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Emotional Multi-Agents System for Peer to peer E-Learning (*EMASPEL*)

Mohamed BEN AMMAR [1], Mahmoud NEJI [2], ADEL.M ALIMI [3]
[1,2,3] **RE**search **G**roup on **I**ntelligent **M**achines (**REGIM**)
University of Sfax, ENIS
P.O.Box. W-3038 – Sfax – Tunisia

Abstract: - The extraction and recognition of facial expression has been the topic of various researches subject to enable smooth interaction between computer and their users. In this way, computers in the future will be able to offer advice in response to the mood of the users. Humans tend to attribute human qualities to computers. It is expected that people, when using their natural communicational skills, can perform cognitive tasks with computers in a more enjoyable and effective way. For these reasons human-like embodied conversational agents (ECAs) as components of user interfaces have received a lot of attention. In this article, we propose a collective and collaborating e-learning system on the peer to peer network, using the PECS model (Physics, Emotion, Cognition, and Social status) integrated on the Emotional Embodied Conversational Agent (EECA). In order to handle difficulties of learner, to guarantee a more available support at distance and to carry over relevant support due to the learner's emotional state. We describe an affective dialogs with an EECA. We present an update of Emotional Markup Language (EML).
Key-Words: facial expression, e-learning, EECA, PECS, EML

1 Introduction

The traditional e-learning is usually used in lot of situations and contexts, like the classroom, the laboratory. So far, these last years, these new shapes of education knew pressures to be accessible to everyone. At the same time, trying to reduce their costs and support as well as improve the quality of achieved trainings. In this context, a peer to peer conversation (Nguyen, 2004) is proposed: development of the e-learning that associates a traditional vision to a wider and omnipresent vision. The survey presented in this article consists to explore the possibility of using a training system at distance based on the P2P network with the assist of Emotional Embodied Conversational Agent (EECA) (Sansonnet, 2004) based on the PECS model (Schmidt, 2000). EECA allows giving efficient supports to learners and automatically distributing some relevant resources to the different learner's profiles and needs in chorus with the learner's emotional aspects. (Chaffar, 2004) (Laporte, 2004)

In this article, we pay particular attention to facial expressions of emotions. Facial expressions are characterized not only by the signals of the expression itself but also by temporal parameters: time of appearance and disappearance of an expression etc. In Section 7 we describe these various parameters. Facial expressions occur continuously during speech, both complementing and reinforcing the information delivered in the audio channel. For example, the raising of eyebrows may complement the corresponding speech by signaling surprise, or may punctuate an emphatic element of the speech.

Several main tasks are to be considered in this article:

- Recognize and interpret the learner's emotional state: Acquisition of the face's image with a numeric camera placed on the computer's screen to analyze eventual facial expressions which may identify learner's emotions in a training situation. Expressions taken as entry are type "happiness", "fear ", "disgust", "sadness", "anger", "surprise". The interpretation finds out if learner feels "satisfaction", "confidence", "surprise", "confusion" or "frustration ". Therefore, the tutor can undertake required actions to improve the quality of the training. The achievement or blockage of a goal will give rise to different emotions. We will feel happy if the goal we give importance to is attained. On the other hand if an event has as consequences to block our goal so it becomes difficult to reach it, we might get angry.
- Popularize training's services at distance: representation of every learner (Ai) as a peer. Peers have the fundamental role, which is the coordination of different activities in the distributed training.
- Improve training's resources: give consideration to the advantages relating to researching and sharing resources (documents, courses, support,...) in a P2P network. This drives us to an efficient development of such functionalities, so offers maximum support to learners during their trainings.
- Services: possibility to maintain learner's motivations while receiving immediate support.
- Individuating the student learning objectives and evaluating his competence gaps.
- Controlling the student improvements and (re)adapting and integrating the courseware content and presentation structure.
- Creating a bridge between single user learning objectives and general organization learning objectives.

