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Embodied Conversational Agents: A New Kind of Tool for Motor Rehabilitation?

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Abstract

In this paper, we follow a pluridisciplinary approach to propose a concept of emotional and social interfaces. This concept has been developed in a social and emotional behavioral model for Embodied Conversational Agents (ECA) in the context of virtual therapy[1]. In our paradigm, a virtual therapist interacts with a patient in order to guide and encourage him to fulfill their exercises. We are interested in the production of a sense of immersion in the patient by the expression of a social as well as emotional presence in ECA. This In order to improve the patient / virtual therapist interaction and thus to stimulate the participation of patient during the rehabilitation therapy.

Keywords--- **Embodied Conversational Agents, Social Immersion, Emotional and Social Interaction, Virtual Therapy, Motor Rehabilitation**

1. Introduction

Social interaction in virtual worlds opens new horizons in the field of information technologies. Introducing virtual characters with some level of social interaction, allows the development of many professional applications, which could not have only been developed until now in the field of human-machine interaction.

Concerning therapy applications, virtual reality and virtual worlds make possible the creation of an interactive environment, where the exercises could be controlled, quantified and modulated, reinforcing the cognitive abilities of the patient and minimizing the cost of rehabilitation.

In this paper we propose a concept of emotional and social interfaces through the use of Embodied Conversational Agents (ECA). We describe a social and emotional behavioral model for Embodied Conversational Agents in the context of a virtual therapist for the rehabilitation of people with brain injuries caused by cerebral vascular accidents (CVA).

[1] This work is done in collaboration with the INSERM research centre (French National Institute of Health and Medical Research) in the context of a joint PHRC (Hospital Clinical Research Program) dedicated to the improvement of therapeutic paradigms.

The paper is structured as follows. Section 2 provides an overview related to the use of virtual reality in motor rehabilitation. The section 3 is a review of literature on Embodied Conversational Agents and immersion. Section 4 covers our approach and components for the behavioral model in order to create an intelligent emotional character. Section 5 concludes with the description of the virtual platform developed and our first conclusions.

2. Virtual Reality and Rehabilitation

Virtual reality technology has been used for several decades in health care areas like surgical procedures, medical therapy; medical education and training [1, 2].

The clinical use of virtual reality technology for brain injured people due to cerebral vascular accident (CVA) are numerous : care of cognitive disorders, such as the attention disorders or the executive functions, motor rehabilitation, coordination work and increase in the force and speed of movement execution [3, 4]. Usually the motivation for developing such applications is the need to reproduce at a lesser cost a virtual environment that is close to the real one and less distractive [4, 5].

Virtual reality offers the opportunity to bring the complexity of the physical world into the controlled environment of a laboratory and makes it possible to create an interactive environment, where the therapeutic exercise could be controlled, quantified and modulated in order to improve the rehabilitation process for the patient.

The most frequent applications in this domain are the 3D simulations of reality that can be explored by patients under the supervision of a therapist. Such applications, frequently use a totally immersive VR system like head mounted display (HMD) where the patient sees only the computer-generated image (and not the physical world round them).

Although there is a lot of potential for the use of this kind of immersive virtual reality environments in clinical applications, there are problems which could limit their ultimate usability. Some users have experienced side-effects during and after exposure to hardware devices of virtual reality environments. The symptoms include ocular problems, nausea, disorientation and balance disturbances. Susceptibility to side-

effects can be affected by age, ethnicity, experience, gender and physical fitness, as well as the characteristics of the display and the tasks [6, 7].

But virtual reality cannot merely be reduced to a hardware system. We consider that a way to achieve the optimal experience, is to produce a sense of immersion associated to an emotional and social experience inside the virtual environment. This experience could be reached through the interaction with a virtual character able to express a social and emotional behavior.

3. Embodied Conversational Agents and Immersion

The potential applications of virtual characters are considerable. Last years have been characterized by an increasing number of projects and groups of research working on the use of virtual characters for educational and professional purposes [8]. This evolution concerns particularly the design of affective interfaces and the creation of tools for simulation, in fields such as education [9, 10], training [11, 12] or therapy [13, 14].

The virtual characters try to capture the richness and the dynamics of the human behavior. Their behavior is strongly based on psychological, sociological and communication theories in order to create a character able to express personality, emotions as well as nonverbal behaviors.

There are several ideas about what can give believability to virtual characters [15-17]. Bates [17] defines a believable character, as a character that provides the illusion of life, and thus allows the audience's suspension of disbelief.

When an interactive virtual character is controlled by a software agent and demonstrates many of the same properties as humans in face-to-face conversation, it is called *Embodied Conversational Agent* [18].

Cassell, T. Bickmore, L. Campbell, K. Chang, H. Vilhjàlmsson, and H. Yan [19] suggest that an Embodied Conversational Agents (ECA) is a virtual human that has the social and linguistic abilities to carry on a face-to-face conversation. They identifies four properties for ECA's : 1) the ability to recognize and respond to verbal and non-verbal input 2) the ability to generate verbal and non-verbal output, 3) the use of conversational functions such as turn taking, feedback, and repair mechanisms and 4) a performance model that allows negotiation of the conversational process, and contributions of new propositions to the discourse.

