What can a computer learn about emotion from sensing your body?

Rosalind W. Picard
MIT Media Lab; 20 Ames St.
Cambridge, MA 02139
+1 617 253 0611
picard@media.mit.edu

ABSTRACT

Emotion involves both thoughts and feelings, and these in turn involve bodily events that are potentially measurable by computers. These bodily events may include electrical and biochemical changes in the brain, biochemical changes in the bloodstream, potentiation changes in muscles that drive facial expressions, respiration and vocal changes, and many other physiological signals. As computers assume new forms that are wearable, portable, and implantable, they increasingly provide opportunities for natural physical contact with you: they can sense physiological changes as you go about your daily activity, perhaps even in an entirely comfortable and unobtrusive way. In turn, the information they sense can aid in monitoring subtle changes that indicate progress or problems related to usability, health, or activities such as learning. This short presentation highlights a handful of the efforts in the MIT Media Lab aimed at sensing bodily changes that occur in conjunction with emotional events.

Keywords

Affective Computing, Emotion and Physiology, Wearable Computing, Stress monitoring

MAPPING EMOTION TO PHYSIOLOGY

There has been a huge amount of prior work investigating ways in which emotion is or is not revealed in physiological changes. Journals such as *Psychophysiology* and the associated meetings of the Society for Psychophysiological Research (SPR) are rich in reporting such studies and provide a valuable resource for newcomers to this area of research. A recent review of work specifically directed at computer recognition of affect from physiology can be found in the introduction section of a recent article I co-authored (Picard et al, 2001). HCI and ergonomics researchers also have a history of looking at physiological factors – especially heart-rate variability, skin conductivity, and other signals or behaviors that may change with cognitive load or stress. There is a rich and varied literature from which one can draw for constructing investigations into physiology for HCI.

That said, there is still a lot that needs to be done before physiological information can be fully exploited by HCI researchers. In the affective computing group at MIT, we focus on two areas of research related to physiology: First, we aim to design and build physically and psychologically comfortable sensors for gathering information as people go about natural activities. Second, we aim to create algorithms that can detect patterns within a constellation of input signals, and produce outputs that give useful insight into the person's affect for improving a human-computer interaction.

Designing for comfort

Comfort is especially important when measuring affect, because a feeling of a lack of comfort will show up in the signals being measured, and possibly mask the effects of interest. Traditionally, physiological measurements have been taken in laboratory settings with people literally wired to a stack of equipment. They have pre-pasted electrodes stuck to their body, gels applied under other electrodes, wires carefully coiled and taped to their arms and legs, and sometimes a dripping wet electrode cap with over a hundred wires nestled into their hair. Once all of this preparation is complete, then they are told to relax. They cannot get up to use the restroom without the help of an assistant to disconnect them, and they are not likely to have the same "natural" feelings that they would have relaxing in their own home or office environment.

In order to maximize chances for getting natural data, we have tried to restrict our scope to measuring signals that could potentially be captured as you go about ordinary day-to-day activities. Because computer-human interactions assume a variety of forms, e.g., wearable, palmtop, desktop, and these are used in many contexts, e.g. banking, socializing, writing, there can be many solutions to the question of "what sensors will be most comfortable and natural?" Mouse-based sensors appropriate for a desktop or laptop would generally not be appropriate while bicycling or driving a car, although similar signals might be able to be sensed if incorporated into a bicycling glove or steering wheel.

Our concern with comfort has led us to develop a variety of form factors for traditional sensors. For example, we have shown how four traditional physiological sensors can be incorporated into jewelry, shoes, and clothing in an effort to make them not only portable, but also to make them appear playful and perhaps even stylish (e.g., Picard and Healey, 1997). We have also created a wireless, wearable (and washable) glove version of a skin conductivity sensor, which displays the signal level in an intuitive way with a red LED, allowing the wearer to easily interpret the output, and thus learn about his or her skin conductivity changes while going about daily activities (Picard and Scheirer, 2001). These are just some ways in which traditional physiological sensors can be measured without using the traditional apparatus of electrodes, wires, and electronic boxes, which may be unnerving to some subjects. Perhaps more importantly, the making of these new form factors allows researchers and subjects to take the measurement apparatus out of the lab and into environments where the subject can experience a greater variety of naturally occurring emotions.

Crafting new tools for pattern recognition

The problem goes beyond one of comfort and naturalness. Most researchers working in this area have a paucity of analysis tools for inferring information from physiological signals. Typical analyses include examinations of means and variances, usually of one signal at a time, and tests of significance for differences among different conditions. This approach can be informative and useful under controlled conditions; however, it is needlessly limited, especially given many recent advances in signal processing and pattern recognition. Instead of asking, "Do these signals show a significant difference on average?" I like to ask a more challenging question: "What state do these signals indicate for this individual?" I would like the computer to be able to infer *what you are experiencing* and not merely if you and a group of people show a subtle change in some signal once it is averaged across all of you. In this day when computers can be customized to your liking, we could program them to behave as if they truly respect your feelings, and not just the designers' notion of some average set of feelings.

Thus our approach is fundamentally different from the typical mode of inquiry. With this approach we have demonstrated over 80% classification accuracy for long-term recognition (over twenty days of daily recordings) of eight affective states for a single individual using four physiological signals (Picard et al, 2001). These findings indicate that physiology can be useful not only for telling significant differences, but also for beginning to identify the kind of affective state an individual is in.

WORK IN PROGRESS

We continue to develop new analysis tools that can interpret the signals and provide estimates of state such as: Is the user showing signs of frustration? Is she bored or interested? Is she looking tired or distracted? Does she appear confused or look like she is really moving along quite nicely? We have also been working more with facial expressions, posture, and pressure patterns applied to objects the user is in natural physical contact with. The challenge is to develop automated algorithms that extract state information from these physiological signals.

Even if precise labels such as "confusion" or "frustration" can't be confidently provided, the analysis tools can still aim to grade levels of variation that correspond to measurably different behaviors. For example: How does a student behave when all appears to be going well and he chooses to continue with a learning experience vs. how does he behave right before he decides to give up and quit? If such measurable predictors could be obtained with reasonable confidence, then a system could try to intervene in such a way that could encourage the child to persevere with a learning task.

The rest of this presentation will show examples of systems we are developing and preliminary results of their ability to detect physiological changes triggered by usability bugs, boredom, and other cognitive-affective events that give rise to computer-measurable physiological patterns.

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