1992; Laureano-Cruces, Ramírez-Rodríguez & Terán-Gilmore, 2004; Laureano, et al., 2006; Mora-Torres, 2007; Mora-Torres, et al., 2009 and Laureano-Cruces, et al., 2010).

The sum of the effects of each node (Nj for j = 1,2,3, ... n, where n is the number of nodes) is obtained according to (1):

$$Nj = \sum_{k=1}^{n} (Ve_{1,k} M_{k,j}) \qquad (1)$$

Where:
$Ve_{1,k}$ is the input vector.
$M_{k,j}$ is the value of each element of the relations matrix.

Different threshold functions can be used; in this paper the following logistic function is used (2):

$$S(x) = 1 / (1 + e^{-5x}) \qquad (2)$$

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where:
S(x) = logistic function and represents the future state of input vector
x = Sum of the effects

7. Concepts of the affective-motivational structure tied to the structure of the teaching-learning process.

The concepts of the affective structure are tied to the elements of the structure of the teaching-learning process (Laureano-Cruces, 2000; Laureano-Cruces & de Arriaga, 2000; Laureano-Cruces, et al., 2004; Laureano-Cruces, Terán-Gilmore & de Arriaga, 2004, Laureano-Cruces, et al., 2009, and Laureano-Cruces, et al., 2010) through facets of motivation such as: effort, latency, persistence, and choice, among others.

Interest and *desire*, for example, are especially related to persistence and effort. Joy, admiration, pride, and love, for their part, provide the energy of motivation.
Help is related to choice, and the affect that feeds that choice is relief.
Interruption and strategies are related to choice. Love, hate, reproach, and admiration feed that choice.
Quitting is related inversely to persistence; in other words the greater the persistence, the less the likelihood of quitting and vice-versa (less persistence, greater likelihood of quitting).
Learning is related to all aspects of motivation. Joy, pride, relief, love, and admiration feed motivation.
Latency has relief as its source of energy.
Errors are related to effort (complexity of the task), persistence and the probability of response. The affects experienced at this stage of the process are disappointment (frustration), confirmation of fear (distress) and shame.

Relationships of causality

There are several concepts involved in the affective motivational architecture described in Section 4. These concepts are interrelated through what are known as relationships of causality. Relationships of causality refer to the effect a concept has on the rest of the concepts involved in the description of an environment. The effect is to increase or reduce the likelihood of another concept appearing.

Consequently, there are two kinds of relationships:

Negative: A negative relationship is one in which the increase in the likelihood of one element appearing causes a proportional reduction of the likelihood of another appearing. And the reduction in one causes a proportional increase in the other. It is expressed numerically by taking a value in the range [-1, 0). For example, greater interest and desire, to cause the less likelihood of error and consequently less likelihood leave the system. As well as decreasing the likelihood of reproach or hate the system.
Positive: A positive relationship is one in which an increase in the likelihood of one element appearing causes a proportional increase of the likelihood of another element appearing and a reduction in the likelihood of one causes a proportional reduction in the likelihood of the other. For example, an increase in errors causes an increase in the likelihood of quitting. Numerically it is expressed by taking values in the range (0, 1].

If *there is no effect* or the effect is *neutral*, the relationship is expressed with the value 0 (zero), as shown in Table 2. The Table 1 summarizes the relationships between the concepts.

Elements	Relationships	
Interest & desire	Positive	Joy-pride, admiration-love, learning
	Negative	Quit, errors, hate-reproach
Help	Positive	Relief, strategies cog/affec-op, interruption, latency
	Negative	Errors