We thought that the interaction with a character able to reproduce these kind of properties could transmit an immersion's experience in a virtual world.

Many researchers use the term *presence* to describe the subjective feelings of immersion's experience. This subjective experience is usually defined as the "sense of being there" or the "perceptual illusion of non-mediation". In other words, they see the sense of presence as a result of the immersion in a virtual environment [20].

In an ecological view of presence Mantovani and Riva [21] proposed a socio-cultural focus of presence, where experiencing presence and telepresence does not depends so much on the reproduction of the physical reality as on the capacity of simulation to produce a context in which social actors may communicate and cooperate.

We will follow this approach and emphasize the role of the social interaction and its related feeling that we will call *social immersion*. We believe that a sense of social immersion could affect the subjective experience and stimulate the participation of the patient during a rehabilitation therapy. This is particularly important in post-CVA patients because they are frequently depressed and have difficulties in evaluating their performances.

4. Designing an Emotional and Social Character

We consider that the human-like interactive social style through nonverbal expressions, social behaviors and empathy expressions are the key factors in the generation of social and emotional immersion. For this reason, it is important that the characters with which the user interacts express emotional and social behaviors in their interaction.

To be able to produce this behavior, the virtual characters must communicate credibility in their emotional expressions and be able to express their indexical (like pointing an object with a finger) and reflexive behavior (like face to face interaction).

Our aim is to create an *intelligent emotional character* based on an emotional and social interaction paradigm. We define an intelligent emotional character as a character able to modify its emotional states in relation to the evaluation of actions and attitudes of his interlocutor.

4.1. A Multidisciplinary Approach

The theoretical background of our approach is related to the concept of *situated interaction*, which emphasizes the role of the context (external artifacts as well as interpersonal history) in behavior interpretation and the fact that the meaningful part of the communication is *co-constructed* by the actors during the ongoing interaction. We tried to make this concept operational in terms of the quality of the coupling between actors as well between actors and their environment [22].

The main difficulty is to produce a dynamic human interaction that makes sense for the tasks and actions that must be achieved by the characters. We thought that this kind of interaction could produce a sense of social and emotional immersion.

In order to develop such a dynamic, we have referred to 1) the concepts of situated cognition (taking into account the role of the objects of the environment), and 2) the representational approaches (for the production of speech acts).

We combined these two epistemological approaches in order to create our model since both approaches bring complementary aspects for modeling human-like behavior.

The *representational approach* enables us to describe the communication acts and emotional states in stable terms. In order to represent the emotional expression of behavior we had to adapt the theories of emotions [23, 24] and personality [25, 26]. We will also consider the concept of *emotional intelligence* put forward by Salovey and Mayer [27] in order to simultaneously take into account emotional expression and social interaction.

We will also emphasize constructivist theories in order to analyze the processes of co-construction of sense during social interaction. In order to understand this kind of problematic and to produce credible social interactions, we put into practice an analysis of interactions (ethnomethodological approach [28]) based on a video recording of the rehabilitation sessions. This analysis helped us to 1) structure and formalize the dynamic of the interaction and 2) to understand how interactions were context dependant.

4.2. Character Attitude and Model of Behavior Dynamics

Our aim is to create a behavioral model for characters that expresses emotional and social behaviors in their interaction (see Figure 1). These behaviors express the predisposition to react in a positive or negative manner to a stimulus (character's attitude). The attitude is transmitted by verbal, paraverbal and non verbal activity.

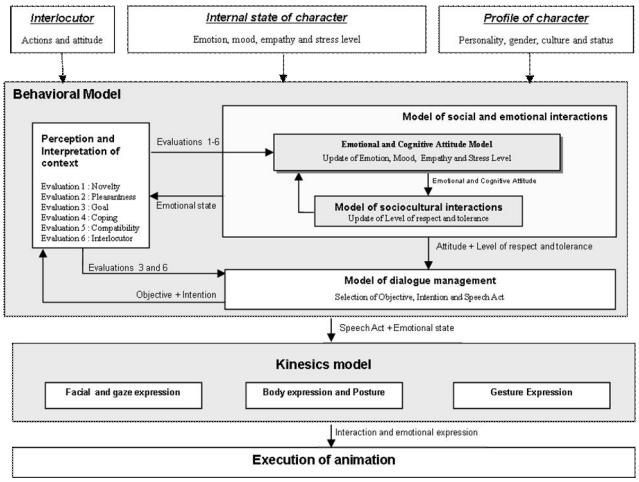

Figure 4 Components of the animation architecture

In our model, the attitude is influenced by 1) the profile (traits of personality, culture, status and gender) and internal state of the character (cognitive state, emotional state, mood and empathy and stress level), 2) the perception and interpretation of the interlocutor actions and attitude (context) and 3) the protocol of dialogue as well as the objectives and intentions of character's task.

In order to update the attitude, the behavioral model has a module which manages the perception of the context and two models that delineate the interaction: a model of social and emotional interaction and a model of management of the dialogue (see Figure 1).

