

# Agent-based Collaborative Affective e-Learning Framework

Mahmoud Neji<sup>1</sup> and Mohamed Ben Ammar<sup>2</sup>

<sup>1</sup>Faculté des Sciences Economiques et de Gestion, University of Sfax, Tunisia

<sup>2</sup>Superior institute of Data Processing and Management, University of Kairouan, Tunisia

[Mahmoud.Neji@fsegs.rnu.tn](mailto:Mahmoud.Neji@fsegs.rnu.tn)

[ben\\_ammam@acm.org](mailto:ben_ammam@acm.org)

**Abstract:** Based on facial expression (FE), this paper explores the possible use of the affective communication in virtual environments (VEs). The attention of affective communication is examined and some research ideas for developing affective communication in virtual environments are proposed. We place an emphasis on communication between virtual entities, which make use of other data apart from the information being communicated. In particular, we explore the capacity of VEs to communicate affective states, i.e. those aspects of communication concerned with emotional response, and discover how agents within VEs can model and use affective states to enhance the realism of the VEs. Moreover, we discuss the social intelligence that renders affective behaviours of software agents and its application to a collaborative learning system. We argue that socially appropriate affective behaviours would provide a new dimension for collaborative e-learning systems.

**Keywords:** affective communication, virtual environments, virtual entities, affective states, e-learning systems

## 1. Problem formulation

The field of affective computing was proposed and pioneered by Rosalind Picard (Picard 1997) from the MIT Media Laboratory. Her definition of affective computing is: “computing that relates to, arises from, or deliberately influences emotions.” Her argument for putting emotions or the ability to recognise emotions into machines is that neurological studies have indicated that emotions play an important role in our decision making process. Our “gut feelings” influence our decisions. Fear helps us to survive and to avoid dangerous situations. When we succeed, a feeling of pride might encourage us to keep on going and push ourselves even harder to reach even greater goals. Putting emotions into machines makes them more human and should improve human-computer communication. Also exploiting emotions could lead to a more human decision-making process. Consequently, in this paper, collaborative affective e-learning framework aim at reintroducing emotional and social context to distance learning while offering a stimulating and integrated framework for affective conversation and collaboration. Learners can become actively engaged in interaction with the virtual world. Further, the use of avatars with emotionally expressive faces is potentially highly beneficial to communication in collaborative virtual environments (CVEs), especially when they are used in a distance E-learning context. However, little is known about how or indeed whether, emotions can effectively be transmitted through the medium of CVEs. Given this, an avatar head model with human-like expressive abilities was built, designed to enrich CVEs affective communication. This is the objective of introducing the Emotional Embodied Conversational Agent (EECA) (Ben Ammar, Neji and Gouardères, 2006). We are arguing, then, that the use of peer-to-peer network in combination with collaborative learning is the best solution to the e-learning environments. Peer-to-peer (p2p) technology is often suggested as a better solution because the architecture of peer-to-peer networks and collaborative learning are similar. (Biström 2005). This paper explores CVEs as an alternative communication technology potentially allowing interlocutors to express themselves emotionally in an efficient and effective way. Potential applications for such CVEs systems are all areas where people cannot come together physically, but wish to discuss or collaborate on certain matters, for example in e-learning, based on the affective communication.

There are several novel elements to this research. Firstly, although CVEs as a technology have been available for more than a decade, user representations are still rudimentary and their potential is not well explored, particularly the avatar as a device for social interaction. Secondly, the use of emotions to complement and indeed facilitate communication in CVEs is equally under-explored. This is partly because early CVEs research was mainly technology driven, leaving aside the social and psychological aspects, and partly because the required computing, display and networking resources became available only recently. Thirdly, design guidelines for an efficient, effective, emotionally expressive avatar for real-time conversation did not exist prior to this research. The multi-agent methodology can certainly bring several advantages to the development of e-learning systems since it

deals well with applications where such crucial issues (distance, cooperation among different entities and integration of different components of software) are found. As a result, multi-agent systems, combined with technologies of networking and telecommunications, bring powerful resources to develop e-learning systems. In this research work, we propose emotional framework for an intelligent emotional system. This system is called EMASPEL (Emotional Multi-Agents System for Peer to peer E-Learning), based on a multi-agents architecture. (Ben Ammar, Neji and Gouardères 2006).

## **2. Related works**

Several projects implement learning systems based on multi-agents architectures. Some of them work on a generic platform of agents. (Silveira, Bica and Viccari 2000) For example, JTS is a web-based environment for learning Java language (Rivera and Greer 2001) based on a CORBA platform and using Microsoft agents. In this environment, learners have access to their learner models and they are able to change it, in the case they do not agree with the information represented. Another example is I-Help, a web-based application that allows learners to locate human peers and artificial resources available in the environment to get help during learning activities. I-Help is an example of a large-scale multi-agent learning environment. (Vassileva, Deters, Greer 2001) Moreover, interesting results have been achieved by pedagogical agents (Johnson et al 2000) regarding the learner motivation and companion agents acting sometimes as mediators (Conati, Klawe and Socially 2000) of the learning process. Finally, tutor agents are usually related to learner modelling and didactic decision taking. A virtual learning environment (VLE) provides an environment based on network, and the resources in the network are free to share. Therefore, the study process can enhance the collaboration among learners. The VLE can help learners do cooperative study, and make necessary interactions between each other. For example, ExploreNet is a general-purpose object oriented, distributed two-dimensional graphic based computational environment with features to support role-playing games for educational purposes, and cooperative learning of many kinds. Among the research works, Prada (Prada, Otero, Vala, and Paiva 2004) in his Belief system implements an explicit collaborative mode of utilisation. The collaborative mode will challenge learners to share a virtual greenhouse. Each group will be able to alter some environmental conditions parameters to maximise their crop. Liu focuses on Web-based collaborative virtual learning environment (Liu 2005). He provides a cognitive learning architecture based on constructivism. The prototype learning system is effective based on the evaluation. Interaction can promote learners' active learning. During the studying experience, interaction can offer the learner various controls, such as interacting with the virtual environment and manipulating characters or objects in the virtual environment. VLE technologies can address a wide range of interaction capabilities. Picard and her affective computing groups (Ahn and Picard 2005), describe affective wearable computers that are with users over long periods, like clothing, and that are therefore potentially able to build up long-term models of users' expressions and preferences. The affective wearables offer new ways to augment human abilities such as assisting the speaking-impaired and helping remember important information that is perceived.