All those tasks are currently carried out “manually”. The idea that we propose here is trying to automatize, as far as possible, those activities by designing suitable Multi-Agent environments. Agents’ technologies seem to be well suited to carry out the main activities listed above. In fact, those activities require communications between distributed components, sensing and monitoring of the environment and autonomous operations. Agents have the ability to reason, they can easily perform sequences of complex operations based on messages they receive, their own internal beliefs and their overall goals and objectives. Furthermore an e-learning agent’s platform is expected to be proactive, interactive, adaptive and cognitive.

2 Architecture of EMASPEL

We call our system **E**motional **M**ulti-**A**gents **S**ystem for **P**eer to peer **E**-**L**earning (EMASPEL). The system we propose includes five kinds of agents:

- **Interface Agent :**

- Transmit the facial information coming from learner to the other agents of the multi-agents system (MAS).
- Serves link between the MAS and the other components of the learning environment.
- Assign the achieved actions and information communicated by learner, to agents Curriculum, EECA and the other agents of the MAS.
- Transmit interventions (helps, assist ...) from the EECA to the learner.

The agent interfacing is a merely reactive agent.

- **Emotional Agents:**

Their roles present the detection of the face, extraction of its features to recognize the emotion representing in the image provided by the interface agent.

- **Curriculum Agent :**

The curriculum is the whole of experiences of teaching and training planned and offered in view to reach the predetermined educational goals. It is responsible of the management of the learner model and its evolution in courses (management of exercises). Model (or profile) of the learner saves the historic of the course of the learner (the number of exercise achieved, the committed mistakes with their emotions ...) The agent Curriculum saves the trace of the evolution of the system in interaction with the learner, the trace constituting the historic of progression of the learner in the exercise. While analyzing the profile of the learner, this agent proposes sessions of activities subsequently to apply.

The role of agent curriculum summarizes in the following points:

- It manages the model of all learner in the learning process;
- It initializes the session of learning, while communicating the exercise of the day to the learners.

- **Tutor Agent :**

The functions of the tutor are the following:

- Corrective: correct the errors (help the learner, eliminate the assimilated information)
- Elaborative: complete the missing information.
- Strategic: control the global strategy of interaction.
- Diagnostic: check the model of the learner by choosing an action for clarifying.
- Predictive: simulate the former to plan his actions.
- Evaluative: evaluate the performances of the learner.

Follow step to step the learner in his process of problem resolution and intervenes when he makes a mistake

- Give feedbacks and directed help.
- Do some activities like giving explanations or advice.

- **EEC Agent:**

Interest of EECA

Our objective is to produce an emotional visual entity be in charge by several software's, able at the same time to enclose, evaluate and react with the effort of the learner, the EECA have three main features permitting them to answer to this new need:

They are agents:

Representation and interpretation on the user: profile, intentions, emotions,

Representation and interpretation on the system's structure and the functioning.

They are interactive:

They allow a dynamic concern, even immediate, of learner's difficulties,

They accompany learner all along his trail (task, lesson, …)

They aim the natural interaction:

They are conversational, according to several modalities (movements, word, expressions,…): this intend to establish a positive psychological relation between the learner and the system: relation of confidence, relation of friendship, relation of faithfulness,…

They are animated: the efficient appearance that may change according to several types, supply to have more accessible and practical applications.

Role of EECA

In our system, the EECA can play three main roles:

Assistants: they meet learners and help them to understand and use the structure as well as the functioning of applications and computer services.

Partners of actors in the virtual environments

Need of tutoring: the relation with learner can become even stronger when it's about training him for a task or teaching or learning some knowledge

Behaviour of EECA

Among all behaviours that can be present, we can mention:

Converse: it concerns the management of the dialogue between the learner and the system.

Context: it concerns agent appropriate to be able to express an advanced representation of the situation, which include some static (system, task) and dynamic (learning, progress of the task, dialogue's state) aspects. in particular, it is basic to concept the EECA's perception about the learner.

Accompany: it's the agent capacity to cooperate and help learner in the provided task.

