Virtual Humans with Affective Minds: Recent Research at Bielefeld

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Motivation

Affective computing and emotional interfaces have become prominent in human-computer interaction, not least in the development of interactive virtual humans (Gratch et al. 2002). Researchers in affective computing (cf. Picard 1997) argue for increasing the expressive capabilities of artificial agents by modeling the influence of simulated emotions on bodily expressions including, e.g., facial expression, body posture and voice inflection. In doing so, different motives have to be contrasted (cf. Becker at al. 2007). On the one hand, there is the *believable agent motive*, which is based on the assumption that the simulation of emotions increases the believability and lifelikeness of an agent in social dialogues. On the other hand, researchers who are driven by the *experimental-theoretical motive* aim at a deeper understanding of human emotions and human emotional behavior, and they use simulated agents to verify their theories from a cognitive modeling perspective. There is growing consent in Cognitive Science that, in order to understand how the human mind works, we cannot ignore its affective aspects and the relationships between cognition and emotion (Hatano et al. 2000).

Making a Virtual Human Emotional

This contribution briefly surveys recent research at Bielefeld University on virtual humans with "affective minds", this is to mean we are building agents that have an "inner life" (i.e. realistic emotions that modulate their behavior) and that can be seen as a testbed for the study of the relationship between cognition and emotion. The virtual human Max has been developed at Bielefeld University's Artificial Intelligence Laboratory to model and examine natural human conversational behavior in Virtual Reality face-to-face encounters. Max rests on a cognitive architecture that tightly integrates the faculties of perception, action, and cognition, running concurrently, with an emotion module (Leßmann et al. 2006). For one thing, perception and action are directly connected in a *reactive layer*; reactive behaviors include gaze tracking, focusing attention, and a variety of secondary behaviors (such as eye blink, breathing, and body sway), which can be modulated by the emotional state of the agent. At the same time, perceptions are also fed to a *reasoning layer* with a BDI (Belief-Desire-Intention) interpreter being employed to take deliberative action.

The emotion module is based on a dimensional emotion theory with pleasure, arousal, and dominance dimensions as described in (Becker at al. 2007) to realize the internal dynamics and mutual interactions of primary and secondary emotions. *Primary emotions* derive, in the reactive layer, from a form of "non-conscious" appraisal of incoming sensor information (e.g. fast movement in the visual field) and involve simple evaluations of positive or negative valence, which can directly give rise to reactive behaviors such as approach or avoidance. The ability to reason about the eliciting factors of one's own emotional state is a mandatory prerequisite for the emergence of *secondary emotions*. Thus secondary emotions are derived from a form of "conscious" appraisal, taking place on the reasoning layer. This appraisal process generally includes aspects of the past and the future, making use of different kinds of memories also present on this layer.

Max has been employed and evaluated in a number of increasingly challenging scenarios. In an everyday application, Max conducts multimodal smalltalk conversations with visitors to a public computer museum (Kopp et al. 2005). In this setting, the emotion module and its dynamics leads to a greater variety of often unpredictable, yet coherent emotion-colored responses. These responses add to the impression that the agent has a unique personality, and the parameters of the emotion module reflect such aspects of an agent's personality trait. Furthermore, this way of modeling emotions is largely domain-independent. This has been shown by a successful application in a gaming scenario (Becker et al. 2005), as well as by simulating how the emotional state of the agent can influence cognitive processing in action selection and dropping unsuccessful plans (Becker et al. 2006).

Outlook: Affective Theory of Mind

Ongoing work pertains to enabling "mind-reading" abilities for virtual humans. Emotional interfaces should profit from understanding what are the other's feelings, by inferring emotions of the other (affective Theory of Mind), and empathy, i.e. an affective reaction to the interlocutors's emotion. A fundamental mechanism of empathy is facial mimicry, which is the basis for simulating another's facial expressions to infer the same 'feelings' (Boukricha et al. 2007). An aspect further important is touch, where touch perception and its emotional appraisal could be used for Max to develop a form of body awareness (cf. Wachsmuth 2008). Thus we have started to work on simulating touch perception for the virtual agent Max, based on attaching a large number of virtual skin receptors to his body (Nguyen et al. 2007). This perceptual capability shall be utilized along with Max's emotion system to appraise tactile stimuli and to determine the affective content of touch, giving rise to connect "body" and "mind" of a virtual human.

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