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Strategies cog/affec-op	Positive	Admiration-love, interest & desire, learning
	Negative	Hate-reproach, quit, errors
Interruption	Positive	Strategies cog/affec-op, quit
	Negative	Interest & desire,
Quit	Positive	Disappointment (frustration)-fears confirmed (distress), shame, errors
	Negative	Joy-pride, admiration-love, relief, interest & desire, strategies cog/affec-op, learning
Learning	Positive	Joy-pride, admiration-love, relief, interest & desire, strategies cog/affec-op
	Negative	Interruption, quit, latency, errors, hate-reproach, disappointment (frustration)-fears confirmed (distress), shame
Latency	Positive	Strategies, interruption
	Negative	Relief, learning
Errors	Positive	Disappointment (frustration)-fears confirmed (distress), shame, strategies, interruption, quit
	Negative	Interest & desire
Joy-pride	Positive	Interest & desire, learning, admiration-love
	Negative	Latency, errors, hate-reproach
Admiration-love	Positive	Interest & desire, strategies,
	Negative	Quit, latency, hate-reproach
Relief	Positive	Strategies, learning, proximity
	Negative	Quit, disappointment (frustration)-fears confirmed (distress)
Hate-reproach	Positive	Strategies, interruption, quit, latency, errors, disappointment (frustration)-fears confirmed (distress), shame
	Negative	Interest & desire, learning, admiration-love, relief
Disappointment (frustration)-fears confirmed (distress)	Positive	Quit, errors, latency, hate-reproach, shame, proximity
	Negative	Learning, joy-pride, admiration-love, relief
Shame	Positive	Strategies, quit, errors, hate-reproach, disappointment (frustration)-fears confirmed (distress)
	Negative	Interest & desire, learning, joy-pride, admiration-love
Proximity	Positive	Disappointment (frustration)-fears confirmed (distress),

Table 1. Relationships of causality

Matrix of causalities

The relationships are represented in a matrix of causalities of the Table 2, based on the description of the positive relationship and the negative relationship. This matrix shows the effects of each concept on the rest. Thus, the T-L process is represented through all the relationships that can be established between all its components, including the affective-motivational elements.

The concepts listed in Table 1 are identified by means of the following nomenclature. ID, for example, refers to the concept: *Interest and desire to continue*.

Affects and elements of T-L process

1	ID	Interest & Desire	9	JP	Joy-Pride
2	H	Help	10	AL	Admiration-Love

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3	S	Strategies cog/aff-ope	11	R	Relief
4	I	Interruption	12	HR	Hate-Reproach
5	Q	Quit	13	DF	Disappointment (frustration)-fears confirmed (distress)
6	L	Learning	14	Sh	Shame
7	Lt	Latency	15	P	Proximity
8	E	Errors			

	ID	H	S	I	Q	L	Lt	E	JP	AL	R	HR	DF	Sh	P
ID	0	0	0	0	-1	1	0	-1	1	1	0	-1	0	0	0
H	0	0	1	1	0	0	1	-1	0	0	1	0	0	0	0
S	1	0	0	0	-1	1	0	-1	0	1	0	-1	0	0	0
I	-1	0	1	0	1	0	0	0	0	0	0	0	0	0	0
Q	-1	0	-1	0	0	-1	0	1	-1	-1	-1	0	1	1	0
L	1	0	1	-1	-1	0	-1	-1	1	1	1	-1	-1	-1	0
Lt	0	0	1	1	0	-1	0	0	0	0	-1	0	0	0	0
E	-1	0	1	1	1	0	0	0	0	0	0	0	1	1	0
JP	1	0	0	0	0	1	-1	-1	0	1	0	-1	0	0	0
AL	1	0	1	0	-1	0	-1	0	0	0	0	-1	0	0	0
R	0	0	1	0	-1	1	0	0	0	0	0	0	-1	0	1
HR	-1	0	1	1	1	-1	1	1	0	-1	-1	0	1	1	0
DF	0	0	0	0	1	-1	1	1	-1	-1	-1	1	0	1	1
Sh	-1	0	1	0	1	-1	0	1	-1	-1	0	1	1	0	0
P	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0

Table 2. Causal matrix

Figure 2 shows the fuzzy cognitive map that represents the matrix of causalities for the T-L process integrated with motivational and affective aspects.

