What Affective Computing and Life-Like Character Technology Can Do for Tele-Home Health Care

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ABSTRACT
Affective computing refers to computing that relates to, arises from, and deliberately influences emotion [6]. The area of affective computing aims to develop computer-based tools that sense, measure, and respond to users' affective information. Life-like characters are animated agents that emulate human-to-human communication skills and thus allow for more natural interaction styles between humans and computers [10]. This paper tries to motivate affective computing and life-like character technology for the tele-home healthcare application domain. In particular, we will describe an interface that takes physiological data of a user in real-time, interprets them as emotions, and employs a life-like character to address the user's (negative) affective states in the form of empathic feedback. For the case where hands-on care is not required, we will argue that this type of "embodied" interface has great potential to improve and complement systems that connect patients at home with medical professionals at the hospital.

Author Keywords
Affective computing, life-like character technology, emotion recognition, human physiology, empathy

ACM Classification Keywords
H5.2. Information interfaces and presentation (e.g., HCI): User Interfaces.

INTRODUCTION AND MOTIVATION
The idea of a computer 'sensing' a user's physiology including skin conductivity (SC), electromyography (EMG), heart rate (HR), and blood volume pulse (BVP) is becoming increasingly popular in the human-computer interface and intelligent interface communities [4, 9]. This is partly because of the recent progress in interpreting users' physiological signals as emotions (or affective states), and also due to the availability of reliable and unobtrusive sensing technologies [6]. The general vision here is that if a computer could recognize a user's emotion, the interaction would become more natural and efficient. The computer could offer help and assistance to a confused user, try to cheer up a frustrated user, or even empathize with the user's situation. A crucial question is by what means the computer should respond to the user. A simple way is to use text-based messages. Psychologists, however, found that if a computer displays some anthropomorphic cues, people interact with computers in an essentially social way [11]. Life-like characters convincingly implement the "computers as social actors" metaphor as their modalities include affective speech, facial display of emotions, hand gestures, head movements, and body posture. They are designed to establish and maintain socio-emotional relationships with human interlocutors, and since they not only display social cues, but also intentionally produce social response in users, they may have a motivating and engaging effect in human-computer interaction tasks.

We believe that affective computing and life-like character technology may significantly improve (tele-) home health care systems. Here we assume that the user (patient) is provided with an internet-enabled computer and some device to process his or her physiological data. *First*, [7] emphasizes the important roles of emotions such as stress, distress, anxiety, and (chronic) anger as a contributing factor to, e.g. decreases in immune system functioning. Thus, it would be desirable if a computer could repeatedly assess the patient's emotion, and react accordingly, e.g. by trying to reduce the patient's negative feelings. *Second*, it has been shown that in therapy, the "working alliance" between patient and therapist toward a desired goal is correlated to the success of the therapy, whereby the therapist's empathy for the patient is a key factor for a functioning alliance [1]. Since life-like characters are endowed with means to express emotions, they are genuinely able to display (artificial) empathy to the patient. *Third*, while the system is verifying the patient's compliance with medicine regimes, a character may have a motivating function in the role of a health companion. For instance, the character can increase the patient's awareness of and interest in his or her health state by giving feedback, or incite the patient to improve his or her physiological sign data by providing encouragement.

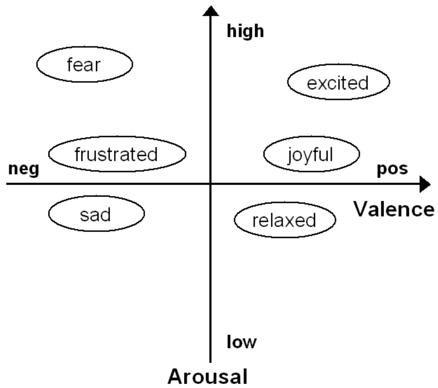

Figure 1. Emotions in the arousal-valence space.

FROM PHYSIOLOGICAL SIGNALS TO EMOTIONS

A fundamental assumption of our approach of using affective computing for tele-health home care applications is that besides collecting physiological signals remotely and sending them to the hospital, they can also be used to assess the patient's emotional state. In [2], Lang claims that all emotions can be characterized in terms of judged valence (pleasant or unpleasant) and arousal (calm or excited). Figure 1 shows some named emotions as coordinates in the arousal-valence space. The relation between physiological signals and arousal/valence is established in psychophysiology which argues that the activation of the autonomic nervous system changes while emotions are elicited [3]. For instance, the galvanic skin response signal is an indicator of SC and increases linearly with a person's general level of arousal; the EMG signal measures muscle activity and has been shown to correlate with negatively valenced emotions. The same is true for heart rate. Hence "frustrated" is defined by increased arousal and negative valence in Lang's model.

Although space does not permit to discuss those issues, we want to mention the following problems in interpreting signals as emotions: (i) "Relative to which physiological state should (state) changes be measured?" (baseline problem) and (ii) When does physiological signal indicate an emotion (and not the result of physical exercise)?" [3].

EMPATHIC CHARACTERS

Our own work is in affective character-based interfaces that *address* user emotion, i.e. interfaces generating affective behavior by a character in response to the user's recognized (negative) affective state. The interface we envision shows concern about user affect, also known as *empathic* (and *sympathetic*) behavior. Although our studies have been carried out in the context of a simple game and a virtual job interview, we believe that our architecture and results could be transferred to the home care setting.