Synthetic characters with its significant feature of interactive and intelligent behaviour can provide a potential tool for learning in VLE. A number of worthy systems and architectures for synthetic character behaviour control have been proposed (Bruce, Marc and Yuri 2002). For example, Blumberg and his synthetic character groups focus on developing a practical approach for real-time learning using synthetic characters. Their implementations are grounded in the techniques of reinforcement learning and informed by insights from animal training. (Burke, Isla, Downie, Ivanov, and Blumberg 2001). Similarly, USC/ISI developed a pedagogical agent called Steve that supports the learning process. Agent Steve can demonstrate skills to students, answer student questions, watch the students as they perform tasks, and give advices if students run into difficulties. Multiple Steve agents can inhabit a virtual environment, along with multiple students. Therefore, it helps to make it possible to train students on team tasks. At the same time, giving synthetic characters with emotions and personality has a powerful ability to capture and hold students' attention. Psychologists and pedagogues have pointed out the way that emotions affect learning. According to Piaget (Piaget 1989), it is incontestable that the affection has an accelerating or perturbing role in learning. A good part of the learners who are weak in mathematics, fails due to an affective blockage. Coles (Coles 2004) suggests that negative emotions can impair learning; and positive emotions can contribute to learning achievement. Some educational systems have given attention to generation of emotion in pedagogical environments (emotion expression and emotion synthesis) (Lester 1999) and to the learner's emotion recognition (Conati and Zhou 2002), pointing out the richness presented in affective

interaction between learner and tutor. We argue that socially appropriate affective behaviours provide a new dimension for collaborative learning systems. The system provides an environment in which learning takes place through interactions with a coaching computer agent and a co-learner, an autonomous agent that makes affective responses. There are two kinds of benefits for learning in the collaborative learning environment. One is what is often called 'learning by teaching,' in which one can learn given knowledge by explaining it to another learner. The other benefit is often called 'learning by observation,' in which one can learn given knowledge by observing another learner working on problem solving, teaching other learners, and so on. While in these approaches of collaborative learning, are primarily concerned with is knowledge-based, goal-oriented, and rational, and thus social intelligence might only be utilised as a side effect.

Affection in our framework is considered from various angles and on different levels.

- The emotional state of the learner will be modelled by an event appraisal system.
- The emotional state of the tutor is modelled as well, including values for emotions and parameters such as satisfaction, disappointment and surprise.
- The dialogue acts come in different forms with variation in affective values.
- Various affective parameters are used in determining which tutoring strategy to use and which instructional act to perform (sympathising or non-sympathising feedback, motivation, explanation, steering, etcetera).

### **3. Emotional concept ontology**

A verbal dictionary can be described as a tool that aims to provide a partial solution for the problem where two persons neither understand the language the other is speaking but still want to communicate. One can just look up the meaning of the words of another language. A nonverbal dictionary has the same concept of a verbal dictionary, but it differs in the type of information that is stored. Instead of words, a nonverbal dictionary contains information about all the ways people communicate with each other nonverbally such as facial expressions in our case to construct the emotional ontology. It is well accepted that a common ontology holds the key to fluent communication between agents; most researchers believe that the common ontology is domain ontology. This assignment can be considered as the extension of a previous work, named FED (an online Facial Expression Dictionary) (Jongh 2002) concerning a nonverbal dictionary. Before we define our research question and objectives, we summarise the idea of a specific part of FED. We only focus on that part of FED, which allows the user to send a picture. This image input will be labelled by emotional word (happiness, sad, etc.). FED requires the user to manually locate the face and facial characteristic points (FCPs). The FCPs are predefined conform the Kobayashi and Hara face model. After manually selecting and submitting the points an emotional word will be output. Thus, FED lacks the ability of automatic extraction of facial characteristic points that are needed for the facial expression recognition process. In the current situation user interaction is needed to complete the whole procedure. In our system the emotional ontology(Cowie, Douglas 2005), cover the major role that helps the emotional agents' to distinguish emotions. These knots represent features of a current emotion: for example labels or distances etc. that is the case of APML (Affective Presentation Markup Language)(VHML 2001).

### **4. Update of emotional markup language (EML)**

What exactly do we mean by "emotion"? There is much disagreement on this, but one of the most useful definitions, by psychologist Magda Arnold, draws a careful distinction between states and behaviours. In Arnold's theory emotional experience proceeds in three steps: (1) Perception and appraisal (external stimulus is perceived and judged good, bad, useful, harmful, etc., mostly based on learned associations); (2) Emotion (internal state of arousal or "feeling" arises, involving physiological effects); then (3) Action (specific behaviour such as approach, avoidance, attack, or feeding, depending on emotional intensity, learned behavioural patterns, and other motivations simultaneously present). In this view emotion is an internal state, not a behaviour or a perception of external reality. (Robert and Freitas 1984) The Emotion Markup Language (EML) (Marriott 2002) defines the emotion elements that affect the VH (virtual human) regarding voice, face, and body. The speech and facial animation languages therefore inherit these elements. We have realised some modifications to the APML (Affective Presentation Markup Language) (DeCarolis, Carofiglio, Bilvi, and Pelachaud) language in order to allow the EECA to communicate a wider variety of facial expressions of emotion as well as to allow for a more flexible definition of facial expressions and their corresponding

parameters. These modifications refer mainly to facial expressions timings as well as to their intensity; intensity corresponds to the amplitude of facial muscles movements. For each APML tag we have introduced some new attributes like frequency. The facial expression of an emotion has a limited duration (1/2 to 4 seconds), and the facial muscles cannot hold the corresponding expression for hours or even minutes without cramping.

