Sensemo: An Emotion Sensing System using Physiological Cues

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Introduction

Emotion is a mind-body phenomenon. It is dynamic and highly subjective. It arises spontaneously with short-lived affective states and is often accompanied by physiological changes in evoking human reactions and expressions. These changes are mediated by the autonomic nervous system, which controls heart muscle, smooth muscle, and exocrine glands.

Physiological signals have considerable advantages, compared to other methods such as facial expression recognition and speech emotion recognition. We can continuously gather information about a user's emotional changes while he is wearing the biosensors. Moreover, physiological reactions are more robust against possible artefacts of human social masking than facial expression recognition method, since they are directly controlled by the human autonomous nervous system. Work done in psycho physiology provides evidence that there is a strong relationship between physiological reactions and affective states of humans. Hence, the goal of this paper is to devise a system that uses physiological signals to accurately infer emotional states of a person.

Sensemo is a new emotion detection system which uses three bio-sensors— a blood volume pulse (BVP) sensor, a galvanic skin response sensor (GSR), and an electromyography (EMG) sensor. These three unobtrusive bio-sensors help the system read bio-signals such as heart rate, skin conductance and muscle potential from the user in real time. We have built a prototype of the system and evaluated it using data from volunteers. The system is able to detect emotional states such as "pleasant", with an accuracy of 97.4% (with EMG), and 91.6% (without EMG).

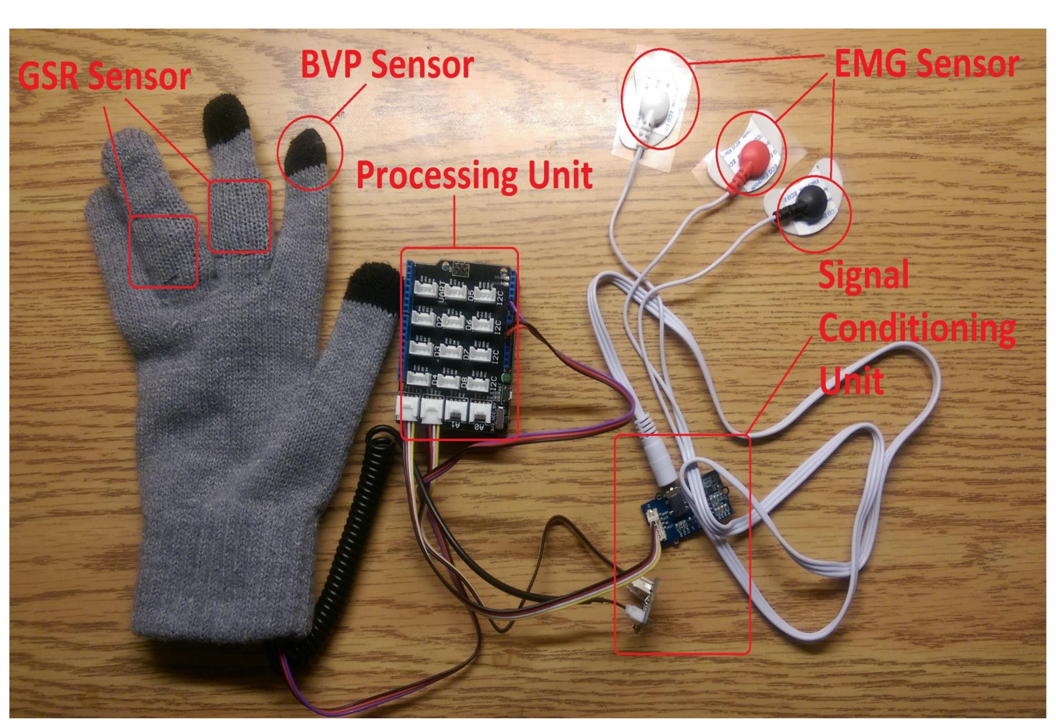


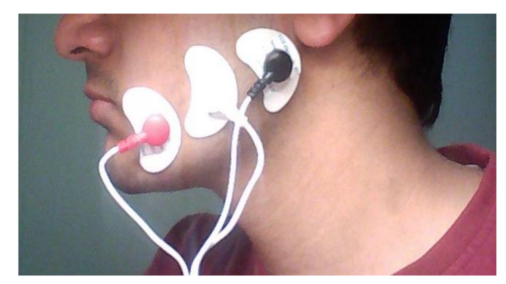
Figure: System prototype of Sensemo

Bio-signals

We use the following bio-signals for detecting emotions-

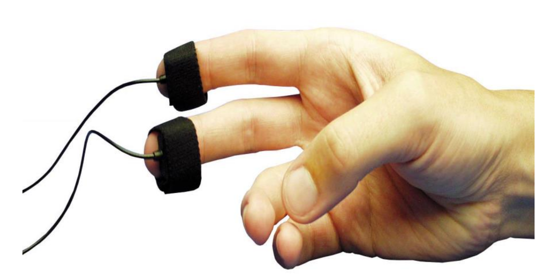
A. Electromyography

- Electromyography (EMG) refers to the muscle activity or frequency of muscle tension of a certain muscle.
- This signal was chosen because high muscle tension often occurs under stress.
- The absolute level of the muscle tension however strongly depends on the muscle where it is measured.



