Combining Multiple Modalities to Detect Learner's Interest

We are interested in combining multiple modalities to detect affect.

So far, most of the work in affective computing focuses on only a single channel

of information. This work extends earlier work by incorporating information from

multiple modalities. The problem is posed as a combination of classifiers in a

probabilistic framework that naturally explains the concepts of experts and critics.

Each channel of data has an expert associated that generates the beliefs about the

correct class using only that modality. Probabilistic models of error and the critics,

which predict the performance of the individual expert on the current input, are used

to combine the experts beliefs about the correct class. We demonstrate the multi-sensor

classification scheme on the task of detecting the affective state of interest in

children trying to solve a puzzle. The sensory information from the face, the postures

and the state of the puzzle are combined in a probabilistic framework and we demonstrate

that this method achieves a much better recognition accuracy than classification based

on individual channels. Further, the critic-driven averaging , which is a special case

of the proposed framework, outperforms all the other classifier combination methods

applied to this problem.

Detection and Analysis of Driver Stress

Driving is an ideal test bed for detecting stress in natural situations. Four types of

physiological signals (electrocardiogram, electromyogram, respiration, and skin

conductivity related to autonomic nervous system activation) were collected in a

natural driving situation under various driving conditions. The occurrence of natural

stressors was designed into the driving task and validated using driver self-report,

real-time, third-party observations, and independently coded video records of road

conditions and facial expression. Features reflecting heart-rate variability derived

from the adaptive Bayesian spectrum estimation, the rate of skin-conductivity orienting

responses, and the spectral characteristics of respiration were extracted from the data.

Initial pattern-recognition results show separation for the three types of driving states:

rest, city, and highway, and some discrimination within states for cases in which the state

precedes or follows a difficult turn-around or toll situation. These results yielded from

89-96 percent accuracy in recognizing stress level. We are currently investigating new,

advanced means of modeling the driver data.

Gene Expression Data Analysis

This research aims to classify gene expression data sets into different categories,

such as normal vs. cancer. The main challenge is that thousands of genes are measured

in the micro-array data, while only a small subset of genes are believed to be relevant

for disease classification. We have developed a novel approach called "predictive automatic

relevance determination;" this method brings Bayesian tools to bear on the problem of selecting

which genes are relevant, and extends our earlier work (with Tom Minka) on the development of

the "expectation propagation" algorithm. In our simulations, the new method outperforms several

state-of-the-art methods, including support-vector machines with feature selection and

relevance-vector machines.

INNER-active Journal

The purpose of the INNER-active Journal system is to provide a way for users to reconstruct

their emotions around events in their lives, and to see how recall of these events affects

their physiology. Expressive writing, a task in which the participant is asked to write about

extremely emotional events, is presented as a means towards story construction. Previous use

of expressive writing has shown profound benefits for both psychological and physical health.

In this system, measures of skin conductivity, instantaneous heart rate, and heart stress

entropy are used as indicators of activities occurring in the body. Users have the ability to

view these signals after taking part in an expressive writing task.

Moral Sensors

The computer's emerging capacity to communicate an individual's affect raises critical ethical

concerns. Additionally, designers of perceptual computer systems face moral decisions about

how the information gathered by computers with sensors can be used. As humans, we have ethical

considerations that come into play when we observe and report each other's behavior. Computers,

as they are currently designed, do not employ such ethical considerations. The subject of this

project will be evaluations that assess the ethical acceptability of perceptual computers.

The goal is to make a perceptual computer that behaves ethically, in the eyes of its users.

More specifically, this project will conduct a series of evaluations of systems that mediate

the communication of affect motivated by different ethical philosophies.

Mouse-Behavior Analysis and Adaptive Relational Agents

The goal of this project is to develop tools to sense and adapt to a user's affective state

based on his or her mouse behavior. We are developing algorithms to detect frustration level

for use in usability studies. We are also exploring how more permanent personality characteristics

and changes in mood are reflected in the user’s mouse behavior. Ultimately, we seek to build

adaptive relational agents that tailor their interaction with the user based on these sensed affective states.

