Integrating Brain and Physiological Sensing with Virtual Agents to Amplify Human Perception

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Abstract
Virtual agents are used in different fields such as games, education, and rehabilitation. They make the interaction feel more natural and can even be integrated with sensing platforms to perform tasks (such as biometric identification, eye tracking, etc. [5]) that a normal human cannot do. The Advanced Interaction Research Lab at Drexel University conducts research on emerging human-computer interaction techniques, with a focus on physiological computing and brain-computer interfaces. Some current projects investigate the effectiveness of virtual assistants in improving human performance during learning and creative tasks. In this workshop, in particular, we would like to discuss the role of an embodied virtual agent in amplifying a person's perceptions of the surrounding world by integrating it with physiological and brain data.

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Human Computer Interaction; Brain Computer Interfaces; Virtual Agents; Embodied Conversational Agents; Augmented Reality.

ACM Classification Keywords
H.5.2 [Information interfaces and presentation]: User Interfaces

Introduction

With brain-computer interfaces and other biosensors, it may be possible to sense elements such as attention, concentration, boredom, fatigue, etc. which are not easy to sense using conventional interfaces such as cameras and microphones. Having this information, a virtual agent may begin to surpass a normal human's understanding during a conversation and become able to collect more information about the other person's state of mind than a human would do.

So how can we use this information to improve the interaction? Can we build agents that are able to predict that a person is going to get angry, and therefore the agent changes its behavior in a way to prevent that? Can we have virtual assistants which can tell us a person is stressed, anxious, or is not paying enough attention, although their facial expression and voice tone say otherwise? These are the type of questions that we are beginning to explore.

Background

Over time, human-computer interaction has evolved to be increasingly responsive. In early computers, there was limited feedback when something went wrong. Now, this has changed, with interactive systems providing meaningful hints, feedback, and error messages. This feedback provides humans with a better understanding of the state of a system and the system's expectations of the user. Nowadays, people interact with computers as intelligent beings. They write a couple of keywords in search engines and expect the computer to fully understand what they are looking for; they call their smartphones by name, ask them questions, or give them commands, and expect them to respond accordingly.

Using human-like voice in computers for feedback and messages to the user has been popular since it was introduced. It can make the communication more natural and pleasant. Adding a human face to the voice can make it look even more natural. An agent that can show different facial expressions and speak with different voice tones can be a big step forward in HCI [9]. An agent that is also able to read and understand a human's emotions and state of mind is even more powerful.

But how can we make such an agent? Sensing physiological data such as heartbeat or skin conductance is a way to monitor elements like stress or anger. In addition to those, there are cameras and microphones, which do not need to be attached to one's body, and they more resemble the human's eyes and ears. Today, sensors are able to detect aspects of a human's face and voice and based on facial expressions, eye movements, and voice tone, categorize their state of mind with an acceptable accuracy. Using such algorithms alongside a virtual agent that performs a fair range of facial expressions and voice tones itself, has the potential to make interaction feel more natural and pleasant [3, 2, 6, 8, 7, 4, 1].

Future Scenarios

In the following example, we investigate how brain and physiological data could be used to augment and amplify our understanding of the surrounding world. Can we make virtual agents that can tell us the state of mind and the anxiety level of a person during a job interview? Can we make Augmented Reality (AR) glasses for teachers to monitor their students' level of attention in the class? Is it possible to have air traffic control agents wear a brain-computer interface (BCI) headband so it can warn them when they are not concentrating enough or too bored or tired to work?

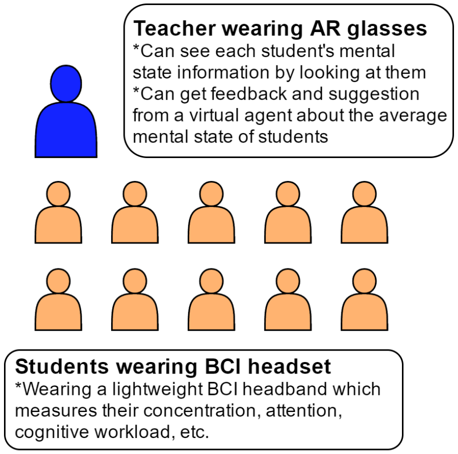

Figure 1: A potential scenario of using BCI alongside AR to help teachers observe their students' mental state.

Take this scenario as an example (Figure 1): Students in a class wear lightweight, non-invasive BCI headsets, and their teacher wears AR glasses while they are holding a regular class session. Through the glasses, the teacher is able to see each student's attention level, concentration level, cognitive load, etc., by focusing his gaze at a specific student. The particular student's information will show up on the screen of the glasses. When the teacher looks at a specific student, the glasses identify the student and retrieve the information for that specific headband and show it on the screen of the teacher's glasses. Also, a virtual agent (either an Embodied Conversation Agent (ECA) or just as a text or voice feedback) could give the teacher feedback and suggestions about the changing mental state of the students. For example, it could suggest to the teacher that a five-minute break is necessary because the average fatigue level is increasing. Or it could recommend that the teacher slow down and explain the course material with more detail because the average cognitive workload level is above average. It could also be useful in classes where students are allowed to use their electronic devices. The combination of BCI headsets and AR glasses can help the teachers to better understand which students are using their electronics to learn the material (the ones with higher concentration and cognitive work load) and which ones are using them for distraction from the class (the ones with lower level of concentration and cognitive work load).

As these types of scenarios become possible, there are new questions that arise that will impact the design of these systems. How do users feel when using such a system? When ECAs and interactive systems can go beyond typical human sensing, what new issues arise in interaction design? Are users accepting of this new level of sensing and perception?

In the Advanced Interaction Research Lab at Drexel University, we are conducting research on emerging human-computer interaction techniques, with a focus on physiological computing and brain-computer interfaces. Some current projects investigate the effectiveness of virtual assistants in improving human performance during learning and creative tasks, and we are exploring many of the questions posed above.

Bios

Reza Moradinezhad is a second year Computer Science PhD student at Drexel University. He works at AIR Lab under Dr. Solovey's supervision. His research interests are in applications of brain-computer interfaces in virtual/augmented reality and prosthetics design, as well as their role in environments in which humans and automated systems work alongside each other.

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