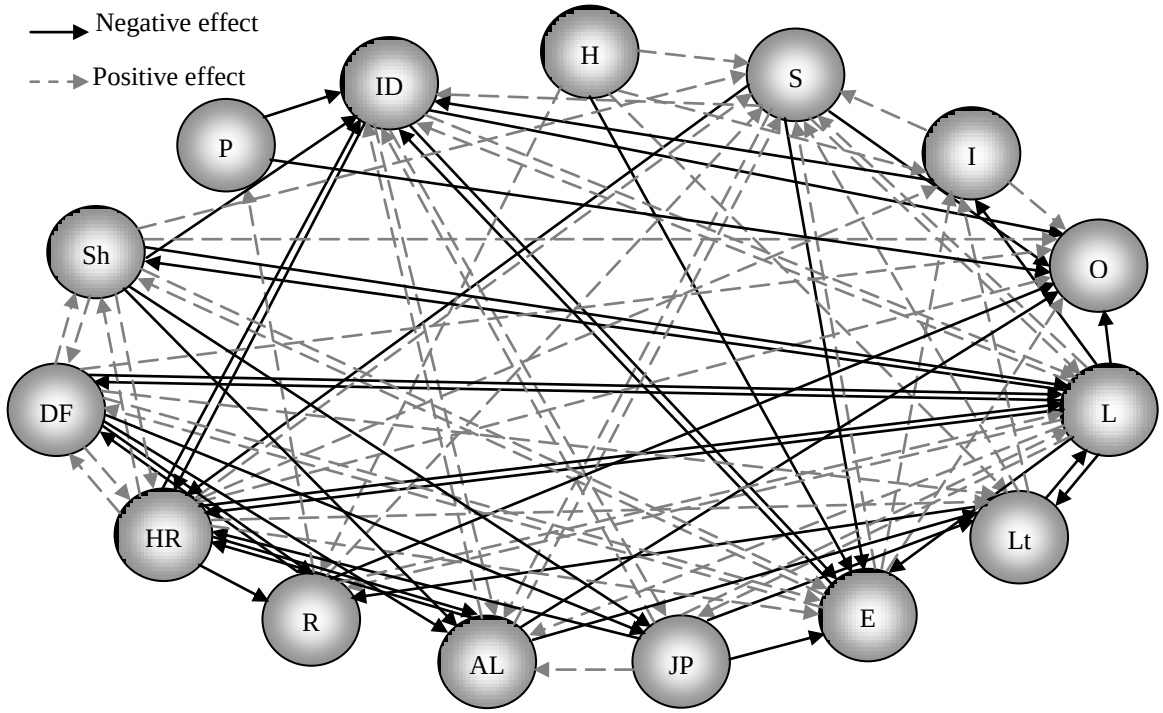

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Fig. 2. Fuzzy cognitive map

8. Test scenarios

As initial tests, three scenarios are described indicating the initial state of each of the concepts or initial vector Vi). In each scenario the sum of effects is obtained through the causal matrix (multiplying l vector by the matrix), and the resulting vector is evaluated using the threshold function. This is repeated until a stable final vector (Vf) is obtained.

Scenario1

The user requests help, has committed errors, and is close to completing the task set.

Vi= 0,1,0,0,0,0,0,1,0,0,0,0,0,0,1

Vf= 0.9,0.5,1,0.9,0.9,0,0,0.5,0.4,0.5, 0,0,0.9,0.9,0.5

Future state (Scenario1)

It is inferred that there is interest and desire to continue, it is possible that less help will be requested, it is necessary to apply strategies and interrupt the user, there is a strong likelihood of quitting, errors diminish, there is a 50% likelihood of experiencing joy, pride, and satisfaction with the system, great disappointment and shame, the perception of proximity diminishes.

Scenario2

The user requests help, strategies are applied, and the user has committed errors and is close to completing the task set.