The *model of social and emotional interaction* is a cognitive model which takes into account the character's personality in a "face-to-face interaction". This model allows us to update the character's attitude and his level of respect and tolerance. This model determine the emotional state and the mental attitude of the character based on the integration of three elements: 1) an emotional model [29], 2) a personality model (Five-Factor Model) [25] and finally 3) an appraisal model (Scherer's [30]). Taking into account these characteristics of human interaction allows us to drive character dialogue utterances and turn-taking.

The *model of dialogue management* is a cognitive-emotional model for the selection of the communication acts. It updates the state of the dialogue (turn-taking regulation and the dialogue game). This model also selects the speech act which express the objectives (e.g. to guide, to correct or to encourage) and intentions (e.g. to order or to inform in order to guide) of the character.

Once selected the speech act and the characters internal states, a *kinesic model* selects and integrates in real-time the non verbal activity (gestures, facial and body expressions) in order to reinforce the speech acts and the attitude of the character. These expressions are executed via Virtools[2], a 3D animation engine.

5. Virtual Therapist for motor rehabilitation

We have implemented this behavioral model through a virtual character in the context of virtual therapy. We have developed a virtual simulation environment for providing therapy to the rehabilitation of the active extension of the wrist to brain injured people caused by CVA. This work is done in the context of a Hospital Clinical Research Program dedicated to the improvement of therapeutic paradigms[3].

5.1. Virtual Session

The virtual session is a triadic situation, where the patient sees at the same time his clone's arms and the virtual therapist (see Figure 2). On the medical protocol, the patient's real arms are hidden and he visualize only his clone's arms carrying out the gesture in the virtual session.

The patient receives their instructions (verbal, paraverbal and nonverbal) concerning the exercise from the virtual therapist. The behavior of the virtual therapist is based on the experimental protocol as well as the carrying out actions of the patient clone's arms.

[2] www.Virtools.com.

[3] Collaboration with the U825 research centre of the French National Institute of Health and Medical Research (INSERM).

The activity of the virtual therapist consists of guiding the patient in his exercises, encouraging and correcting him. For example, according to the course of the session, the therapist express their objectives and intentions by speech acts (e.g. to guide he says, “raise the right hand” and to correct he could say, “follow me!”, “Non!!”, “raise the hand”, etc.). These speech acts could be expressed by a neutral, empathic or directive attitude. The expression of a coherent attitude with the context reinforce the believability of the interaction, as well as the coherence of the emotional state of the character.

5.2. Evaluation of interaction

The first rehabilitation experimentations of the platform allowed us to evaluate the behavior of the patient depending of the user feedback during their interaction with the virtual therapist.

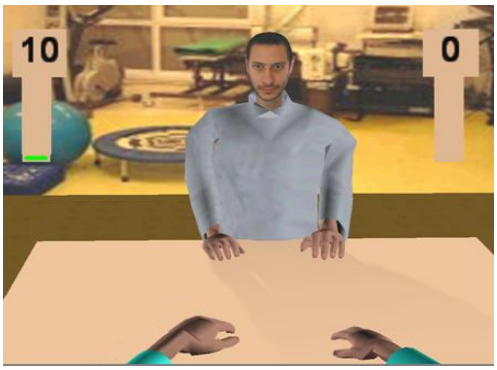

Figure 2 During the therapy session, the patient sees at the same time his clone’s arms and the virtual therapist (in front of him). The movement of the clone wrist is produced by the patient, who gets the exercise instructions from the virtual therapist

During the interaction with the virtual character two factors seem important: the perception of the level of engagement of the therapist and the coherence of the actions of the therapist compared to the context. The feeling of engagement such as it is perceived, is influenced by 1) the coupling between the actions made by the patient and the reactions of the virtual therapist and 2) by the activities implicitly associated to the function of therapist: to guide, to correct and to encourage.

In addition, we observed the importance of the coherence between the gesture of the therapist and his speech acts. For example: (1) If the patient raises the left hand and the therapist says simultaneously “raise the left hand”, the patient can express the inconsistency of the dialogue by a remark of the type “it is what I do...”. (2) If the therapist declares: “Follow me, raise your left hand” and if the gesture is not synchronized, a rupture of immersion is expected.

The immersion in virtual environments and in particular produced by the simulation of human behaviors improve the use of technology in areas like education, training and rehabilitation. This technology is able to produce tools and professional applications, which could have only been developed until now in the field of human-human interaction.

Conclusions

In this paper we presented a behavioral model that express social and emotional interactions. This model was implemented on a virtual character to be used as an emotional an social interface in a virtual simulation environment for providing therapy on motor rehabilitation.

We follow a pluridisciplinary approach to reproduce the dynamic of interaction and take in consideration the influence of context. The feedback provided by the users during their interaction with the virtual character enable us to get some conclusions about the role of the reproduction of social and emotional interactions.

The interaction with a character able to produces a feeling of social immersion is particularly important in post-CVA patients because they have problems of depression and difficulties in evaluating their performances.

We believe that the use of this kind of character is a good option to improve the experience of the rehabilitation therapy and thus stimulate the participation of the patient.

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