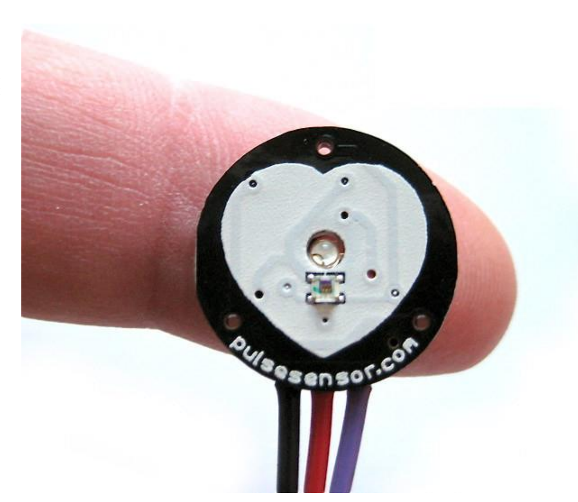
B. Electrodermal activity

- Also referred to as skin conductivity (SC)- basically measures the conductivity of the skin, which increases if the skin is sweaty.
- This signal was found to be a good and sensitive indicator of stress as well as other stimuli and also helps to differentiate between conflict-no conflict situations or between anger and fear.
- It needs reference measurements and calibration, as this signal is also influenced by external factors such as outside temperature.



C. Blood volume pulse

- Blood volume pulse (BVP) is a measure to determine the amount of blood currently running though the vessels, e.g. in the finger of a test subject.
- A photo-plethysmograph (PPG) which consists of a light source and photo sensor are attached to the skin and the amount of reflected light, which depends on the amount of blood, is measured. BVP can be used to measure vasoconstriction and the heart rate.



Results

Different experiments were conducted with and without EMG sensor, to show how it improves the system accuracy. The system showed overall accuracy of 97.4% when using EMG sensor compared to 91.6% without EMG sensor, for a single emotion evaluation, as seen in figures below.

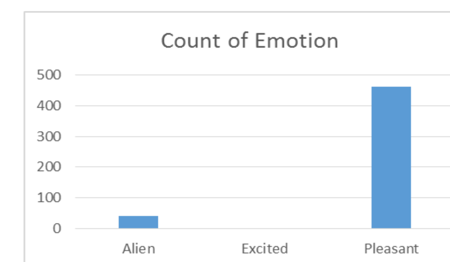


Figure: Evaluation without EMG. The emotion being detected is "pleasant", so other results are errors.

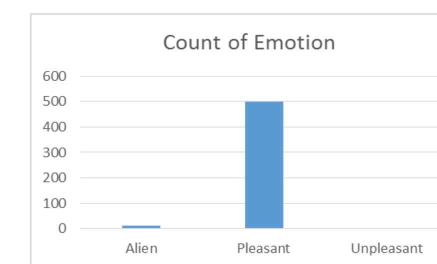


Figure: Evaluation with EMG. The emotion being detected is "pleasant", so other results are errors.

Further, to test the reliability of the system. A different experiment was setup, where different users were made to see music videos while recording the bio-signals. As seen from the figures below the system's response is same for different users for same video. As seen from figure 13, where spikes represent errors, the number of errors between emotion detection of two users during the duration of video are very few.