Vi= 0,1,0,0,0,0,0,1,0,0,0,0,0,0,1

Vf= 0.9,0.5,1,0.9,0.9,0,0,0.5,0.4,0.5, 0, 0, 0.9, 0.9, 0.5

Future state (Scenario2)

It is inferred that there is interest and desire to continue, it is possible that less help will be requested, strategies continue to be applied, and the user is interrupted, there is a strong likelihood of quitting, errors diminish, there is a 50% likelihood of experiencing joy, pride, and satisfaction with the system, great disappointment and shame, the perception of proximity diminishes.

Scenario3

The user presents down time but does not quit the task set and strategies are applied.

V1= 0,0,1,0,0,0,1,0,0,0,0,0,0,0,0

Vf= 0.9,0.5,1,0.9,0,0.9,0,0,0,0.9,0,0, 0.9,0.9,0.9

Future state (Scenario3)

It is inferred that there is interest and desire to continue, there is a 50% likelihood of requesting help, strategies continue to be applied, and the user is interrupted; learning, satisfaction with the system, distress and shame are se inferred, and there is a perception that the task is close to completion.

Conclusions

Previous work, introduce a general teaching-learning process modeled by MCD (Laureano et. al. 2010), that include like and event *Strategies cog/affec-op*, but in that case we don´t have any clue form the emotion. The new MCD, proposes include the elicitation of the affects according the Motivational-affective structure, from the Figure 1. Later give the possibility to choose a more specific interaction strategy.

Relationships of causality allow us to infer, given a scenario (initial vector), the future state of the elements of the Teaching-Learning process and the cognitive representation of the related emotions.

Fuzzy cognitive map modeling the behavior exhibited in the affective-motivational structure. And this structure feeds the student model and the tutor module, to which it provides clues to the user's emotional state. This

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helps in choosing the best cognitive-affective strategy that the pedagogic agent will deploy, thereby maximizing the effectiveness of the intervention. This point is the contribution of our work.

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References

Castañeda, S. y Martínez, R. (1999) Enseñanza y aprendizaje estratégicos. Modelo integral de evaluación e instrucción. *Revista Latina de Pensamiento y Lenguaje. Monográfico: Cognición, educación y evaluación.* 4(2B) 251-278.

Castañeda, S., García, R. y González, R. E. (2006). Diseñando exámenes, en Castañeda, S.(Ed). Evaluación del aprendizaje en el nivel universitario. (pp. 145-170). México, D. F.: Universidad Nacional Autónoma de México.

Khan, M.S., Chong, A., Quaddus, M. (1987). Fuzzy Cognitive Maps and Intelligent Decision Support –A Review. School of Information Technology, Murdoch University, Graduate School of Business, Curtin University of Technology, GPO Box U.

Conati, C., & Maclaren H. (2005) Data-Driven Refinement of a Probabilistic Model of User Affect. *Springer-Verlag*, L. Ardissono, P. Brna, and A. Mitrovic (Eds.): UM 2005, LNAI 3538, 40 – 49.

Jaques, P. & Vicari, R. M. (2007). A BDI approach to infer student's emotions in an intelligent learning environment. *Computers & Education*, Elsevier Science Ltd. (Ed.) Oxford, UK, 49(2), 360-384.

Kosko, B. (1986). Fuzzy Cognitive Maps, International. *Journal of Man-Machine Studies.* 24, pp 65-75.

Kosko, B. (1992). *Neural Networks and Fuzzy Systems. A Dynamical Systems Approach to Machine Intelligence*, New Jersey: Prentice-Hall.

Laureano-Cruces, A (2000). *Interacción Dinámica en Sistemas de Enseñanza Inteligentes.* Tesis Doctoral. Instituto de Investigaciones Biomédicas/UNAM.http://delfosis.uam.mx/~ana/

Laureano-Cruces, A., & de Arriaga, F., (2000). Reactive Agent Design For Intelligent Tutoring Systems. *Cybernetics and Systems* (an International Journal ISSN: 0196-9722). 31(1), 1-47.