Mathematical Quiz Game

The purpose of our character-based mathematical quiz game is to evaluate the effect of empathic feedback in deliberately frustrated users [8].

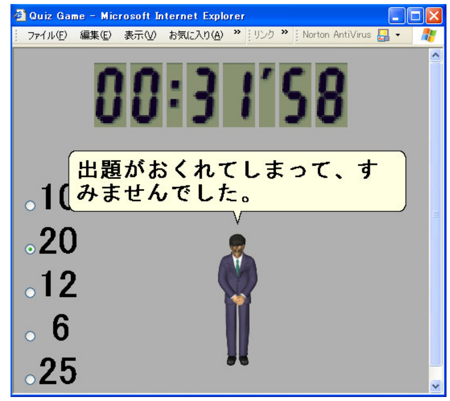

Figure 2. "Shima" character: "I apologize that there was a delay in posing the question."

The impact of the character is measured by comparing the SC of subjects that received empathic feedback with the SC of subjects that did not. Subject data were recorded by using the ProComp+ unit [12]. A simple game was implemented where subjects are instructed to sum up five consecutively displayed numbers, and are then asked to subtract the *i*-th number of the sequence ($i \leq 4$). The instruction is given by the "Shima" character which is controlled by the Microsoft Agent package [5]. Subjects compete for the best score in terms of correct answers and time. In some quiz questions, a delay was inserted before showing the 5th number which was intended to induce frustration. In the game version using the empathic agent, an apology was given to the subject (see Figure 2), whereas in the control version the character ignored the occurrence of the delay. The main result can be summarized as: *If a character shows empathy to a deliberately frustrated user, then the user's SC is significantly lower than when the character does not display any affect, as compared to the SC of the period of induced frustration (the delay period).* This result indicates that empathic feedback may undo some of the user's negative feeling.

Virtual Job Interview

The aim of the job interview application is two-fold: first, to implement a system that allows processing physiological signals in real-time, and second, to investigate the overall effect of an empathic character (as compared to a non-empathic one) for the entire interaction period. As a demonstrator scenario, we chose a virtual job interview, where the user is accompanied by a character – the *Empathic Companion* – that addresses the user's emotion resulting from being queried by an animated interviewer agent. Being interviewed is likely to elicit emotions in the user, especially when the interviewer asks potentially unpleasant or probing questions, such as "What was your final grade at university?" or "Are you willing to work unpaid overtime?" and then comments pejoratively upon the user's unsatisfactory answer. In order to emphasize the training aspect of the interview situation, the user is led by the Empathic Companion that addresses the user's (negative) emotions by giving empathic feedback, e.g. "It

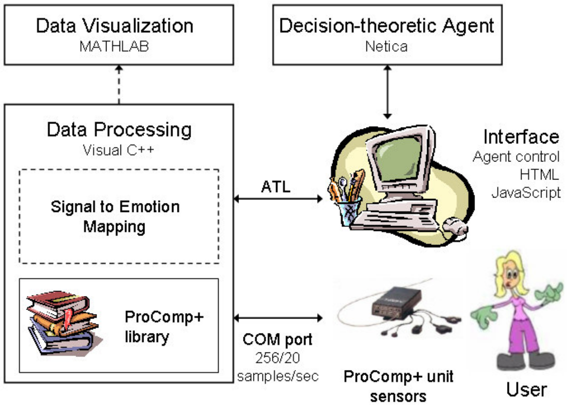

Figure 3. System architecture.

seems you did not like this question so much" or "Maybe you felt a bit bad to be asked this kind of question".

The architecture of our system for real-time emotion recognition is depicted in Figure 3. One core component is the decision-theoretic agent that derives an emotion from the user's physiological data input and selects an appropriate response for the Empathic Companion [9].

Recently, we conducted an exploratory study on the overall effect of the presence of the Empathic Companion. As the control condition a "Not Supportive" companion type is used that does not address the user's affective state. Since the ProComp+ unit cannot be simultaneously employed for real-time data assessment and monitoring, our colleague Hiroshi Dohi designed a signal processor that reads users' SC and HR. We hypothesized that averaged over the entire interview period the presence of an Empathic Companion will have users with lower levels of arousal and less negatively-valenced affective states. The SC and HR values were normalized by *(signal(interview) – signal(baseline)) / range*, where "signal" refers to the mean value, and the baseline was obtained during an introductory relaxation phase. Initial results with a very small number of subjects (10) did not support our hypothesis. We only observed that the group mean for HR was slightly lower in the version with the character showing empathy, but this result was not statistically significant. One reason for this negative result (besides the small number of subjects) might be that subjects interact with the interviewer agent most of the time, and the interaction periods with the Empathic Companion are possibly too short to make a difference in the subject's physiological state. A more direct experimental setting may show different results.

CONCLUSION

In this paper, we suggest using methods from affective computing and life-like character technology in order to develop novel functionality for (tele-) home health care systems. Since emotions are recognized as an important factor for the well-being of people, interfaces that assess and respond appropriately to human emotions may become a key technology for preventive medicine, distant monitoring of patients' physiology, and health behavior change. We reported on a study that demonstrates the frustration-reducing effect of empathic feedback given by a life-like character. A modified version of the Empathic Companion application described in this paper may play a crucial role in addressing patients' emotional and social needs, and thus leave them more satisfied and hopefully, even more healthy.

ACKNOWLEDGMENTS

This research is supported by the JSPS Research Grant (1999-2003) for the Future Program.

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