#### 4.1 Attributes of EML

EML is an XML (W3C 2002) (Extensible Markup Language) compliant text marks up language. This implies that it conforms to a standard for the World Wide Web and hence it can be used with (sufficiently powerful) web browsers.

**Frequency:** the number of times an emotion is felt

**Duration:** Specify the time taken in seconds or milliseconds of the emotion existence in the human being.

**Intensity:** Specify the intensity of this particular emotion, either by a descriptive value or by a numeric value.

**Wait:** Represent a pause in seconds or milliseconds before continuing with other elements of EML (<angry> <disgusted><neutral><surprised> <happy><sadness><fear>)

#### 4.2 Update of EML elements

In our framework we propose is the EmotionStyle language, designed to define style in terms of multimodal behaviour, and make an EECA display, and recognise emotion accordingly. A new feature was added to the EML language. This was to add a distances and frequency attributes to EML in order to make to describe more carefully the facial expression. For each we have introduced some distances like D1 to D6.

##### < Neutral >

The neutral face represents the reference emotion. The concept of the neutral face is fundamental because all the distances describe displacements with respect to the neutral face.

Description: Facial expression. {D1-D6}=initialised

Attributes: Default EML attributes.

Properties: All face muscles are relaxed, the eyelids are tangent to iris, lips are in contact, the mouth is closed and the line of the lips is horizontal.

##### < Angry >

Description: Facial expression. {D2 decreases}, {D1 increases}, {D4 either decreases D4 increases}

Attributes: Default EML attributes.

Properties: The internal corners of the eyelids decrease together, the eyes are opened largely; the lips join each other or they are opened to make the mouth appear.

##### < Disgusted >

Description: Facial expression. {D3 increases AND D4 increases}, {the other distances remain constants}

Attributes: Default EML attributes.

Properties: The superior lip gets up and is stretched in asymmetrical manner, the eyelids are deconstructed.

##### < Surprised >

Description: Facial expression. {D2 increases}, {D1 increases}, {D4 increases}, {the other distances remain constants}

Attributes: Default EML attributes.

Properties: the eyelids gets up, the mouth is opened.

##### < Happy >

Description: Facial expression. {D4 increases}, {D3 decreases and D6 decreases}, {the other distances remain constants}

Attributes: Default EML attributes.

Properties: (the mouth is open), the commission are stretched back to the ears, the eyelids are stretched. The eyelids gets up, the mouth is opened.

##### < Sadness >

Description: Facial expression. {D2 increases and D5 decreases}, {D1 decreases}, {the other distances remain constants}

Attributes: Default EML attributes.

Properties: The internal corners of the eyelids to the height; the eyes are closed slightly; the mouth is stretched.

< Fear >

Description: Facial expression. {D2 increases and D5 increases but more that D2}

Attributes: Default EML attributes.

Properties: the eyelids get up together and their internal parts go to the height. The eyes are contracted and in alert.

### 4.3 Temporal facial expression features

The facial expression can be defined in relation with the time of changes in the facial movement and can be described according to these three temporal parameters:

**Duration of Onset:** how much time is necessary for the emotion to appear?

**Duration of Apex:** how much time the expression remains in this position?

**Duration of Offset:** how much time so that the expression will disappear?

## 5. EMASPEL framework

### 5.1 Architecture

The figure1 illustrates the architecture of a peer in our P2P e-learning system. In order to promote a more dynamic and flexible communication between the learner and the system, we integrate five kind of agent:

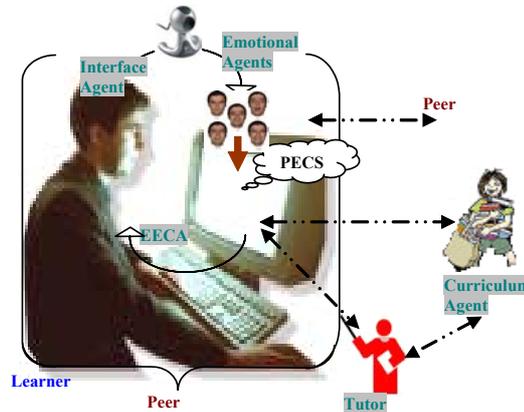


Figure 1: EMASPEL architecture

#### 5.1.1 Interface agent

- Transmit the facial information coming from the learner to the other agents of the Multi-Agents System (MAS).
- Assign the achieved actions and information communicated by the learner, to agents Curriculum, EECA and the other agents of the MAS.

#### 5.1.2 Emotional embodied conversational agent

##### 5.1.2.1 Motivation

Agents cannot be content to be intelligent, but must be endowed also by emotions and personality. In the same way the communication in natural language is not enough, it must be doubled by nonverbal communication. Agents are able to give natural responses and therefore come across as believable and even interesting conversational partners. (Prendinger, Ishisuka 2004) Animated pedagogical agents are "lifelike autonomous characters that cohabit in learning environments with learners to create rich, face-to-face learning interactions". Animated agents carry a personal effect, which is the presence of a lifelike character that can strongly influence learners to perceive their learning experiences positively (Alexander, Sarrafzadeh and Hill). It is widely accepted that animated agents capable of emotion expression are crucial to make the interaction with them more enjoyable and compelling for users (e.g. Lester, Towns, and FitzGerald 1999). Emotional behaviour can be conveyed through various channels, such as facial display (expression). The so-called 'basic emotions' approach (Ekman 1999) distills those emotions that have distinctive (facial) expressions

associated with them and seems to be universal: fear, anger, sadness, happiness, disgust and surprise. More accurately, Ekman prefers to talk about (basic) emotion families. Thus, it consists to have many expressions for the same basic emotion. The characteristics of basic emotions include quick onset (emotions begin quickly) and brief duration, which clearly distinguish them from other affective phenomena such as moods, personality traits or attitudes. Note that only enjoyment and possibly surprise are 'positive' emotions. The enjoyment family covers amusement, satisfaction, sensory leisure, pride, thrill of excitement and contentment. Interestingly, the positive emotions do not have a distinct physiological signal. Ekman explains this by referring to the minor relevance of positive emotions in evolution.