Pattern Recognition and Learning

This project develops basic theories and tools enabling computers to make inferences from data,

such as determining a user's affective states. The approach is Bayesian: formulating probabilistic

models on the basis of domain knowledge and training data, and then performing inference according

to the rules of probability theory. Bayesian approaches have been implemented in the context of

curve fitting, mixture-density estimation, principal-components analysis (PCA), automatic

relevance determination, and spectral analysis. Current work has yielded a Bayesian spectral

analysis tool for nonstationary and non-evenly sampled signals, such as electrocardiogram

(EKG) signals, which outperforms other known methods. We have developed a new adaptive Monte

Carlo method, which can be applied to any generalized linear model and which greatly speeds up

the sampling process. Additionally, we have proposed a new principled way to combine multiple

classifiers in a Bayesian framework. Recently, we have developed Bayesian conditional random fields

for joint classification of structured data, such as sequences, images, and webs.

Personal Heart-Stress Monitor

The saying, "if you can't measure it, you can't manage it" may be appropriate for stress.

Many people are unaware of their stress level, and of what is good or bad for it. The issue

is complicated by the fact that while too much stress is unhealthy, a certain amount of

stress can be healthy as it motivates and energizes. The "right" level varies with temperment,

task, and other factors, many of which are unknown. There seems to be no data analyzing how

stress levels vary for the average healthy individual, over day-to-day activities. We would

like to build a device that helps to gather and present data for improving an individual's

understanding of both healthy and unhealthy stress in his or her life. The device itself

should be comfortable and should not increase the user's stress. (It is noteworthy that stress

monitoring is also important in human-computer interaction for testing new designs.) Currently,

we are building a new, wireless, stress-mornitoring system by integrating Fitsense's heart-rate

sensors and Motorola's iDen cell phone with our heart rate variability estimation algorithm.

Posture Recognition Chair

We have developed a system that recognizes posture patterns in real time, in an unobtrusive way,

from a set of pressure sensors on a chair. This system detects affective states of children in

learning situations, such as when the child is interested, or is starting to take frequent breaks

and looking bored. Leaning forward for long periods of time toward a computer screen and taking

only occasional breaks tends to be a sign of attention (on-task), while slumping in the chair or

fidgeting suggests boredom (off-task). The system uses pattern recognition techniques, while

watching natural behaviors, to "learn" what behaviors tend to accompany which states. The system

thus detects the surface-level behaviors (postures) and their mappings during a learning situation

in an unobtrusive manner so that they don't interfere with the natural learning process. Through

the chair, we can reliably detect nine static postures, and four temporal patterns associated with

affective states.

Robotic Computer

A robotic computer that moves its monitor "head" and "neck," but that has no explicit face, is

being designed to interact with users in a natural way for applications such as learning,

rapport-building, interactive teaching, and posture improvement. In all these applications,

the robot will need to move in subtle ways that express its state and promote appropriate movements

in the user, but that don't distract or annoy. Toward this goal, we are giving the system the

ability to recognize subtle expressions as well as the ability to have them.

Sharing Emotions Through Active Expression

The purpose of the Sharing Emotions Through Active Expression (SETAE) system is to help address

emotional needs and develop emotional understanding. SETAE allows users to reflect actively

upon the emotions related to their situations through the construction of pictorial narratives.

Users will be able to gain new knowledge and understanding about themselves and others through

the exploration of authentic and personal experiences. SETAE employs new, common-sense reasoning

technology, enabling it to infer affective content from the users' stories. SETAE extracts a

similar story from the database and displays it to the users, allowing them to hear real stories,

share their feelings and experiences, and reflect upon these in relation to their personal situations.

We expect that such reflection can facilitate development of new perspectives on dealing with life’s events.

Wearable Relational Devices for Stress Monitoring

This research aims to build a system for data collection, annotation, and feedback that is part

of a longer-term research plan to gather data to understand more about stress and physiological

signals involved in its expression. The first phase consists of building a wearable apparatus for

gathering data. The challenge here is getting as many accurate labels (annotations) from the user

as possible, while he or she goes about natural daily activities. The problem is that getting such

annotations is disruptive, and is itself likely to increase stress, which can interfere with the

signals being measured, and make users less likely to collect a lot of data. The hypothesis is that

some ways of interrupting would be less stressful than others. Thus, the second phase focuses on

implementing different means of interrupting the user for annotations. These ways will be informed

by prior results on both relational and attentional strategies. Overall, this research should

contribute not only a new system for gathering annotations useful for studies of stress, but also

to provide new insights into the value of using relational/attentional strategies in a task that

involves a large number of interruptions.