Exploring Psycho-physiological Measures for the Design and Behavior of Socially-Aware Avatars in Ubicomp Environments

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Abstract
Ubicomp environments pose many challenges due to their reliance on implicit input and their tendency to take actions on the user's behalf. Avatars can assist users by explaining the behaviour of this kind of environment and by assisting users in intervening and controlling the environment's behaviour. In this work, we intend to move beyond avatars that represent the user towards an avatar that serves as a mediator between the system and the user. We hope to achieve this goal by designing a socially-aware avatar that adapts its behavior according to the user's current emotion inferred from his psycho-physiological measurements.

Keywords
Psycho-physiological signals, avatar, ubicomp environment

ACM Classification Keywords
H.5.2 User Interfaces: Input devices and strategies;
B.4.2 Input/Output Devices: Channels and controllers;

Introduction

In this paper we describe our first set of experiments for defining an affective avatar in a ubicomp environment. We want to create a strong personal connection between the user and their virtual representation that goes beyond simple identification. For this reason we aim to use psycho-physiological signals from the user to steer the avatar behavior. Our avatar acts as a companion of the user in exploring the ubicomp environment and serves as a feedback mechanism to "survive" in a ubicomp environment. Since an avatar can be considered as a means of communication between the user and a computing system, we believe the behavior and representation of an avatar should be strongly and continuously connected with the current status of the user it presents.

In ubicomp environments, an avatar can support the user in navigating and manipulating the environment, and provide explanations of things that happen in that environment. We presented an embedded presentation of these types of explanations in [5][1]. We make use of a room in which every surface can be projected upon by steerable or wide-angle projectors. Figure 1 shows a conceptual sketch of the setup we envision in this work.

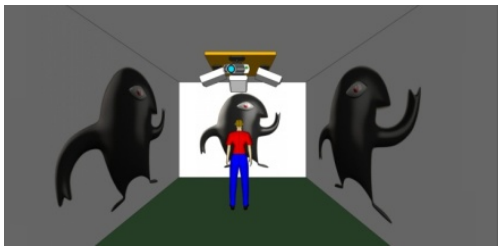

Figure 1. Conceptual overview of the environment setup

With our work, we aim to create an avatar that plays a role as a companion to the user in a ubicomp environment. We believe that by using physiological signals to detect user's emotions and adapt an avatar according to the inferred emotional state, the avatar can also mirror or show similar emotions as a form of empathy to the users. For example, when we know that a user is frustrated while interacting in the ubicomp environment, we can steer the avatar so that it shows comforting behavior. One step further, we can also employ the physiological measures to investigate user experience such as users' reaction to the avatar itself.

This paper describes our initial work of employing physiological measures to infer user's emotions for designing a socially aware avatar with adaptive behavior. At the current stage we are investigating how social relationships between people influence their emotional state. This data helps us to determine the behavior of the avatar and can hopefully support in presenting it as a companion for the user. By creating a continuous feedback loop – measuring the reactions of the user during interaction with the avatar – we hope to avoid walking in the famous Microsoft Office Clippy trap.

Avatars as Mediators between Users and the Ubicomp Environment

Ubicomp systems often act without explicitly involving the user, which may surprise users as to why the system behaves in a certain way. Moreover, system actions are usually a result of complex reasoning that might be hard for users to understand. Bellotti et al. [1] have proposed two key principles to overcome these problems:

- *Intelligibility*: How can systems be designed to allow users to understand how the system works?
- *Control*: How can systems allow users to exert control over the system to recover from possible mistakes?

[1] http://www.youtube.com/watch?v=gztUqtvvMHs

We believe an *affective avatar* could support intelligibility and control by serving as a mediator between the user and the ubicomp system. The user would then interact with the avatar both for understanding why the system behaves in a certain way, and for intervening when the system would take an undesired action. In this way, we exploit our inherent social skills as humans.

