A First Approach for Simulating Affective Theory of Mind through Mimicry and Role-Taking

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1 Introduction

Inferring the cognitive states of others (e.g., their beliefs, desires, intents) is referred to as *theory of mind* (ToM) [11] and has become relevant in research on virtual humans because it would allow them to behave more believably in human-computer interaction. One aspect often not considered is the ability to address the other's emotions by inferring their affective states. Based on two different definitions of the term *empathy* (cf. [7]) we define *affective theory of mind* as the process of inferring the affective states of others by sharing their emotions and by understanding the other's emotions cognitively. Hoffman [7] accentuates the importance of many modes of empathy (mimicry, role-taking, classical conditioning, etc.) to match the feelings of others. We present an approach to simulate affective ToM for a virtual human, which therefore acknowledges two different mechanisms to gain knowledge about another's emotional state: *mimicry* and *role-taking*.

Hoffman [7] defines mimicry as a process involving the simulation of another's facial expressions, voice and posture, that triggers an afferent feedback eliciting the same feelings in oneself as that of the other. In our work we concentrate on how the simulated changes in the facial musculature of a virtual human can give rise to emotion and how this can be complemented by the more cognitive mechanism of role-taking.

Metaphorically, role-taking is described as the ability of "seeing the world through another's eyes" or "putting yourself in another's shoes". Higgins [6] distinguishes two aspects of the role-taking process: situational role-taking vs. individual role-taking. Situational role-taking refers to inferring that the other's viewpoint would be the same as our's in the same circumstances, whereas in individual role-taking the additional implications of the other's characteristics are considered. In our work we will apply both processes of role-taking to understand the emotional states of others cognitively.

2 Toward a Computational Model for Affective Theory of Mind

Our virtual human Max [9] constitutes a testbed to investigate human-like behaviour in natural face-to-face interaction. While our long-term objective is to endow Max with the capability to adjust his behaviour relative to the recognised emotions of the human interactant, in this paper we introduce a concept contributing to a computational model of an affective ToM.

The starting point of our conception to realise facial mimicry is a set of *action units* —the core elements of the *Facial Action Coding System* [4]— available from tracking facial features of a human interactant expressing emotions or from simulated action units of another virtual agent's face. Inspired by the concepts used to implement imitation algorithms as in [8] and [3], the idea is that the available set of action units can be mapped onto the facial muscles of our virtual agent Max.

In the study by Grammer and Oberzaucher [5], a two-dimensional regression analysis of the correlation between pleasure and arousal and action unit activations was performed. Single action unit regression spaces were calculated and different distributions in

the pleasure-arousal space for different action units were found. Based on the results of these study, the activated facial muscles of Max will be mapped backwards onto these empirically found distributions. Then, the resulting distributions will be combined (e.g. added up) in order to compare them with those calculated in [5] for each of the six basic emotions, thus yielding a form of "motor-simulation-based empathy".

However, evaluating solely the tracked facial features of the human interactant without integrating contextual information may lead to false assumptions. Thus by only relying on facial mimicry our virtual human is likely to falsely interpret, e.g., a facial expression accompanying the secondary emotion of relief as the primary emotion of happiness (cf.[1]). In order to make the interpretation process more adequate (e.g., to distinguish between happiness and relief) we propose to make use of the additional mechanism of role-taking.

Situational role-taking can be realised (following our prior work [2]) as follows: based on the cognitive architecture [10] of our virtual human, the agent generates a hypothesis about the emotional state of the interaction partner. This hypothesis is generated by observing the situation of the interaction partner and then appraising it with the same appraisal mechanisms that the agent would use if he were in these situation himself. In the cognitive architecture of Max, partner-specific knowledge (e.g., his preferences or goal achievement) will be extracted from an episodic buffer. We will explore how far this information allows the realisation of individual role-taking, enabling the agent to account for the viewpoint of the interaction partner when inferring his emotional state.

3 Conclusion

Based on psychological theories and on previous work we present a conception that concentrates on a more detailed analysis of two important processes involved in the elicitation of empathy between humans, mimicry and role-taking. Thus we aim to contribute to a simulation of an affective ToM for a virtual human in order to enable it to behave more human-like.

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