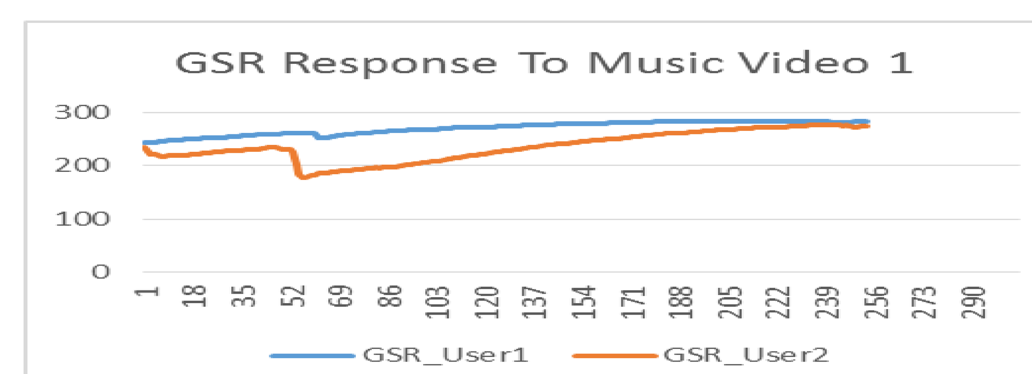


Figure: GSR Response of Two Users for Video 1

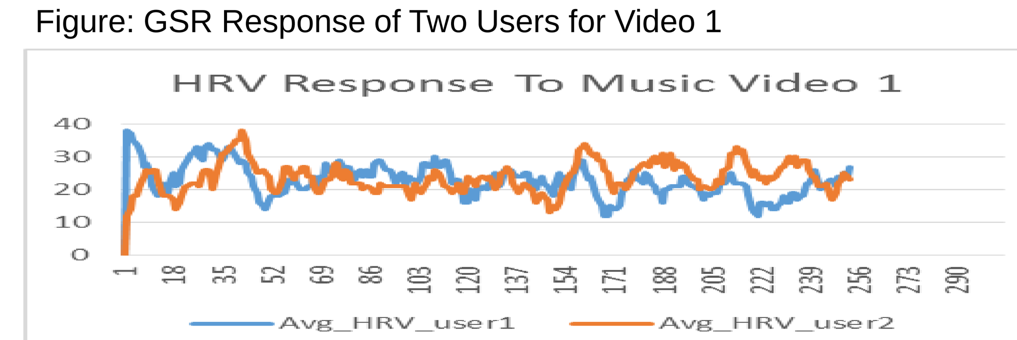


Figure: HRV Response of Two Users for Video 1

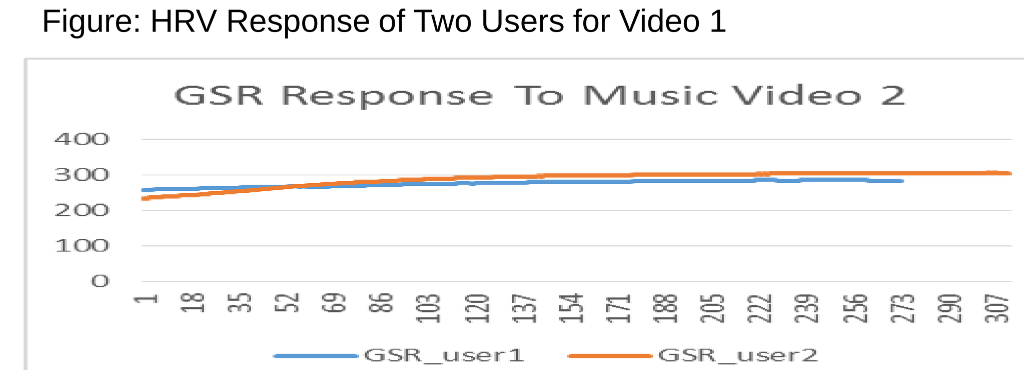


Figure: GSR Response of Two Users for Video 2

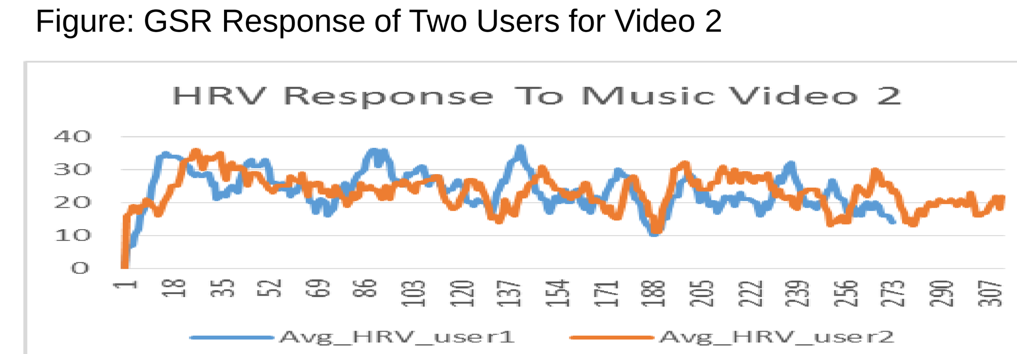


Figure: HRV Response of Two Users for Video 2

Conclusions

The emotion sensing device is capable of reliably gathering data from various sensors in real time and with the help of training, it is able to classify those input data signals into emotional states. The system is capable of detecting emotions with accuracy of 91.6% without the use of EMG sensor and with accuracy of 97.4% with use of EMG. However, in practical situations the EMG sensor is difficult to implement.

With this accuracy and improved efficiency, there are many motivating applications of our system. Some of these are as below.

- *Adaptive Tutoring System*. Sensemo can be used to develop an adaptive e-tutoring system which interprets a user's emotion data, uses the information as a measure of his learning ability, and adapts the difficulty level of the content. Such a system would be able to create a more real effective classroom experience, and keep the user involved.
- *Road Accident Prevention System*. Work-related stress when combined with the difficulties in driving environment (e.g., traffic jams and long drives) impacts our driving performance and can cause fatal accidents. Sensemo can be used to detect a driver's stress and suggests interventions to reduce the stress level of the driver and prevent dangerous situations.

Bibliography

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