Agent-based Collaborative Affective E-learning System

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ABSTRACT
In order to promote a more dynamic and flexible communication between the learner and the system, we integrate five kinds of adaptive agents in emotional framework. We focus on human facial characteristics to develop general-purpose agents that can recognize human emotion and create emotional framework with the implications of peer-to-peer technology. Emotions play an important role in cognitive processes and specially in learning tasks. Online learning is no exception. Detecting a learner's emotional reaction for a given situation is an essential element for every e-learning system. In this paper a system for identifying facial expressions by using facial features is presented, it can recognizes 6 basic emotional expressions (happiness, sadness, surprise, fear, anger, and disgust).

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

1. INTRODUCTION
On the one hand, the affective states are one of the most important factors in communication, and for virtual environments (VEs) to be truly realistic, it cannot ignore such factors. A core function of VEs is using to facilitate communication between entities in their environment and entities human users or agents. It is often assumed that the ultimate objective of communication within VEs is to model communication between humans in the physical world. In order to achieve these objective communication capabilities within the virtual world, they must not be limited to the simple exchange of information. Everyday, human communication involves a level of affective communication which is absent from many VEs. If VEs are to be truly representative of the real world they aim to model, they must both (i) facilitate the communication of affect, and (ii) agents situated in the environment must react in a way that respects the affective context in which they find themselves. Sloman argues, quite properly, that voluntary or even involuntary emotional responses are generally very broad and we are not able to perceive the underlying condition, which led to the affective state. On the other hand, current forms of electronic communication generally lose the emotional context, along with the ability to express emotional states in the ways experienced in face-to-face conversations. Social psychologists assert that more than 65% of the information exchanged during a person-to-person conversation takes place in the non-verbal band. [11] In a learning environment, for example, the ability to show emotion, empathy, and understanding through facial expressions and body language is central to ensuring the quality of tutor-learner interaction.[4]Recent findings in psychology and neurology suggest that emotions are also an important factor in decision-making, problem solving, cognition, and intelligence in general.[12] Collaborative Virtual Environments (CVEs) in this paper, aim at reintroducing emotional and social context to distance communication while offering a stimulating and integrated framework for 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 used in a distance Elearning context. However, little is known about how or indeed whether, emotions can effectively be transmitted through the medium of CVE. Given this, an avatar head model with limited but human-like expressive abilities was built, designed to enrich CVE communication. [6] This is the objective for introducing the Emotional Embodied Conversational Agent (EECA) [13]

We argue that the used peer-to-peer network in combination with collaborative learning is the best solution to the Elearning environments. Peer-to-peer (p2p) technology is often suggested as a better solution because the architectures of peer-to-peer networks and collaborative learning are similar. [10]

2. PROBLEM CONTEXT
This paper explores Collaborative Virtual Environments (CVEs) as an alternative communication technology potentially allowing interlocutors to express themselves emotionally in an efficient and effective way. Potential applications for such CVE systems are all areas where people cannot come together physically, but wish to discuss or collaborate on certain matters, for example in distance learning, based on the affective communication. Moreover, we will explore how the agents can communicate emotions. To investigate how emotions can efficiently and effectively be visualized in a CVE, an animated virtual head (EECA) was designed to express, the six universal emotions (happiness, sadness, anger, fear, surprise and disgust).

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There are several new elements to this research. Firstly, although CVEs as a technology have been available for more than a decade now, 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 CVE 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 Elearning 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 (MAS), together with technologies of networking and telecommunications, bring powerful resources to develop Elearning 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 Elearning), based on a multi-agents architectures.[1]

