Simulating Empathy for the Virtual Human Max

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Abstract. Addressing user's emotions in human-computer interaction significantly enhances the believability and lifelikeness of virtual humans. Emotion recognition and interpretation is realized in our approach by integrating empathy as a designated process within the agent's cognitive architecture. In this paper we describe this empathy process which comprises of two interconnected components: a belief-desire-intention (BDI) based cognitive component and an affective component based on the emotion simulation system of the virtual human Max. The application and a preliminary evaluation of this empathy system are reported on in the context of a 3D competitive card game scenario.

1 Introduction and Related Work

Empathy plays a prominent role in human-human interaction because it represents a motivational basis of prosocial behaviour and contributes to moral acts like helping, caring and justice [7].

Brave et al. [5] accentuate that empathy is a fundamental and powerful means to manifest caring in humans. They investigate the psychological impact of affective agents, which are endowed with the ability to behave empathically. In their study [5] two conditions were evaluated in which the agent expresses self-oriented emotions and other-oriented, empathic emotions. Based on online questionnaires, they found that subjects judge the empathic agent as more likeable, trustworthy and caring as the self-emotional agent.

Prendiger et al. [9] investigate the impact of the affective virtual human Max upon humans within a 3D card game on the basis of human player's physiological responses in four different conditions: non-emotional condition, self-centered condition, negative-empathic condition and positive-empathic condition. It was found that, first, the absence of negative emotions within a competitive card game is stress-inducing and, secondly, the valence of the human's emotion is congruent with the valence of the emotion expressed by the agent.

These findings demonstrate that realizing empathic agents is important in human-computer interaction. The authors of these studies primarily investigate the impact of empathic agents upon humans. Their implementations of an agent's empathic reactions to human's emotions, however, are based on simple heuristics rather than a more detailed analysis of the internal processes involved in the elicitation of empathy between humans.

Definitions of empathy fall into one of two major categories (cf. [5], [7]): (1) empathy is defined as an affective reaction to the emotions of others, (2) empathy is viewed as cognitive understanding of another's emotions. In our approach we acknowledge both of these definitions by combining an affective component with a cognitive component in the cognitive architecture of our virtual human Max.

2 A First Approach for an Empathy System

We have experimentally implemented an empathy system for the virtual human Max [4]. It is based on the fundamental assumption that Max is quasi-egocentric. Quasi-egocentrism is observed in two-year-old children [7], who know that empathic emotions are to be ascribed to another individual although being experienced subjectively. However, due to cognitive limitations they do not yet understand that others have their own independent inner states and may appraise a given situation differently. These children appraise observed situations of others in the same way as if they were in that situation themselves.

The architecture of the virtual human Max can be divided into a cognition module and an emotion module (cf. [8], [3]). Following our understanding of empathy we also divide the empathy system into two interconnected components (see Figure 1). The cognitive component of the empathy system is characterized by the cognitive understanding of how emotions occur in humans. This component is implemented within the cognition module. The affective component of the empathy system then assures the simulation of a similar emotion dynamics for the human as it is generated for Max himself (cf. [1]). As an example scenario the interactive implementation of the card game Skip-Bo is chosen (cf. [2]). In this game the agent performs sequences of plans to reach his intended goal of winning the game. In our realization of empathy the agent generates a hypothesis about the emotional state of the human player by appraising the game situation for the human player in the cognitive component. This appraisal is based on the same mechanism that is used in the agent's own appraisal processes. Every human's action is analyzed by plans that generate the same emotional impulses (EI in Figure 1) as if Max would perform these actions himself. These impulses, however, are now driving the hypothesized emotion dynamics of the human player which is simulated within the emotion module of Max. In this appraisal processes the agent does not integrate any information concerning the cognitive state of the human player. Thereby, Max behaves quasi-egocentric and our approach follows the idea of the situational role-taking as described in [6].