Appearance: realism; +/- humanism;

Intensity: +/- theatrical; +/- discreet (a virtual agent must replicate non verbal signals, generally moderate, of a human agent).

3 Communication in the group

3.1 Principle of communication in the group while basing on the emotion

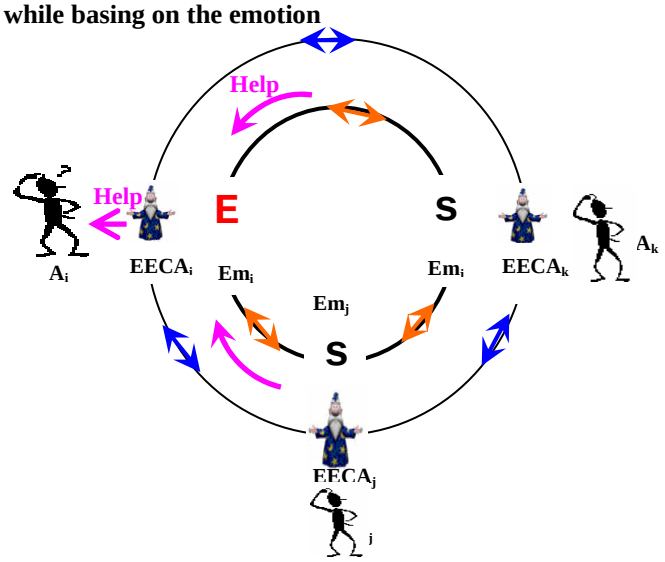

Figure 1: Propagation of the emotion (Emi) and assistance from learners

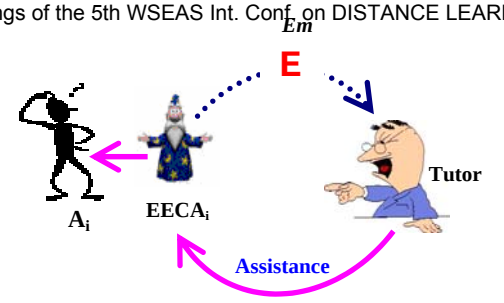

Figure 2: Propagation of the emotion (Emi) and assistance from Tutor

The diffusion of the emotion of ambiguousness or hesitation of a learner in the group lasting a session of learning at distance triggers the assistance from the tutor or from the others learners without losing him the concentration, incentive and the interesting. All this procedure takes place in real time while basing on a request messenger of QBE type (Query By Emotion) triggered of an automatic way following a change of state Ai.

Below one will explain the two manners of intervention on behalf of the tutor and the learners what proves our choice of architecture P2P:

Then learners: After detection and recognition of the corresponding facial expression (Emi) of learner (Ai) in the instant (ti) by the emotional agents, the identified emotion will be sent to the EECAi that propagates it to the different other EECA under the form of a universal emotional message: angry, fear, sadness or surprise. In addition, it contains the met difficulty. If a learner can assist him, he formulates his message of help and the send it with his EECA.(figure 1)

Then tutor: The tutor intervenes in the case where the emotion in question correlates to a difficulty met by most learners. In this context -under the management of agent curriculum- he must rephrase question or provide other explanations. (figure 2)

In the two presented above cases he exists an update of the profile of learner: the progress of the exercise (points of gaps) and the corresponding emotion in the goal to draw his emotional and scientific process.

3.2 Types of communication

Affective states produce changes in active beliefs, in goal activation and priority and in the reasoning skills; they consequently influence learning, decision making and memory. Simulating dialogues in domains in which affect plays a relevant role requires modeling these dynamic phenomena and building agents that are able to show a reactive behaviour during the dialogue, as far the situation evolves. To this aim, models of emotion activation have to be built and connected to the reactive component of the dialog planner. Emotions must drive reasoning behind the dialog and regulate it. If the dialogue occurs between the user and an Embodied Conversational Agent (ECA), the influence of emotional factors must also be visible in its 'body': this requires implementing the agent's ability to express emotions through face.