#### *5.1.2.2 Description*

In the construction of embodied agents capable of expressive and communicative behaviours in the e-learning environment, an important factor is the ability to provide modalities and conversational facial expressions on synthetic faces. For example, an animated interface agent is now being used in a wide range of application areas including personal assistants, e-commerce, entertainment and e-learning environments. Amongst our objectives, is to create a model to generate and visualise emotions on embodied conversational agent. The emotions are particularly important for a conversational agent since they reveal an essential share of the speech through nonverbal signals. William James perceives the emotions like a direct response to the perception of an event contributing to the survival of the individual and insists on the changes induced on the body behaviour of the individual. The body answers initially in a programmed way of this change; constitutes so what one calls the emotions. The feedbacks of the body by the nervous system contribute largely to the experiment of the emotions. Research proved that the emotions succeed the facial expressions. During the learning process and when interacting with the learner, some tutoring agents may want to express affects. Thus, they use EECA, which is able, within a specific activity to translate through a character the emotions of the tutoring agent. It has to be aware of the concerned task and of the desired emotional reaction (by the designer or the concerned tutoring agent). The emotional state of EECA is a short-term memory, which represents the current emotional reaction. To be able to compute emotion, a computational model of emotion is required. Our approach was built on Fridja model. (Frijda 1986)

#### *5.1.2.3 Design of EECAs*

This sub-section is about the design of Emotional Embodied Conversational Agents (EECAs). In this field of Human Computer Interaction (HCI) and Artificial Intelligence (AI), the design of EECAs or 'virtual humans' and the communication between those agents and human users is the main object of research. A lot of effort was put into making ECAs more natural, believable, and making communication with ECAs more affective, efficient, and fun. One way to improve communication in this way is to make the agent more actively involved in building a relationship with the user. An agent that is able to observe the user, and with its personality, appearance, and behaviour is able to respond to the (implicit) likes and dislikes of the user, in such a way that it can become acquaintances with the user and create an affective interpersonal relationship. Such an agent could have additional benefits over a 'normal' Embodied Conversational Agent in areas such as e learning. EECA is made of three layers (modules) (figure.2):\_the first one (perception layer) captures and extracts the facial expressions (image acquisition and face tracking) and proceeds to its categorisation (classification).

The second one (cognition layer) analyses and diagnoses the perceived learner's emotional state. The third one (action layer) takes decision on remedy pedagogical actions to carry out in response to the actual emotional state. Tutoring agents are then informed and may access information in the new affective state to adapt the current tutoring flow accordingly. The cognitive layer includes two main processes named analysis and diagnosis. The analysis of an emotional state recognised by the perception layer makes it possible to translate the meaning of this emotion in the learning context. It is carried out by taking into account several elements including the recognised emotion, the current affective profile, the historic of the actions realised before the emotion expression, the cognitive state of the learner, the emotion evolution and the social context (if it corresponds to social or a collaborative learning).

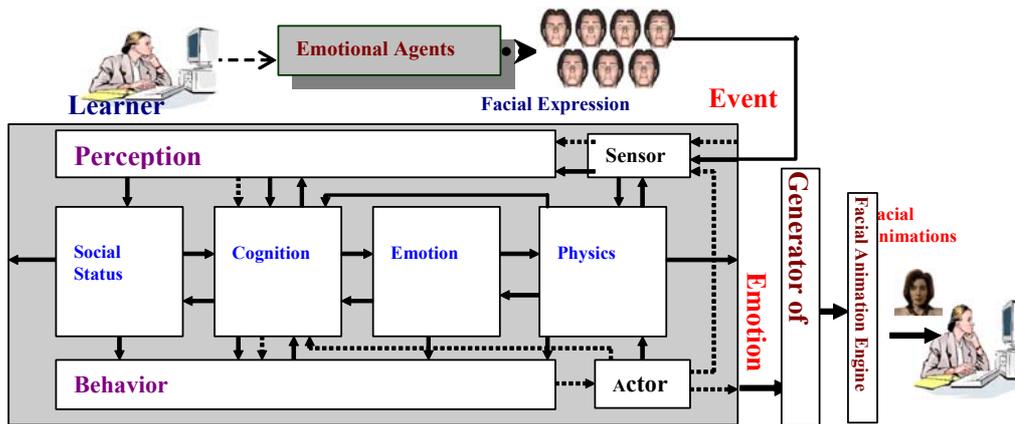


Figure 2: The emotional embodied conversational agent (EECA) Architecture

Agents are virtual human beings. They are designed to imitate or model human Behaviour. Human Behaviour is complex and many-sided. Nevertheless it is possible to argue that human Behaviour can within limits be modelled and can thus be made comprehensible and predictable. Physical, emotional, cognitive, and social factors occur in all forms of human behaviour. Approaches, which regard human beings exclusively as rational decision makers, are of limited value. The modelling of human Behaviour plays an important role in all areas in which action planning, decision-making, social interacting and suchlike play a part. These areas include in particular: Sociology Teaching and education. Consequently, the internal state of the EECA agent is based on the PECS architecture proposed by Schmidt (2000). The PECS architecture is a model of agent that aims to simulating the human behaviour in a group. PECS stands for Physical Conditions, Emotional State, Cognitive Capabilities and Social Status. These are the four main building blocks of a particular PECS agent architecture adding a Sensor-Perception module and a Actor-Actor module. (figure.2) The PECS reference model aims at replacing the so-called BDI (Belief, Desire and Intention) architecture. (Rao 1995) Architectures, such as BDI, which conceive of human beings as rational decision makers, are sensible and useful to a very limited degree only. Restriction to the factors of belief, desire and intention is simply not appropriate for sophisticated models of real systems where human factors play an important role. PECS's agent model consists of three horizontal layers:

**1. Information Input Layer:** This layer processes the input taken from the agent environment and consists of two components: The Sensor and Perception components. The sensor component takes the external data by means of a set of sensors and the Perception component filters the no relevant data and processes the information. The perceptions are used to update the mental state of the agent or for learning purposes.