In the affective component the course of emotions and moods over time and their mutual interaction as well as the mapping to pleasure-arousal-dominance-space are also modeled for the human player now. Reflecting the assumption that the agent is quasi-egocentric, we use identical parameters for the human player's emotion dynamics as we are using for our virtual human Max. The emotional state of the human player is represented by two additional reference points in

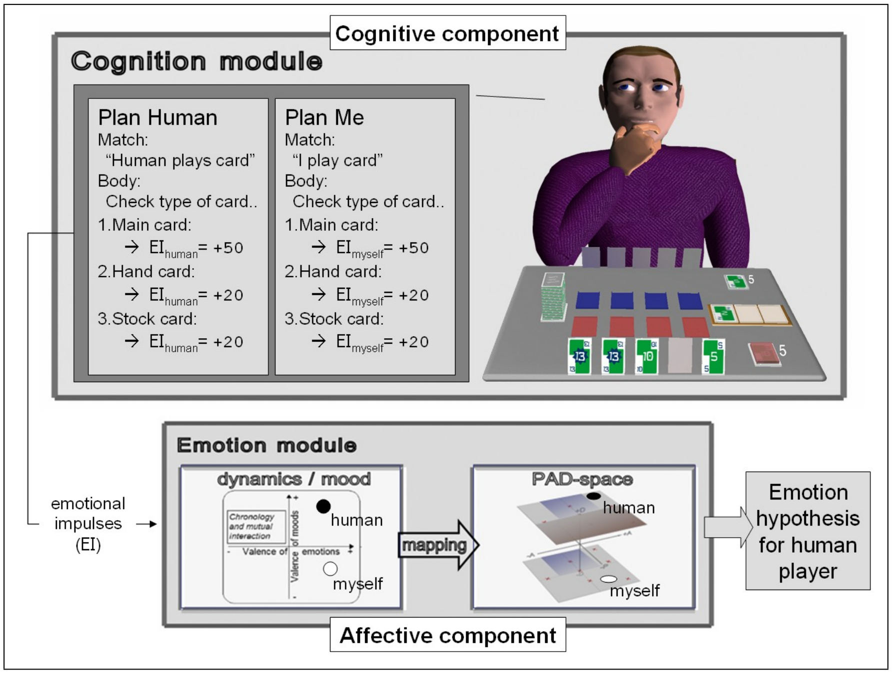


Fig. 1. Empathy simulation as a combination of cognitive appraisal and affect dynamics: The events "Human plays card" and "I play card" trigger appropriate "Plan Human" and "Plan Me" leading to emotional impulses (EI) for Max himself and the human player. These two impulses drive two independent emotion dynamics as represented in the "Emotion module" by their respective white and black circles. After mapping into pleasure-arousal-dominance-space (PAD-space) an emotion hypothesis for the human player is derived.

the emotion module as indicated by the two black circles in Figure 1. Thus, Max always distinguishes between his own and another one's emotional state. Even though he might experience fear himself at a given moment during the game, he might hypothesize at the same time that the human player is happy.

3 A Preliminary Evaluation of the Empathy System

To evaluate our approach to modeling empathy we are currently comparing the hypothetical arousal values generated by our empathy system with arousal values we reassigned to the emotion categories provided by the emotion recognition system of [9].

3.1 Procedure

So far, three of a total of 32 game sessions (sessions 24, 25 and 28) were replayed in realtime. During replay the empathy system generated an emotion hypothesis which was analyzed as follows. The emotion recognition system of [9] provided us with five discreet emotion categories. As these categories are based on a mapping in valence-arousal-space, we reassigned pleasure and arousal values as shown in table 1.

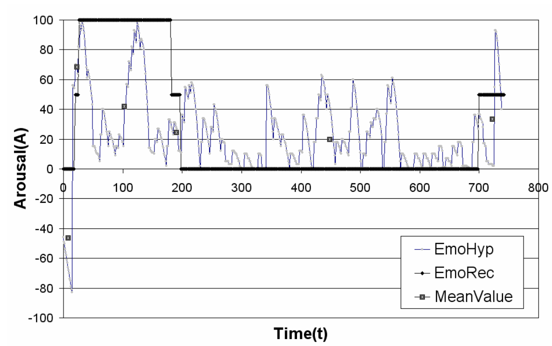
Emotion Cat.	**Pleasure**	**Arousal**
Exited	100	100
Joyful	100	50
Relaxed	0	0
Frustrated	-100	50
Fearful	-100	100

Table 1. The pleasure and arousal values reassigned to the emotion categories provided by the emotion recognition system of [9]. These values were chosen with respect to the valence-arousal-space introduced by Lang (cf. [9]).