Laureano-Cruces, A., Ramírez-Rodríguez, J., Terán-Gilmore, A. (2004). Evaluation of the Teaching-Learning Process with Fuzzy Cognitive Maps. *IBERAMIA-04 Advances in Artificial Intelligence. Lecture Notes in Artificial Intelligence Series*, Vol. 3315. Springer- Verlag 922-931.

Laureano-Cruces, A., Terán-Gilmore, A., J. & de Arriaga, F., (2004). A Learning Model Based on a Didactic Cognitive Approach: The Case Of Single-Degree-Of-Freedom Systems. *Computer Applications in Engineering Education*, ISSN: 1061-3773, John Wiley and Sons. Inc. USA. 12(3), 152-164.

Laureano-Cruces, A., Ramírez-Rodríguez, J., Mora-Torres, M. & Espinosa-Paredes, G. (2006). Modeling a Decision Making Process in a Risk Scenario: LOCA in a Nucleoelectric Plant Using Fuzzy Cognitive Maps. *Research in Computing Science*. ISSN: 1870-4069. 26, 3-13.

Laureano-Cruces, A., Sánchez-Guerrero, L., Mora-Torres, M. & Ramírez-Rodríguez, J. (2008). Learning Objects and Personalized Instruction. . *E-Learn 2008 World Conference on E-Learning in Corporate Govermment, Healthcare, & Higher Education. November 17-21, 2008, Las Vegas. Nevada, USA.*

Laureano-Cruces, A., Mora-Torres, M., Ramírez-Rodríguez, J. & Gamboa-Rodríguez, F. (2009). Emotions as an Element that Maximizes the Effectiveness of a Pedagogical Agent. *E-Learn 2009 World Conference on E-Learning in Corporate Govermment, Healthcare, & Higher Education. October 26-30, Vancouver, Canadá*

Laureano-Cruces, A., Ramírez-Rodríguez, J., Mora-Torres, M., de Arriaga, F. & Escarela-Pérez, R. (2010). Cognitive-Operative Model of Intelligent Learning Systems Behavior. *Interactive Learning Environments*. ISSN: 1049-4820. UK. Vol. 18, No.1, pp 11-38.

Mora-Torres, M. (2007). *Sistema Experto en la Toma de Decisiones de un Escenario de Riesgo: LOCA Pequeño en una Planta Nucleoeléctrica.* MSc. Degree Thesis. Posgrado en Ciencia e Ingeniería de la Computación-Universidad Nacional Autónoma de México. Consultado en http://delfosis.uam.mx/~ana/

Mora-Torres, M., Laureano-Cruces, A., Ramírez-Rodríguez, J. & Espinosa-Paredes, G. (2009) Analysis and Design of the Knowledge Representation for the Implementation of a Distributed Reasoning. *Revista de Matemática: Teoría y*

En Proceedings de E-Learn 2010 World Conference on E-Learning in Corporate Govermment, Healthcare, & Higher Education, pp. 1930-1938. ISBN: 1-880094-53-5. Orlando, Florida, October 18-22. **2010**.

Aplicaciones. Escuela de Matemática (Spanish, English, French), Universidad de Costa Rica, San José. Indizada en Zentralblatt MATH. ISSN 1409-2433 y en Latindex 1409-2433. 16(2), 267–281

Mora-Torres, M., Laureano-Cruces, A., Velasco-Santos, P. (2010). Estructura de las Emociones dentro de un Proceso de Enseñanza-Aprendizaje. *Perfiles Educativos*. UNAM. Aceptado. Junio 2010.

Ortony, A. Clore, G.L., Collins, A. (1996). *La estructura cognitiva de las emociones*. ISBN: 84-323-0926-5. Siglo XXI de España Editores, S.A.

Picard, R. W., (1995). *Affective Computing*. MIT Media Laboratory Perceptual Computing Section Technical Report N°321. Cambridge, Massachussets: MIT

Reeve, J. (2001). *Motivación y Emoción*. ISBN: 978-970-10-3788-1. McGraw Hill