**2. Internal Components Layer:** The personality of the agent is modelled at the second layer. Thus, the parameters of this second layer are crucial to find out the response of the agent to the input taken by the information layer. They consist of four components: Physics, Cognitive, Emotional and Social Status. The physical and material properties of the agents are modelled in the Physical component. The emotions that can affect the behaviour of the agent are modelled as part of the Emotional component. The agent's experience and knowledge are part of the Cognitive component; and finally, the social features of the agent (e.g., whether the agents like to socialise or they prefer to be alone) are described in the Social Status component.

**3. Agent Output Layer:** This layer is in charge of modelling the set of possible actions and the selection process, and thus it produces the response of the agent and consists of two components: The Behaviour and Actor components. The Behaviour Component selects the action(s) that are associated with the input information that reaches the agent and the agent's response is based on its internal parameters. The actor component takes the action and executes them. The PECS architecture is not based on any social or psychological theory. The architecture is mainly an integrated model in which several fundamental aspects to human behaviour and decision-making process are taken into account. (Miranda and Aldea 2005). The purpose of the emotional agents consists at extracting the facial expressions (acquisition and facial alignment) and subsequently categorising them using the temporal evolution of distances  $D_i$  like it is demonstrated in table 1. The analysis of table 1 shows that it will be possible to differentiate between different emotions while being interested in priority in the  $D_i$  distances which undertake significant modifications. Indeed, there is

always at least one different evolution in each scenario. The EECA first carries out an analysis of the emotional state of the learner. The purpose of this analysis is to translate the meaning of the emotion in the training context. It is achieved based on several factors such as: the emotion sent by the emotional agents, the current emotional profile, the history of the actions carried out before the appearance of the emotion, the cognitive state, the evolution of the emotion and the social context (if it is about a social training or collaborative).

The expressions in input are "joy", "fear", "dislike", "sadness", "anger", "surprised" and the analysis make it possible to conclude if the learner is in state of "satisfaction", "confidence", "surprise", "confusion" or "frustration". The interpretation of the analysed emotional state is then established. It will consequently determine the causes having led to this situation (success/failure with an exercise, difficulty of work, misses knowledge, etc), while being based again on the cognitive state of the learner and thus making it possible to the tutor to take, if it is necessary, the suitable teaching actions. The role of the action layer is to define, even if necessary, a whole of tasks that allows to remedy at the observed emotional state; in order to bring the learner in a state more propitious to the knowledge's assimilation. (figure.2). For this reason a collaborative reciprocal strategy in ITS can gain advantage from "mirroring" and then assessing emotions in P2P Learning situations.

### 5.1.3 The emotional agents

Integrated into a learning environment, aim at capturing and managing the emotions expressed by the learner during a learning session. They currently capture emotions only through facial expression analysis and they are in charge of learner emotion detection. They recognised the learner emotional state by capturing emotions that he or she expressed during learning activities. (Nkambou 2006). For making the affective communication between an EECA and a learner, they need to be able to identify the other's emotion state through the other's expression and we call this task emotion identification established by the emotional agents. Extracting and validating emotional cues through analysis of users' facial expressions is with high importance for improving the level of interaction in man machine communication systems. Extraction of appropriate facial features and consequent recognition of the user's emotional state is the topic of these emotional agents.

- Analysis of facial expression. The analysis of the facial expressions by the emotional agents is generally done according to the following stages: detection of the face, the automatic extraction of contours of the permanent features of the face: the eyes, the eyebrows, and the lips. Extracted contours being sufficiently realistic, we then use them in a system of recognition of the six universal emotions on the face.
- Recognition and interpretation of facial expression

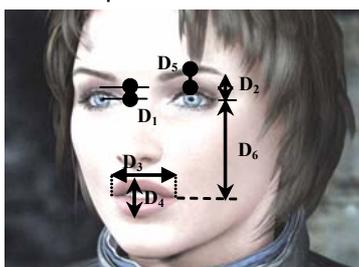


Figure 3: Definition of the distances  $D_i$

The Classification is based on the analysis of the distances computed on face's skeletons. The distances considered make it possible to develop an expert system (for classification), which is compatible with the description MPEG-4 of the six universal emotions. Contours of the eyes, the eyebrows and the mouth are extracted automatically by using the algorithms described in (NEJI, Ben Ammar and Alimi 2004, BEN AMMAR, Neji and Alimi 2005). The segmentation leads to obtain what we call skeleton of expression. Six distances were defined: D1: opening of the eye, D2: outdistance between the interior corner of the eye and the eyebrow, D3: opening of the mouth in width, D4: opening of the mouth in height, D5: outdistance between the eye and eyebrow and D6: outdistance between the corner of the mouth and the external corner of the eye (cf Figure 3).

- Joy: {D4 increases}, {D3 decreases and D6 decreases}, {the other distances remain constant}
- Sadness: {D2 increases and D5 decreases}, {D1 decreases}, {the other distances remain constant}

- Anger: {D2 decreases}, {D1 increases}, {D4 either decrease D4 increases}
- Fear: {D2 increases and D5 increases but more that D2}
- Disgust: {D3 increases AND D4 increases}, {the other distances remain constant}
- Surprised: {D2 increases}, {D1 increases}, {D4 increase}, {the other distances remain constant}

The table 1 gives a scripts of evolution of the distance  $D_i$  for the six emotions ( $\uparrow$  means increase,  $\downarrow$  means decrease and " = " translates the absence of evolution). Notice that for the fear, we do not make any hypothesis on the evolution of D1 because we do not know how to translate the condition {eyes are contracted and in state of alert}.