3. RELATED WORKS

Several projects implement learning systems based on multi-agents architectures. Some of them work on a generic platform of agents. [2,6] For example, JTS is a web-based environment for learning Java language [26] 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. [25] Moreover, interesting results have been achieved by pedagogical agents regarding the learner motivation and companion agents acting sometimes as mediators of the learning process. Finally, tutor agents are usually related to learner modelling and didactic decision taking. Recently, researchers in computer science have acknowledged that models of emotions presented by psychologist are very useful to variety of computerized applications such as: personal assistance application, intelligent interfaces, intelligent tutoring systems, etc. Recent years have seen a growing body of literature that aims to integrate emotions to architectures of autonomous agents. Reilly and Bates, within the OZ project, create an environment for simulating believable emotional and social agents; each agent has a set of goals trying to achieve. Based on the event-appraisal model of Ortony and al., these agents are able to express emotions after evaluating the impact of an event on the agent's goals.[20]

4. COLLABORATIVE AFFECTIVE ELEARNING SYSTEMS

Psychologists and pedagogues have pointed out the way that emotions affect learning. According to Piaget [9], it is incontestable that the affectivity has an accelerating or perturbing role in learning. A good part of the learners that are weak in mathematics, fails due to an affective blockage. Coles [9] 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) and to the learner's emotion recognition, pointing out the richness presented in affective interaction between learner and tutor.

We argue that socially appropriate affective behaviors 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 to collaborative learning, learning takes place in the interactions between the learners, the kind of intelligence these approaches are primarily concerned with is knowledge-based, goal-oriented, and rational, and thus social intelligence might only be utilized as a side effect.

Affect in our framework is considered from various angles and on different levels:

– The emotional state of the learner will be modeled by an event appraisal system.

– The emotional state of the tutor is modeled 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 (sympathizing or non-sympathizing feedback, motivation, explanation, steering, etcetera).

Collaborative interactions enable the design, critique management and distribution of knowledge within the community by its members. Learning, in this framework, focuses on developing meta-cognitive skills to facilitate reflection, internalisation and self-directed knowledge discovery. Virtual learning communities are information technology based cyberspaces in which individual and collaborative learning is implemented by groups of geographically dispersed learners and providers of knowledge to accomplish their goals of learning.

Cooperative learning systems, called also social learning systems, adopt a constructive approach using the computer more as a partner than as a tutor. Multiple agents that are either computer simulated or real human beings can work on the same computer or share a computer network. In some instances, e-learning can foster a greater degree of communication and closeness among learners and tutors than face-to-face learning. The e-learning community is increasingly recognizing the importance of learners learned from their study peers. When peers come together in a learning context, they form an Online Learning Community. Tu & Corry (2002) [23] summarize Online Learning Communities as having four basic components:

- Community - occurring with social interaction about common interests
- Learning - non-formal; the attainment of knowledge, skills, and attitudes through social interaction with peers
- Network - defined as a pattern of communications and relationships
- Technology - either a synchronous or asynchronous platform

5. 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) [5] concerning a nonverbal dictionary. Before we define our research question and objectives, we summarize 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 labeled 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 [18], 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) [24].

6. 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 behaviors. 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 behavior such as approach, avoidance, attack, or feeding, depending on emotional intensity, learned behavioral patterns, and other motivations simultaneously present). In this view emotion is an internal state, not a behavior or a perception of external reality. [21]

The Emotion Markup Language (EML) [15] 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 realized 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.

6.1 Attributes of EML

EML is an XML [27] (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>)

6.2 Update of EML elements

In our framework we propose is the EmotionStyle language, designed to define style in terms of multimodal behavior, and make an EECA display, and recognize 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 describe more carefully the facial expression. Thus, 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}=initialized

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.

6.3 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?