Socially-aware Avatars

According to Maslow's hierarchy of needs, humans have social needs. This involves the need to love or be loved in our social relationships such as families, friendships or colleagues. To maintain and enhance human social relationships, people have the necessity of connectedness-oriented communication, a type of communication that fosters a feeling of connectedness [4]. Putting this onto our research context, such connectedness can also be attained when people interact with socially-aware avatars that can express emotions and respond to user's emotions. The user can start building a "social relationship" with the avatar when the user has a feeling of connectedness to the avatar mediating him with the ubicomp system.

Many applications have incorporated emotionally expressive avatars for several roles such as representation, companion, and assistance. The design of these avatars is mostly based on the detection of users' facial expressions, body postures, or hand and arm gestures. Additionally, users' physiological signals have also shown to be effectively utilized in the design of emotional avatars. Cooper et al. [2] discussed the use of physiological sensors to detect students' emotional expression and provide adaptive feedback to an intelligent tutoring system based on their affective states. The tutoring system is equipped with an intelligent avatar that is not only capable of encouraging students to use the help function (assistance) but also expressing emotions to students and mirroring the students' emotion (companion).

Designing a socially-aware avatar, who not only represents its user but also behaves as a companionably agent with whom the user interacts, is a fragile combination. Any incorrect actions of the avatar can lead to loss of identification of the user with the avatar. On the other hand, an avatar that adapts according to the psycho-physiological measurements is likely to be of interest of the user, since it shows correspondence with the current state of the user.

Measuring Physiological Signals for the Design and Behavior of Intelligent Avatars

To address the challenges we are facing for designing a socially-aware avatar, we decided to first get insight in the specific psycho-physiological state of the users when interacting with peers. To make sure we could detect how two peers relate to each other when undergoing more "explicit" emotions, our measurements are done using a multiplayer game with two persons in the same room. The game ensures several emotions come to the surface that would be harder to trigger otherwise. Emotions such as frustration, euphoria, relief, etc. are all experienced while playing the game. By making a careful selection of the participants, these emotions can vary according to the social relationship between the players: just imagine two good friends; a teacher and his student; or two ex-lovers playing such a game against each other.

Figure 2. The test setup for measuring the effect of social relationships when playing a multi-player game

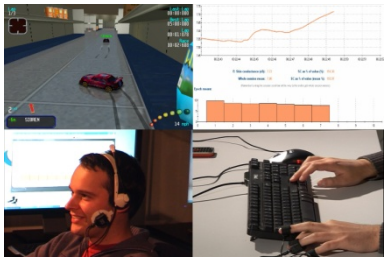

Figure 3. One participant playing the game while physiological signals being captured

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We hypothesize that there will be differences in the user's psycho-physiological states depending on the social relationship between the user and the rival. An overview of the test setup can be found in figure 2. There are two computers that are used for playing the multiplayer game and one computer that captures all data. The data originate from cameras that capture the participants' face and their interaction with the keyboard, and from a ProComp Infiniti[2] device that measures the psycho-physiological signals (galvanic skin response (GSR), electromyography of the jaw (EMG), and blood volume pulse (BVP)).

We have initiated this investigation with an informal experiment with several pairs of good friends. Figure 3 shows one of the participants playing the game while his physiological measures are being monitored. Alongside this participant there is a good friend competing with him in the game environment. We found that participants experienced higher physiological values when playing against a friend than against a computer, which is in line with previous work [4]. Currently, we are preparing some experiments to explore how different social relationships influence the emotional state between participants while playing a multiplayer game. With the findings, we hope to continue with the design of a socially-aware avatar for ubicomp environments, starting with determining its behavior as a companion for the user.

Next Steps

Our measurements captured during the experiment allow us to classify different emotions and define the related avatar actions they trigger. The goal is to provide different avatar behavioral styles for supporting intelligibility. According to the context of use the behavioral style that is most suited can be selected. For example, when involved in a game in a ubicomp environment, the avatar should mimic being a friend of the user. For execution of a critical task the avatar might behave more as a teacher. We think also artistic applications that aim to evoke the user using the avatar can benefit from our experiments.

[2] http://www.thoughttechnology.com/proinf.htm

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