**Table 1:**  $D_i$  evolution for every emotion

	D1	D2	D3	D4	D5	D6
Joy	=	=	$\uparrow$	$\uparrow$	=	$\downarrow$
Sadness	$\downarrow$	$\uparrow$	=	=	$\downarrow$	=
Anger	$\uparrow$	$\downarrow$	=	$\uparrow$ or	=	=
Fear	?	$\uparrow$	=	=	$\uparrow$	=
Disgust	=	=	$\uparrow$	$\uparrow$	=	=
Surprise	$\uparrow$	$\uparrow$	=	$\uparrow$	=	=

The classification of an emotion is based on the temporal evolution of the information contained in the "skeleton" resulting from this stage of segmentation (temporal evolution of six characteristic distances). For example, joy and disgust differ by the evolution of the distance D6. One notes that emotions (joy and surprise) differ by the evolution of distances D1, D2, D3 and D6. This permits a distinction between these two emotions.

#### 5.1.4 Curriculum agent

Saves the history of progression of the learner in the exercise. While analysing the profile of the learner, this agent proposes sessions of activities subsequently to apply. The agent curriculum keeps the trace of:

- The evolution of the interacting system with learner
- The history of progression of learner in the exercise.
- The agent curriculum carries out the following operations:
- To manage the model of learner throughout the training.
- To initialise the session of training by communicating the exercise to the learners according to their courses.
- To be the person in charge for the individualisation of the training.
- To carry out the update of the history of the learner model.
- To record in the base of errors the gaps met (errors made by learner) to help the tutor to be useful itself of this base to direct its interventions.

#### 5.1.5 Tutoring agent

The tutor's role is:

- To ensure the follow-up of the training of each learner.
- To support learners in their activities.
- To support the human relations and the contacts between learners.
- To seek to reinforce the intrinsic motivation of learner through its own implication from guide who shares the same objective. These interventions aim at the engagement and the persistence of learner in the realisation from its training.
- To explain the method of training and to help to exceed the encountered difficulties.
- To help the learner how he can evaluate his way, his needs, his difficulties, his rhythm and his preferences.

## 5.2 Implementation

### 5.2.1 The Interaction among agents

The interaction among human agents is not restricted to the proposed computational model. On the contrary, the computational interaction among the artificial agents aims at contributing even more for the communication and the exchange among the human agents. The interaction will be one of the main objectives of this model, because the proposal is about a model of collaborative learning. The several interaction forms involved in the model are interaction among artificial agents; interaction among artificial and human agents, and interaction among human agents. In respect to communication among the human agents, the system offers tools (synchronous or asynchronous) when physical presence is not possible (for example, in the case of virtual classes).

### 5.2.2 The organisational model

Our organisational model is based on the Agent, Group and Role Meta Model (AGR for short) (Ferber and Gutknecht 2003). This Meta Model is one of the frameworks proposed to define the organisational dimension of a multi-agent system, and it is well appropriate to the e-learning context. According to this model, the organisation of the system is defined as a set of related groups, agents, and roles. There are several reasons, which justify the importance of this Meta Model. The main reasons are the following: (i) it is possible to construct secure systems using groups viewed as “black boxes” because what happens in a group cannot be seen from agents that do not belong to that group. (ii) it is possible to construct dynamically components of system when we view system as an organisation where agents are components. Adding a new group or playing a new role may be seen as a plug-in process where a component is integrated into a system. (iii) Semantic interoperability may be guaranteed using roles because a role describes the constraints (obligations, requirements and skills) that an agent will have to satisfy.

### 5.2.3 Implementation

We programmed agents used in the EMASPEL Framework (figure 4) with the MadKit (Ferber and Gutknecht 1998) Platform. MadKit is a modular and scalable multi-agents platform written in Java and built upon the AGR (Agent/Group/Role) organisational model: agents are situated in groups and play roles. MadKit allows high heterogeneity in agent architectures and communication languages and various customisations. In fact, MadKit does not enforce any consideration about the internal structure of agents, thus allowing to a developer to freely implement his own agent architecture. Communication among agents is implemented by a set of communication primitives, which is a subset of FIPA-ACL (FIPA 2004), extended with specific primitives. We used the JXTA Framework (Gong 2002) to build an open source p2p network.

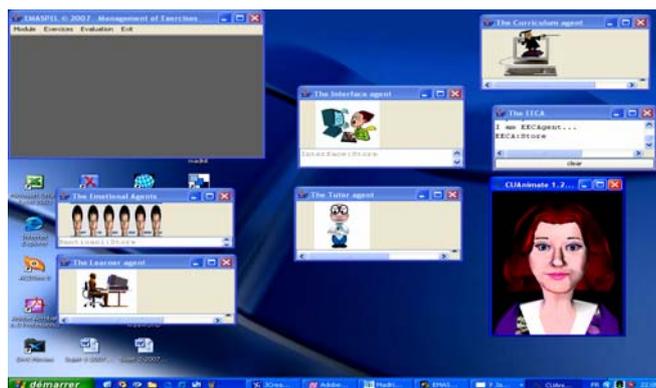


Figure 4 : EMASPEL Framework

## 6. Conclusions and further work

Emotion analysis may reveal if the learner feels “satisfaction”, “confidence”, “surprise”, “confusion”, or “frustration”. These states are more precise in an educational context and appropriate pedagogical actions can be taken in order to influence those emotions. Another important process is the diagnosis of the analysed emotional state. This process determines the possible causes which has led to this situation (success/failure in an exercise, difficulty of the tasks, lack of knowledge, incorrect command of the knowledge, etc.). This is done using the learner’s cognitive state and the history of his actions.