There is two types of communication (verbal and non verbal). Our interest is focused on the non verbal that transmits non linguistic messages (emotions). Emotions have the chief role in oral communication as well as in non verbal one. Their perception being multimodal. In a cognitive activity as the training, the communication is a primordial aspect and her quality can influence the training. So, the relevance of training implies, in addition to intellectual aspects, socio-emotional one. (Pesty, 2003) (Bisognin, 2004) According to Mehrabian, 93% of the social significance in the face-to-face communication are given through non verbal channels. For Birtdwhistell (Moss, 94), it is 65%. The non verbal messages can replace, emphasize or either contradict a verbal message. Thus, a non verbal message that replaces a verbal message is often easy to interpret. Besides, when a non verbal message reinforces a verbal one, the meaning is quickly and easily transmitted, with a higher understanding (Spielmann, 2000). The human face can easily indicate the boredom, the surprise, the affection, the disapproval. Of this fact, the facial signals are the most important sources of non verbal communication. Some statistical analyses bring to the following findings: eyebrows half lift up indicate the worry, only one eyebrow lift up means skepticism, eyes half closed : the boredom, eyes closed : the sleep, the up tilted mouth: the joy, the down-tilted mouth : the sadness.

Darwin found that most of the expressive actions in the human beings are instinctive and not acquired behaviours, what makes them universal. It is suggested that 2 separated communication's processes exist: a spontaneous process based on the emotional states / motivational affective interactions AND a symbolic process that involve some intentional messages.

3.3. Emotional concept ontology

In our system the emotional ontology, cover the major role that helps the EECA 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). The training of the emotional concepts for this ontology is done by dynamic manner. Facing a situation of uncertainty, we find out that it is about such an emotion after clarification and explanation. Then we add it to the existing ontology by a dynamic way.

4 The peer to peer e-learning

4.1. Architecture

The P2P is a concept of a communication on a network like the Internet in which a node can be a server or a client. That's allows to share and to benefit all the resources and the available services in the system. (Guillaume, 2002)

Our P2P network is composed of two parts:

Central part: Super node (tutor) and the shared information.

Decentralized part: Peer (learner) and the demand of information from the super node;

Therefore it is a direct communication between learners. The P2P network comprises several advantages like the resources sharing, the collaboration and the parallel computations. (Figure 3)

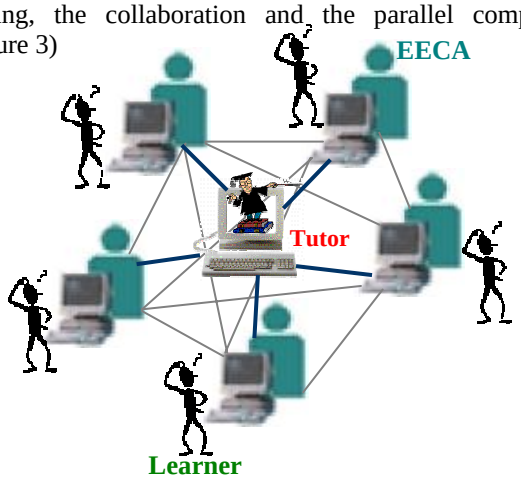

Figure 3: P2P – Arch. Centralized / Decentralized

4.2. Using Peer-to-Peer for E-Learning

Currently, peer-to-peer computing and e-learning are being combined and used by businesses, academic institutions, and by individuals. For example, businesses are conducting new-hire orientation via their intranets, and new-hires can interact with each other during the training. Students can do research together or view draft documents and mark-ups real time, and then electronically submit their final project to their teacher for grading. Individuals are sharing their knowledge and experiences with others through chat rooms and on-line support groups. The prospects for e-learning in formal or informal virtual settings are tremendous and as long as people want to share information, there is an opportunity to learn. Most experts in the peer-to-peer and e-learning industries agree that there is a great deal of hype and many companies are at the trial stage of bringing these two areas together to produce effective results. Peer-to peer e-learning involve a change of paradigm or a change in how people deal with knowledge and information. Because it's a paradigm change, it is uncomfortable and the outcome is somewhat unpredictable. Peer learning is a powerful, self-directed tool to help motivated individuals continue their educational and professional development. Peer learning groups offer an excellent outlet for busy leaders to not only gain critical skills, but also find the support and encouragement necessary to assist them as their organizations mature.

