Emotions, personality and social interactions 
modelling in a multiagent environment

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Abstract
In this paper we will present our approach to describe the emotional state of agents influenced by their personality profile and the behaviour of other agents evolving in the environment.

To model emotion and personality we made the choice of Fuzzy Cognitives Maps (FCM). For this purpose we use the virtual reality platform, called ARéVi 1, developed in our laboratory at the CERV. In this simulations environment we are able to associate the FCMs at the decision level of each agent. The design of personality profiles is based on the models proposed by PerformanSe company, specialised in behavioural competences. To adapt their models with the FCM model, we have defined emotions as concepts of the cognitive maps of the agent and links between concepts of the FCM as personality profile of the agent. Finally, these fuzzy Emotional Maps (FEM) are plugged to our agents, so they can have actions in the environment which are based on their emotional states and personality profiles.

Keywords: Virtual reality, multiagent systems, fuzzy cognitive maps, theory of emotion, social interaction

1 Introduction
The aim of these research works is to define a simulations environment in which we will be able to integrate human dimension and observe believable behaviours of entities as, for instance in group meeting simulations. In the nineties of the last century, Damasio [1] suggested that emotions lead an important role in decision-making process by providing a selection mechanism for elimination of bad solutions. Decision-making is then simplified, because there are fewer choices left to be evaluated. To obtain a believable behaviour of emotional agent, we need to be able to describe the inherent uncertainty of emotions. For this purpose fuzzy logic model is a solution and had been used for mobile robot applications [2]. In this article we will describe a solution based on fuzzy cognitive maps [3] that we have used in our ARéVi platform to define a model of emotion on which we can add different types of personality.

Until now, research on emotional and personality modelling are mainly based on the OCC model [4] and the FFM 2 model [5]. From those studies we have developed a reusable model for each emotion type in our ARéVi platform.

1ARéVi : Atelier de Réalité Virtuelle

2FFM: Five Factor Model
2 **ARéVi Environment**

We will use the simulation engine *ARéVi*, developed at the CERV, to define our entities and their abilities to use emotions, based on fuzzy cognitives maps, in their decision process. Users of the environment will be able to observe the behaviour of the emotional entities and to interact with them in 3D representation of the environment.

2.1 **ARéVi Platform**

The LI2 laboratory, located in France at the CERV, has developed the *ARéVi* platform which is a toolkit for creating distributed virtual reality applications with autonomous 3D entities, agents. The simulation engine is based on a scheduler whose aim is to execute activities associated to objects at different frequencies during each step, cycle, of the simulation. *ARéVi* is developed in C++ offering functionalities that are specific to virtual reality. This platform has a 3D graphics rendering based on OpenGL. *ARéVi* also uses kinematics, that will be used for gestural animation of emotional expressions, based on H-Anim which adds to the possibilities for expressing agent behaviours in a three-dimensional environment. A fuzzy cognitive map library is available in the *ARéVi* platform and user can describe cognitive maps in an XML format style that can be parsed to create FCM and associate them to our agents in an *ARéVi* simulation.

2.2 **Fuzzy Cognitive Maps**

We will use the *ARéVi* FCM library as a tool to model emotional behaviour of believable agent.

This section will describe the design of a fuzzy cognitive map for a simple prey-predator behaviour as defined by Parenthoën [6] and we will describe later, in the section about fuzzy emotional maps, how we relocated FCMs on each agent’s level to model their emotional states within a virtual world.

Agent is defined by his perception-decision-action abilities. Sensors and effectors of the agent can be associated in an FCM with sensormotors concepts by fuzzyfication (perception) and defuzzyfication (action) of these concepts. The internal concepts of the cognitive maps will define the decisional model of the agent. Fuzzyfication and defuzzyfication will represent the dynamics of the FCM.

The above exemple illustrate a model of an agent in a prey-predator application. Prey perceive his distance to an enemy. According to this distance and its fear it will decide to flee or not. The closer the enemy is, the more it is frightened and conversely. The more it is frightened, the more quickly it flees. We model this escape by the FCM of the Figure 1

![Prey Fuzzy Cognitive Map](image1)

**Figure 1: Prey Fuzzy Cognitive Map**

This FCM has 4 concepts and 3 links: “enemy close”, “enemy far”, “fear” and “escape”, with exiting links (+1) from “enemy close” to “fear” and from “fear” to “escape”, and an inhibiting link (-1) from “enemy far” to “fear” that have the following matrix representation (figure 2):

\[
L = \begin{bmatrix}
0 & 0 & +1 & 0 \\
0 & 0 & -1 & 0 \\
0 & 0 & 0 & +1 \\
0 & 0 & 0 & 0
\end{bmatrix}
\]

**Figure 2: Prey FCM matrix**

The activation of the sensitive concepts “enemy close” and “enemy far” is carried out by fuzzyfication of the sensor of the distance to the enemy (figure 3) while the defuzzyfication of “escape” gives a speed of escape to this

![Prey Fuzzyfication model](image2)

**Figure 3: Prey Fuzzyfication model**
3 Emotion and Personality

This section will initially enable us to present the various existing models for emotional agents and then to describe the model of personality on which we rest to work out profiles behavioural.