Showing emotions, empathy and understanding through facial expressions and body language is central to human interaction. More recently, emotions have also been linked closely with decision-making, problem solving and intelligence in general. We therefore argue that computer-based communication technologies ought to emulate this in some way. We have conducted an experimental study on visualisation and recognition of emotion in the human face and an animated face. The study used six "universal" facial expressions of emotion, as established by Ekman: happiness, surprise, anger, fear, sadness, disgust, together with the neutral expression. Results show that emotions can be visualised with a limited number of facial features, and build a potentially strong basis for communication in collaborative environments. To further establish the possible role emotions can play in collaborative environments, we are currently concentrating on real-time interaction. A group of people enters the virtual space and is assigned a task to complete.

The main objective of the experiment is to investigate how the perception of emotion affects individual and group experience in the virtual world. From the real world, we know that emotions of others influence us in our decisions and in our own emotional state. Emotions can motivate, encourage, can help us achieve things. But they can also change our mood to the negative, make us feel angry or sad when someone else feels that way. Emotions are contagious, and their contagious nature in the real world is potentially transferable and beneficial to the virtual world. The proposed framework mainly includes the peer-to-peer based network platform, for further work we would like to: Integrate the peer-to-peer based network platform into grid system. The newly emerged Peer-to-Peer (P2P) and grid computing will serve as the key driven forces to bring revolutionary impact on the future society. Standardise the e-learning materials: we will implement the SCORM (ADL 2004) specification to describe the educational resources in EMASPEL, which will provide the interoperability with other system as well as the reusability of learning materials.

## References

- ADL Technical Team, Sharable Content Object Reference Model (SCORM), 2004
- Ahn H, Picard RW (2005). Affective-cognitive learning and decision-making: a motivational reward framework for affective agents. In: The First International Conference on Affective Computing and Intelligent Interaction. 22–24, Beijing, China.
- Bailenson J, Beall A, Blasovich J, Raimundo M, Weishbush M (2000)« Intelligent agents who wear your face: User's reactions to the virtual self » Technical Report, Center for the Virtual Environment and Behaviours Department of Psychology, University of California, Santa Barbara.
- Ben Ammar M, M. Neji, G. Gouardères, (2006), Conversational Embodied Peer agents in affective E-learning, G. Rebolledo-Mendez, E. Martinez-Miron (Eds): Workshop on Motivational and Affective Issues in ITS. 8th International Conference on ITS 2006, pp 29-37.
- BEN AMMAR, M Mahmoud NEJI, ADEL.M Alimi (2005)“The integration of an emotional system in the Intelligent Tutoring System”, Computer Systems and Applications, 2005. The 3rd ACS/IEEE International Conference Page(s):145.
- Ben ammar, M. and Neji, M. (2006). Affective E-learning Framework. In T. Reeves and S. Yamashita (Eds.), Proceedings of World Conference on E-learning in Corporate, Government, Healthcare, and Higher Education 2006 (pp. 1595-1602). Chesapeake, VA: AACE.
- Bernd Schmidt, The Modelling of Human Behaviour; SCS Publication, Ghent, 2000;
- Biström J(2005), “Peer-to-Peer Networks as Collaborative Learning Environments”, Seminar on Internet working.
- Blomqvist, U. and Sjödin, C. (2006) ”From Peer Learning to P2P Learning – new life or obsolescence for the traditional learning institutions?” eChallenges 2006 Conference. Barcelona, Spain.
- Bruce B, Marc D, Yuri AI, (2002). Integrated learning for interactive synthetic characters. Proceedings of SIGGRAPH, , p. 417–426
- Burke R, Isla D, Downie M, Ivanov Y, Blumberg B. CreatureSmarts (2001): The art and architecture of a virtual brain. In: Proceedings of the Game Developers Conference, San Jose, CA, , p. 147–166.
- Chan, W, W.S. Wong. Literature Survey: Relevance Vector Machine for Face Detection and Face Model Feature Extraction. TU Delft, 2004.
- Coles G, (2004) Reading Lessons: The Debate over Literacy, Hill and Wang, New York.
- Conati, C and X. Zhou, (2002) ‘Modelling students’s emotions from cognitive appraisal in educational games’, in International Conference on ITS.
- Conati, C. Klawe, M. Socially (2000) Intelligent Agents to Improve the Effectiveness of Educational Games. In: Proceedings of AAAI Fall Symposium on Socially Intelligent Agents - The human in the loop. Available at <http://www.cs.ubc.ca/~conati/publications.html>.
- Cowie, R, E. Douglas-cowie, queen's university of belfast, uk, j. Taylor, King's College, UK, S. Ioannou, m. Wallace, S. Kollias, an intelligent system for facial emotion recognition, national technical university of athens, Greece. Icme 2005
- Darwin, C. (1872/1998). The Expression of the Emotions in Man and Animals (1872). New York: Philosophical Library. 3rd edn (1998) with Introduction. Afterword and Commentary by Paul Ekman: London: Harper Collins New York: Oxford University Press.