4.3. Peer architecture

The architecture of a peer in our P2P e-learning system is the following (figure 4):

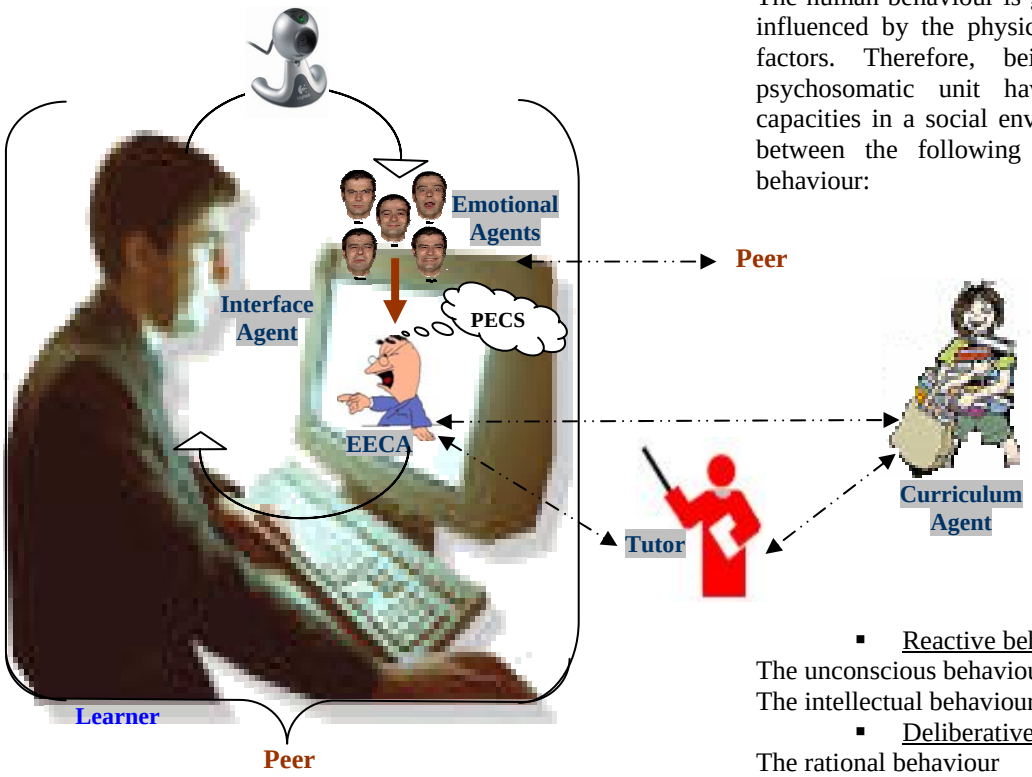

Figure 4: Peer – Architecture

Over the past few years, peer-to-peer (P2P) networks have revolutionized the way we effectively exploit and share distributed resources. In contrast to the traditional client-server architecture, P2P systems are application level, collaborative systems where agents work together to perform certain tasks; thus multi-agent system technology seems very relevant for implementing these types of systems.

4.4 Advantages of collaborative and cooperative learning

Doesn't base on the individual performances but on the optimization of interactions between members. In the heterogeneous teams, team's members must be not only capable to accomplish their own functions, but also to remain in cohesion with all the team. Decision will be collective, efficient and fast while basing on the shared mental model. Learner can play the tutor's role and it unloads this last to constantly supervise interactions between team's members.

5 The PECS reference model

PECS is defined by: Physical conditions, Emotional state, Cognitive capabilities and Social status that aim to replace the BDI architecture (Belief, Desire, and Intention) (Rao, 95). The BDI architecture conceives the human beings as constructors of the rational decision. This architecture is useful to a limited degree. By restriction to factors of belief, desire and intention, it is not merely suitable for real systems where the human factors have important role.