7. EMASPEL FRAMEWORK

7.1 Architecture

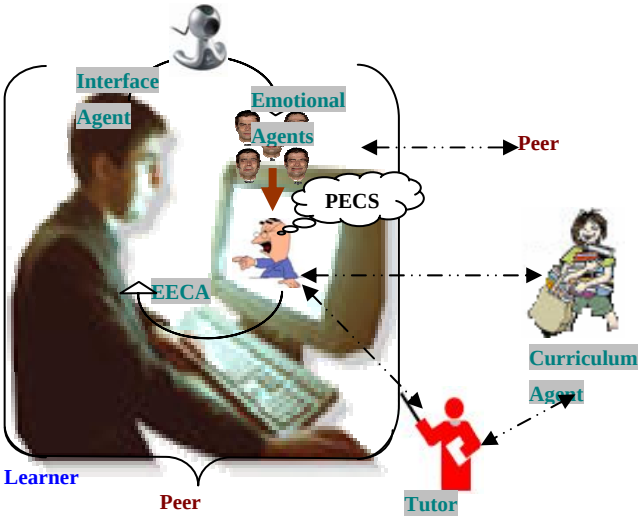

Figure 1. EMASPEL architecture

The architecture of a peer in our P2P Elearning system is the following (figure 1). In order to promote a more dynamic and flexible communication between the learner and the system, we integrate five kinds of agent:

7.1.1 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.

The agent interfacing is a merely reactive agent.

7.1.2 The EEC Agent

Emotional Embodied Conversational Agents (EECAs) are a powerful user interface paradigm, aiming at transferring the inherent richness of human-human interaction to human-computer interaction. ECAs are virtual embodied representations of humans that communicate multimodally with the user (or other agents) through facial expression.

Our work aims at creating one EECA [7,3]which is able to:

- To interact with the learner: not only communicating information in a general deterministic way but also exhibiting a consistent behavior with his personality and with contextual environment factors.
- Expresses emotions: in reaction to the learner's actions.

The action of the EECA includes processes that take decision about relevant pedagogical actions, which can control the observed emotional state, in order to place the learner in a better state.

Our goal is to create a model to generate and visualize emotions on embodied conversational agent. One ascertains that an agent exhibit an emotional behavior was treated like human and that the interpersonal distance between the user and the avatar was reduced when the glance or the smile was maintained between the two. In addition, 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 behavior of the individual. The body answer initially in a programmed way of this change constitutes 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 is built on Fridja model.

7.1.3 The emotional agents

The emotional agents have been successfully integrated in a learning environment and aims 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 recognized the learner emotional state by capturing emotions he or she expressed during learning activities.[19] 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 of 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 that can be robust to facial expression variations among different users is the topic of these emotional agents.

7.1.3.1 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.

7.1.3.2 Recognition and interpretation of facial expression

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 [14,16]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 2).

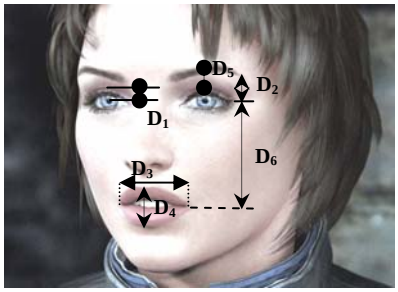

Figure 2. Definition of the distances D_i

The table 1 gives a scripts of evolution of the distances D_i for the six emotions (↑means increase,↓ 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}.

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.

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}

Table 1: Di evolution for every emotion

	D1	D2	D3	D4	D5	D6
Joy	=	=	↑	↑	=	↓
Sadness	↓	↑	=	=	↓	=
Anger	↑	↓	=	↑or↓	=	=
Fear	?	↑	=	=	↑	=
Disgust	=	=	↑	↑	=	=
Surprise	↑	↑	=	↑	=	=

7.1.4 Curriculum Agent

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 initialize the session of training by communicating the exercise to the learners according to their courses.
- to be the person in charge for the individualization 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.

7.1.5 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 realization from its training.
- to explain the method of training and to help to exceed the encountered difficulties.
- to help the learner how it to evaluate his way, its needs, its difficulties, its rhythm and its preferences.

8. CONCLUSIONS

The emotion analysis may reveal if the learner feels “satisfaction”, “confidence”, “surprise”, “confusion”, or “frustration”. These states are more precise in educational context and appropriated pedagogical actions can be taken in order to influence those emotions. Another important process is the diagnosis of the analyzed 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 in this paper using the learner’s cognitive state and the historic of his actions. Although, 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.

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