- de Jongh E, FED: An online facial expression dictionary as a first step in the creation of a complete nonverbal dictionary. TU Delft, 2002.
- DeCarolus, B, V. Carofiglio, M. Bilvi, and C. Pelachaud. 2002 APML, a mark-up language for believable behaviour generation. In Embodied conversational agents - let's specify and evaluate them!, Proceedings of the AAMAS'02 workshop, Bologna, Italy.
- DeCarolus, N, V. Carofiglio, and C. Pelachaud. (2002) From discourse plans to believable behaviour generation. In International Natural Language Generation Conference, New-York,.
- Ekman, P. Basic Emotions In T. Dalgleish and T. Power (Eds.) The Handbook of Cognition and Emotion Pp. 45-60. Sussex, U.K.: John Wiley and Sons, Ltd. (1999)
- Elegi (2004) [Online], Available: [www.elegi.org](http://www.elegi.org) [Juin 2004].
- Fabri M, Moore D, Hobbs, D (2004) Mediating the Expression of Emotion in Educational Collaborative Virtual Environments: An Experimental Study, in International Journal of Virtual Reality, Springer Verlag, London
- Ferber J and O. Gutknecht (1998) : Le méta modèle AGR : a meta-model for the analysis and design of organisations in multi-agent systems. Dans DEMAZEAU, Y., éditeur : 3rd International Conference on Multi-Agent Systems, pages 128–135, Paris. IEEE.
- Ferber J, O. Gutknecht and F. Michel (2003): From Agents to Organisations : An Organisational View of Multi-agent Systems. in P. GIORGINI, J. P. MÜLLER et J. ODELL, éditeurs: Agent-Oriented Software Engineering IV, 4th International Workshop, AOSE 2003, Melbourne, Australia, July 15, 2003, Revised Papers, volume 2935 de Lecture Notes in Computer Science (LNCS), pages 214–230. Springer-Verlag,.
- FIPA (2004) Agent Management Specifications [Online], Available: <http://www.fipa.org/specs/fipa00023/>
- Foster I, and C. Kesselman (1999), The Grid: Blueprint for a New Computing Infrastructure, Morgan Kaufmann.
- Frijda, N. H.. The emotions. Cambridge : Cambridge University Press. (1986)
- Gratch J, Marsella S. Tears and Fears (2001): modeling emotions and emotional behaviours in synthetic agents. In: Proceedings of the Fifth International Conference on Autonomous Agents, Montreal, Canada.
- Guy Gouardères, Emilie Conté, Saber Mansour, Liana Razmerita, (2005) « Ontology based user modeling for personalisation of grid learning services”, 1st International ELeGI Conference on Advanced Technology for Enhanced Learning Vico Equense (Naples), Italy.
- Hai Jin (2004), “APPLE: A Novel P2P based E-learning Environment”, 6th International Workshop on Distributed Computing (IWDC 2004), Indian Statistical Institute, Kolkata, India
- Lester J (1999), ‘Achieving affective impact: Visual emotive communication in lifelike pedagogical agents’, International Journal of Artificial Intelligence in Education, 10(34), 8278–291,.
- Lester, J.C., Towns, S.G. and FitzGerald, S.G., Achieving affective impact: Visual emotive communication in lifelike pedagogical agents, International Journal of AI in Education, 10 (3-4), pp. 278-291. (1999)
- Li Gong (2002). Project JXTA: A Technology Overview. Technical Report. Sun Microsystems, Inc.
- Liu G (2005). Design and implementation of a collaborative virtual learning system. Microcomputer Development;15(2):87–90 (in Chinese).
- Martinez-Miranda Juan, Arantza Aldea, Emotions in human and artificial intelligence; in Journal Computers in Human Behaviour 21- 323–341. (2005)
- NEJI M, Mohamed BEN AMMAR, ADEL.M Alimi (2004)“Emotion expression function in human computer interaction”, Medianet, Tozeur, Tunisia.
- Nkambou, R (2006) Towards Affective Intelligent Tutoring System, Workshop on Motivational and Affective Issues in ITS. 8th International Conference on ITS 2006, pp 5-12,
- Piaget J, (1989) Les relations entre l'intelligence et l'affectivité dans le développement de l'enfant, 75–95, Les Emotions, Paris.
- Picard RW (1997). Affective computing. Cambridge, MA: MIT Press;
- Prada R, Otero N, Vala A, Paiva (2004) A. BeLife: teaching greenhouse management using an agent based simulator. Agent Based Simulation Workshop—ABS.
- Prendinger, H., Ishisuka, M. (eds): Life-Like Characters, Tools, Affective Functions, and Applications. Cognitive Technologies Series, Springer, Berlin Heidelberg (2004)
- Rao, A.S, BDI-Agents: From Theory to Practice; in: Proceedings of the First International Conference on Multi-Agents-Systems (ICMAS); San Francisco, (1995);
- Robert A. and Freitas Jr. Analog Science Fiction/Science Fact, Vol. 104, April 1984, pp 41-53
- Samuel Alexander, Abdolhossein Sarrafzadeh and Stephen Hill, Easy with Eve: A Functional Affective Tutoring System, Workshop on Motivational and Affective Issues in ITS. 8th International Conference on ITS 2006, pp 5-12, 2006
- Silveira, R.A.; Bica, F.; Viccari, R.M.(2000) JADE - Java Agents for Distance Education Framework. In: Proceedings of the Third Iberoamerican Workshop on Distributed Artificial Intelligence and Multi-Agent Systems. Ivaes,L.O.,Bazan, A.L.(Eds.), Brazil. pp.112-122.
- Tubbs, (1994). “The non verbal message. In Human communication” (7th edition, chap.4) Singapore McGraw-Hill
- Vassileva, J.; Deters, R.; Greer, J. McCalla, G.; Bull, S.; Kettel, L.(2001) Lessons from Deploying I-Help. In: Proceedings of the Workshop Multi-Agent Architectures for Distributed Learning Environments, AIED, San Antonio, TX, USA. pp. 3-11.
- VHML, VHML. Available:<http://www.vhml.org>, [August 5, 2001]. 2001.
- W3C (2002) The World Wide Web Consortium, [Online], Available: [www.w3c.org](http://www.w3c.org) [2002, March 22].
- Zapata-Rivera, J.D.; Greer, J. (2001) SMODEL Server: Learner Modelling in Distributed Multi-Agent Tutoring Systems. In: Artificial Intelligence in Education. J.D.Moore, C.L.Redfield and W.L.Johnson (Eds.). IOS Press,. pp.446-455.