The PECS model is a universal model of reference for the simulation of the human behaviour in a social environment. The human behaviour is greatly complex in its structure. It is influenced by the physical, emotional, cognitive and social factors. Therefore, being human is discerned as a psychosomatic unit having some cognitive and living capacities in a social environment. It is useful to distinguish between the following forms of control of the human behaviour:

- Reactive behaviour

The unconscious behaviour.
The intellectual behaviour.

- Deliberative behaviour

The rational behaviour
The reflective behaviour

The reference model that is supposed to model the human beings in his whole must provide an architecture modeling all these forms, if it's possible. The agent's world for the PECS reference model consists on these fundamental components:

The environment: the component environment is used for modeling the external events that are important for the agent's behaviour and actions.
Connectives: The most essential aspect of multi-agents system is communication. Thus, agents must have the possibility to communicate between them.
Agents: The PECS reference model seeks a conception structure of a multi-agents system with a special objective, which is the human interaction with agents. It is possible, with PECS, to make several dynamic models agents based on physics, emotion, cognitive, social factors and their interactions. More particularly, the opportunity to specify these three controls modes of the behaviour: reactive behaviour, deliberative behaviour and reflective behaviour.
We are going to integrate this model in the EECA to give back the interaction learner/agent more natural and more human.

6 Classification and interpretation of the emotion

The norm MPEG-4 (Tekalp, 1999) gives a description of transformations undertaken by every feature of the face during the production of each of six universal emotions. This description is the following.
In order to translate digitally all these descriptions, we can rely on certain particular distances on each skeleton: figure 5 describes all the distances Di considered. Each distance Di was normalized with its value on the face when no emotion is presented. D2 and D7 give a measure of the distance between the eyes and the mouth. D3 and D4 measure the opening degree of the mouth. D1 measures the opening degree of the eyes.

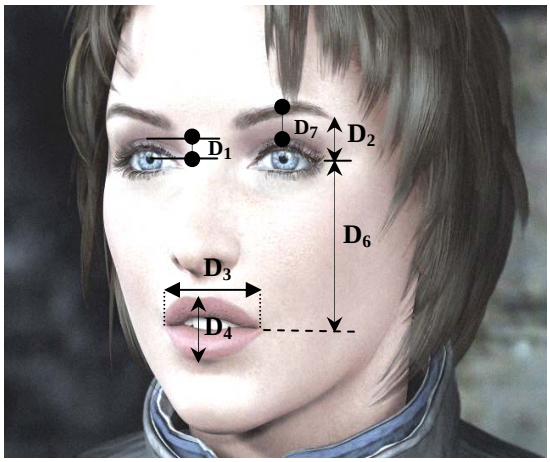

Figure 5: Definition of the distances D_i

7 Update of Emotional Markup Language (EML)

The Emotion Markup Language (VHML, 2001) (EML) defines the emotion elements that affect the VH (virtual human) regarding voice, face and body, these elements are therefore inherited by the speech and facial animation languages. The elements in EML provide the VH with looks and sounds for the specified emotion. The elements defined are the following:
<neutral> <anger> <happy> <sadness> <fear> <disgust> <surprise>
This language is conceived to interpret several aspects of human machine interaction with the facial animations, text produced in voice, body's animation, more hyperactive emotional representation and media information. It will use some existing standards further more it will describe new languages to adjust to new functionalities (Quoc, 2004).
We are going to use this language to surround all the emotional information between the different agents of the system (EECA, tutor,...). We have realized some modifications to the APML (Quoc, 2004) 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 (Moss, 94).

7.1. Attributes of EML

EML is an XML (W3C, 1997) (Extensible Markup Language) compliant text mark 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>)

7.2. Update of EML elements

The framework we propose is the EmotionStyle language, designed to define style in terms of multimodal behaviour 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 make to describe more carefully the facial expression. For each we have introduced some distances like D1 to D7.

