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Frustrating the User On Purpose: Using Biosignals in a Pilot Study to Detect the User's Emotional State

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Abstract

Our goal was to develop a computer system trained to sense a user's emotional state via the recognition of physiological signals. In the course of developing an exploratory pilot study toward this end, we encountered and addressed unique and context-dependent interface design and synchronization challenges. We used social science methods to induce a state of frustration in users, collected the physiological data, and developed an effective strategy for coupling these data with real-world events.

1 Introduction

Affective computing, a new area of computing research, has been described as "computing which relates to, arises from, or deliberately influences emotions [5]." Why build an affective computer? Recent evidence demonstrates that humans have an inherent tendency to respond to media in ways that are natural and social, mirroring ways that humans respond to one another in social situations [6]. Since affect is such an integral part of human-human social communication, we believe that computers with affect-recognition skills would make better interaction devices. An affect-recognizing computer would also be able to perform a variety of tasks, ranging from helping the user build emotional skills to assisting medical personnel in monitoring patient stress triggers. Pattern recognition of biosignals may be a way to inform an affect-recognizing computer. Recent research argues that variables such as skin conductivity and heart rate may covary with affective state [1,2,4]. While researchers in computer vision and audition have already developed methods for capturing nonverbal affective cues, there are instances when cameras and microphones are undesirable. Additionally, biosensors may be incorporated into already-existing input devices, such as the keyboard or mouse.

A fully-operational affective computer is probably years away, but many issues relevant to its design confronted us in this study. For instance, we must be able to present information to the computer in a way that is both ready for analysis, and valid in its reflection of real-world events. We believe that the best starting point is carefully controlled studies, and we offer the following pilot experiment as an initial step toward this goal.

2 The Pilot Study

Our task in developing a study protocol was twofold. First, we wanted to induce an affective state which modeled real life as closely as possible, and which could be tied to an event or events experienced by a computer user. Our second task was to develop methods for synchronizing the physiological data and the computer events.

2.1 Inducing Frustration

Thirty-five subjects participated in a vision-oriented computer game using a (seemingly) traditional graphical user interface. The game consisted of a series of puzzles. Subjects were instructed to click the mouse on the correct answer at the bottom of the screen to advance the screen to the next puzzle, and they received ten dollars for their participation. However, the individual who achieved the best overall score and speed at the end of the data collection was also awarded a one-hundred dollar prize. Thus, an incentive was created to increase the subjects' desire to play the game as fast as possible and receive a good score. Evidence from behavioral psychology suggests that if an individual is prohibited from attaining a specified goal, that individual will experience primary frustration [3]. Based on this evidence, we expected that if we created seemingly random, insurmountable obstacles to attaining a good score in the computer game, our subjects would experience frustration at approximately the same times that the obstacles occurred. We achieved this as follows: At specific, but irregular intervals during the game play, we designed the software interface to simulate the mouse failing or "sticking". Thus, as subjects competed for the fastest score, their goals were thwarted by the failure of the machine. This deception was approved by the MIT Committee on Use of Human Experimental Subjects, and all subjects were thoroughly debriefed upon finishing the study.

2.1.1 Measuring Physiological Indices of Frustration

Three physiological signals have been demonstrated to covary with increased frustration/anxiety: GSR (Skin Conductivity) [2] BVP (Blood Volume Pressure) [4], and EMG (Muscle Tension) [1]. Subjects wore sensors on the first three fingers of their non-dominant hand, and on the non-dominant trapezius muscle (midway between the subject's first vertebra and his/her shoulder).

2.2 Methods for Synchronization

Two dependent measures needed to be synchronized: the physiological signals and the game events (see Figure 1):

The biosensors attached via wires to a ProComp Plus (Thought Technology) analog-to-digital unit. The ProComp unit was connected through fiber-optic cable and adapter to a Toshiba 110CS Satellite laptop PC computer

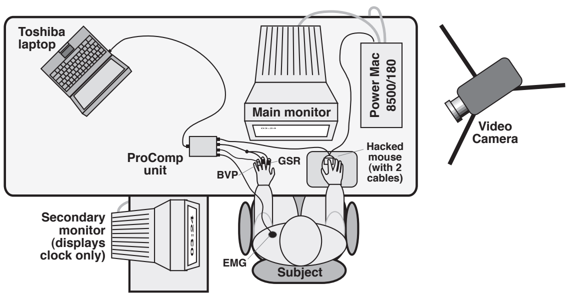

Figure 1: Layout of the experimental setup

with a 10-inch color display. Subjects could not see this display. The laptop computer recorded the signals from the ProComp Plus unit at 20 samples/second, using Thought Technology Software. The game system itself consisted of a Power Macintosh 8500/180 with one large, 21" color monitor that displayed the game, and a second 13" color monitor that displayed a large (124 pt.) digital clock. The sole input device was a standard Macintosh mouse. The mouse had been modified to include a second cable that plugged into both the Power Mac and the psychophysiological sensing system. Each mouseclick yielded both an electrical pulse on the laptop and a textual logfile of mouse click-times and screen-events. This setup served as a critical, high-precision synchronization system between stimulus and biosignals. Additionally, a video camera recorded the subject's upper torso and hands, and the elapsed time of the experiment on the smaller monitor.

2.3 Evaluation and Preliminary Findings

While much of the detailed evaluation of the data continues, the results thus far suggest that this protocol yields highly accurate and synchronized data correlation. Using the two mouseclick-generated files we have been able to correlate physiological signal patterns with game events to within 10 milliseconds of each other - a result unattainable without such a precise coupling methodology. Using this protocol, initial results have yielded distinction between frustration states (defined as the first 10-second interval after the onset of the mouse delay) and non-frustration states in 21 out of 24 subjects using Hidden Markov Models. Detailed analysis of these results is beyond the scope of this paper; however, work continues in the signal processing of this data, and more results will be reported at a later time.

3 Discussion

This study is only an initial step, but the protocol appears promising. Establishing the groundtruth of the user's affect is a difficult problem and has been successfully accomplished in this study. While we are confident in the theoretical basis of our induction method, we did make conservative assumptions about subjects' internal states in order to address the timing issues. Future experiments should include additional means of validating the user's state, either through self-report methods or through independent rating. The signal processing is not yet real time, but this is a goal of our current research that appears achievable. Biosignal monitoring yields data that is easily converted into digital format, and measures it in a potentially unobtrusive manner. In sum, this pilot study presents a reusable method for synchronizing physiological data with real-world events, solving problems inherent in building a computer that can recognize affect.

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