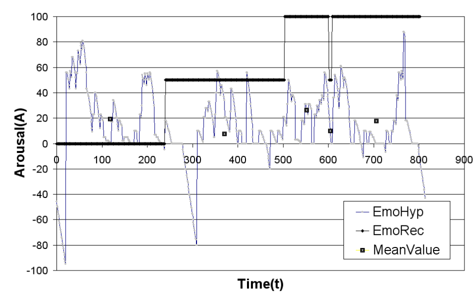
For our first analysis we concentrated on arousal values, because we assume the pleasure values derived from biometrical data (cf. [9]) to be much less reliable. We expected to find similarities between the arousal values generated by our empathy system on the one hand and reassigned to the emotion categories as shown in table 1 on the other hand. Figures 2(a), 2(b) and 2(c) show the courses of the two arousal values over time for the subjects 24, 25 and 28, respectively. The empathy system provides a more continuous course of arousal (EmoHyp) whereas the remapping of the categorical output of emotion recognition results in more discreet course of arousal (EmoRec) over time. In order to compare these values we decided to calculate the mean values (MeanValue) of the arousal values provided by our empathy system over all intervals, in which the reassigned arousal values (EmoRec) remained stable.

3.2 Results and Discussion

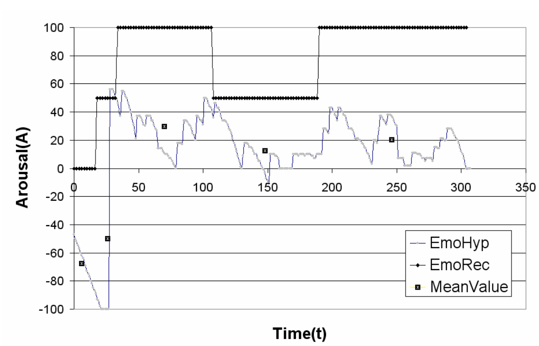
For a preliminary evaluation we compared the arousal mean values of our empathy system with the reassigned arousal values. For subject 28 (cf. Figure 2(c)) we found that the relative offsets of the mean values are comparable to the arousal values of emotion recognition. The mean values corresponding to each interval increase or decrease together with the reassigned arousal values. However, in case of the two other subjects (24 and 25) we found less similarities. For example, in the first interval of Figure 2(b) a mean value of 20 was calculated, while the emotion recognition value remained zero. During the following interval (240 to 502 seconds) the mean value decreases to 7 although the arousal value of emotion recognition increases to 50. Nevertheless, we consider this evaluation as acceptable because some similarities between the two arousal courses could be found. In order to gain statistically significant results we are currently analysing more gaming sessions. We also plan to compare the empathy arousal values to the raw arousal values derived from biometrical data used in the emotion recognition system of [9] thereby avoiding remapping of emotion categories.



(a) Subject 24



(b) Subject 25



(c) Subject 28

Fig. 2. The arousal courses (EmoHyp and EmoRec) and the mean values (MeanValue).

4 Conclusion

We presented a first realization of empathy for a virtual human Max based on the conceptual distinction between cognitive and affective empathy. Some aspects of cognitive empathy are captured by following the situational role-taking approach. The consideration of the course of emotions and moods over time and their mutual interaction in the simulation of the human's hypothesized emotions reflects aspects of the affective component of empathy. Our next step is to evaluate this first approach of an empathy system and to also integrate a cognitive model of the human player to realize an empathy process that follows the individual role-taking approach (cf. [6]).

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