< 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-D7}=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.

Example:

```
<neutral duration="4s" intensity="high" wait="2s" frequency="1st">
        <D2> initialized </D2>
        <D1> initialized </D1>
        <D4> initialized </D4>
        <D6> initialized </D6>
        <D7> initialized </D7>
        <D3> initialized </D3>
 </neutral>
```

<Angry>

Description: Facial expression. {D2 decrease}, {D1 increase}, {D4 either decrease 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.

Example:

```
<angry duration="4s" intensity="high" wait="2s" frequency="1st">
        <D2>decrease</D2>
        <D1>increase</D1>
        <D4>decrease</D4>
        <D6>constant </D6>
        <D7>constant </D7>
        <D3>constant </D3>
</angry>
```

< Disgusted >

Description: Facial expression. {D3 increase AND D4 increase}, {the other distances remain constants}
Attributes: Default EML attributes.
Properties: The superior lip get up and is stretched in asymmetrical manner, the eyelids are decontracted.

Example:

```
< disgusted duration="4s" intensity="high" wait="2s" frequency="1st">
                                <D3>increase</D3>
                                <D4>increase</D4>
                                <D1>constant</D1>
                                <D2>constant </D2>
                                <D6>constant </D6>
                                <D7>constant </D7>
</ disgusted >
```

< Surprised >

Description: Facial expression. {D2 increase}, {D1 increase}, {D4 increase}, {the other distances remain constants}
Attributes: Default EML attributes.
Properties: the eyelids getup, the mouth is opened.

Example:

```
< surprised duration="4s" intensity="high" wait="2s" frequency="1st">
                                <D2>increase</D2>
                                <D1>increase</D1>
                                <D4>increase</D4>
                                <D2>constant </D2>
                                <D6>constant </D6>
                                <D7>constant </D7>
</ surprised >
```

< Happy >

Description: Facial expression. {D4 increase}, {D3 decrease and D6 decrease}, {the other distances remain constants}
Attributes: Default EML attributes.
Properties: (the mouth is open), the commission are stretched bark to the ears) the eyelids are stretched. The eyelids getup, the mouth is opened.

Example:

```
< happy duration="4s" intensity="high" wait="2s" frequency="1st">
                                <D4>increase</D4>
                                <D3>decrease</D3>
                                <D6>decrease</D6>
                                <D2>constant </D2>
                                <D1>constant </D1>
                                <D7>constant </D7>
</ happy >
```

< Sadness >

Description: Facial expression. {D2 increase and D7 decrease}, {D1 decrease}, {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.

Example:

```
< sadness duration="4s" intensity="high" wait="2s" frequency="1st">
                                <D2>increase</D2>
                                <D7>decrease</D7>
                                <D1>decrease</D1>
                                <D3>constant </D3>
                                <D4>constant </D4>
                                <D6>constant </D6>
</ sadness >
```

< Fear>

Description: Facial expression. {D2 increase and D7 increase but more that D2}
Attributes: Default EML attributes.
Properties: the eyelids getup together and its internal port go to the height. The eyes are contracted and in alert.

Example:

```
< fear duration="4s" intensity="high" wait="2s" frequency="1st">
                                <D2>increase</D2>
                                <D7>increase</D7>
                                <D1>constant</D1>
                                <D3>constant </D3>
                                <D4>constant </D4>
                                <D6>constant </D6>
 </ fear >
```

7.3. 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 (VHML, 2001):
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?

8 Conclusion

In this paper, we have presented our system of the P2P e-learning and we have introduced a PECS model integrated in EECA due to learner's emotional state. This system has many advantages especially a better evaluation, help and support the learner during the exercise in real time. We give examples of representation languages that are used to express emotion.
As far as future work is concerned, we plan to extensively test our system on real application cases in order to validate the effectiveness of the approach. In addition, we plan to consider the recognition of gestures jointly with face expressions corresponding to certain emotions. Several applications in the systems of communication between the learner and the systems of communication may be improved by incorporating the information from the gesture and face signs.

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