3.1 Emotional model

Since Elliot employed the OCC model [4] as the basic theory to synthesize emotions in its Affective Reasoner, almost all of the applications are based on this model, even if, a significant number of modifications are made. Models such as Cathexis [7] or Canamero’s Abbotts [8] take into account parameters such as motivation, physiological variables, emotions in progress. Theses emotions are used in some case to modify the facial expression or the dialogue [9], others also uses it to modify the behaviour of the agent. Reilly [10] proposed a behaviour stronger than in reality, where the characters more strongly react to the emotions, as in the animated drawings. In FLAME of El-Nasr [2], the behaviour is selected according to fuzzy rules which can depend on the emotional state. The emotions can also influence the motivation, like in the Canamero’s Abbotts, where this motivation depends also of physiological parameters and is used to choose the behaviour. Gratch and Marsella [11] propose a model based on a theory of Smith and Lazarus [12] making possible to manage emotions while acting on the environment, in order to modify the received stimuli, and on the importance of goals and motivations of the agent.

From these studies on emotional models we have made the choice of fuzzy logic mechanisms, representing a solution to model uncertainty which seems to be the right definition of emotion. Instead of defining fuzzy rules, as El Nasr done [2], we have used our FCM library. With this library we are able, by fuzzification, to connect sensors of agent with sensorial concepts of a cognitive map. The output of the map will be represented by effectors of the agent, computed by defuzzification of the motor concepts of the same cognitive map.

3.2 Personality model

In order to equip our emotional agents with believable behavioural profiles, we chose to integrate the model of personality PerformanSe-Dialecho proposed by PerformanSe company, based on a systemic approach [13].

This model integrates whole of relations like one communication system in perpetual interaction. Our position is based on the postulate that behaviours are related to the features of personality. Based on the model of the “big five” with, consequently, five features [14] (benevolence, emotivity, opening, assertion and responsibilities), the PerformanSe model was supplemented to take in account the motivations of the individual. This model thus integrates ten features of personality distributed in three spheres: personal, work and motivation spheres. The behaviour of the individual is then regarded as one “communication system” characterized by an internal energy and engines; motivations (finalities) and modes of self-adaptation (opening of the system towards the outside).

In this context, the use of the fuzzy cognitive maps seems most relevant for this modelling, because they allow to specify perception modifications using motivational and emotional concepts linked with sensors concepts according to personality profiles as defined by PerformanSe model.

4 Emotional Agents

According to the studies that we have done on emotion and personality in the above section, we have implemented our emotional agent that will evolve in a virtual environment. Agents in the simulation can have the same emotions, each of them will be represented by a Fuzzy Emotional Map (FEM). What distinguishes behaviour of two different agents will be their personality that we have defined as influence coefficients between concepts of an emotional map.

4.1 Fuzzy emotional maps

Based on the OCC model [4] we defined six FEM divided into three distinct groups according to what happens in the environment (hope/fearness, satisfaction/disappointment),
consequences of my actions (joy/sadness, proud/shame) consequences of the other agents actions (sympathy/antipathy, approval/opposition).

Emotions being common to all our agents, what will distinguish them is defined by their personality. We have integrated it in term of influence factors between the various concepts of our cognitive maps. The behaviour of an agent will be selected in the decision module and will result from its own perception of the environment defined in the evaluation module. Both of these modules will use the sensorimotors concepts of FEM.

On figure 4 is represented the FEM for one type of emotion. The “emotion” concept had to be considered to represent a positive/negative pair of emotion. This model can be reuse for each type of emotion. The only features we have to modify is the influence weights between emotional concepts, that means the personality factors influencing a specific kind of emotion. The emotional map, represented in figure 4, describe the Joy/Sadness pair emotional map. In this case of FEM, Relaxation (DET), anxiety (ANX) and so on, are the dimensions of personality adapted to this type of emotion, as defined by the model of PerformanSe. Until now, the user controls the FEM inputs with an adapted Graphical User Interface (GUI).

4.2 Agents implementation

In current state of the project, we are able to define emotional virtual agents with different personality profiles. On figure 5 is represented a GUI, using gtkmm library, allowing to observe behaviour, action tendencies, for emotional agent. User of the simulation can stimulate the agent’s emotional properties connected to sensors concepts of his fuzzy emotional maps. We are able to modify the personality profiles of the emotional cognitive maps during the execution of the simulation and observe a different behaviour of the corresponding agent. The action tendencies of the agent are represented in 3D by gestural attitudes, defined by motion capture, and facial expressions, represented by Free Form Deformation tool implemented in our AReVi platform.

5 Interaction between agents

The joint influence of emotional dimension, perception of Other and reference to a system of values determined by the culture of membership, is a major element of the social interaction. We retained two criteria, which seem to us more important initially, distance of interaction and comprehension of the Other which are described in a Social Interaction Matrices, called MIS.

5.1 Agent attributes for interaction

To define the MIS we have to take account static attributes (personality profile, goals and proxemy rules) which define the emotional rules relative to an interaction between two agents. We need also to use dynamic attributes representing emotional state at the decision moment. These attributes are affinity with the other agents, state of mind, emotional gauges, tiredness and practice. All of these attributes can be modified du-

4MIS: Matrice d’Interaction Sociale
ring the execution of the simulation which mean that in the same situation, the same agents won’t have the same behaviour according to the variation of these characteristics.

5.2 Social Interaction

We have implemented, in our ARéVï platform, social interaction matrices (MIS) including the description defined above, between an agent in a specific emotional state perceiving the emotional state of another agent. To manage this interaction we have use communication mechanisms based on message exchange services, available in the ARéVï platform. With those mechanisms we are able to communicate emotional state between agents as broadcasted messages. Then, to decide what action the agent has to perform, he can extract from his message box, the emotional state of the others agents he want to communicate with and, according to his own emotional state he will have an adapted behaviour.

6 Evaluation of emotions

In order to describe the data processing until the decision-making, it is essential to integrate our FEM in a more complex system to be able to define more accurately what kind of emotion is affected and what is the intensity of the affected emotions. The general principle is composed of an “evaluation module” to be able to select and stimulate emotional sensor concepts and a “decision module”, as described in figure 4, which will allow the appropriate selected action.

6.1 Evaluation module

This module “interprets” what the agent perceives according to its personality, goals and internal states. This information will be specific to each agent and modulate by an \( \alpha \) coefficient (composition of proxemy, affinity and personality). The usage of proxemy is the most significant factor to calculate the value of the \( \alpha \) coefficient. We use five gradients of distances defined by possible physical contact (intrusive distance, 15-40 cm), limit of the physical contact (personal distance, 45-90 cm), interpersonal exchanges (interpersonal distance, 90 cm to 2,1 m), distance of more formal relations (social distance, 2,1-3,6 m) and distances where communication is ensured by gesture and posture (public distance, 3,6-7,5m or more).

6.2 Decision module

Decision module organize action tendencies. First, it receives a defuzzyed value from FEM related to the intensity of potential action. The module uses this value to deduce an appropriate behaviour according to the goals of the agent, its personality and its state of mind at this time. This module acts on the level of the social action of the agents. In the same way, an agent must be able to evaluate the future actions of its partners to adopt good attitude.

These two modules, evaluation and decision, will represent the next step of our research work to define a complete emotional behaviour for autonomous agents. For that purpose we need the use of a rule-based system allowing us to select an appropriate emotional intensity and to choose the right action to do in the environment according to the modification of the environment and sensorimotor concepts of the agents FEM. Thanks to the ARéVï plugs-in mechanisms we have made a close connexion between our simulation engine and the inference engine SOAR \(^5\) which we will use to define those rules.

\(^5\) SOAR: State Operator And Result
7 Conclusion

In this article we have described an emotional model based on the design of fuzzy cognitive maps (FEM). We are able to associate different personality profiles to each FEM, allowing us to distinguish the adapted behaviour of two agents according to the same emotional stimulations.

This model is generic and can be adapted to each kind of emotion and personality profile. It makes it possible to develop simulations built on multiagents systems which integrates emotional dimension. We defined the interaction between emotional agents by developing social interaction matrices (MIS) to allow our agents to communicate their emotional states each other. Finally we have integrated our agents in ARêVi simulations where the user can control the emotional stimulations of an agent and observe the behaviour modifications of all the agents evolving in the simulation.

Next step of our work is to develop the evaluation of emotions, described in this article, to obtain real autonomous simulations of group behaviours.

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References


