Wireless Enabled Remote Co-presence (WERC)

Stress Detection Via EEG

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Introduction

The Wireless Enabled Remote Co-Presence (WERC) system allows a single life coach or personal assistant to remotely monitor and communicate with multiple participants who have cognitive or behavioral challenges. The recipient of these assistive services wears a lanyard suspended smartphone interfaced with various bio-sensors to assess the stress level of a participant (see Fig. 1). In this way, WERC enables voluntary or automatic interventions when the participant becomes stressed in certain situations. By fading remotely delivered services to the minimal level, the recipient gains more independence and sense of purpose in a job setting and/or living environment.

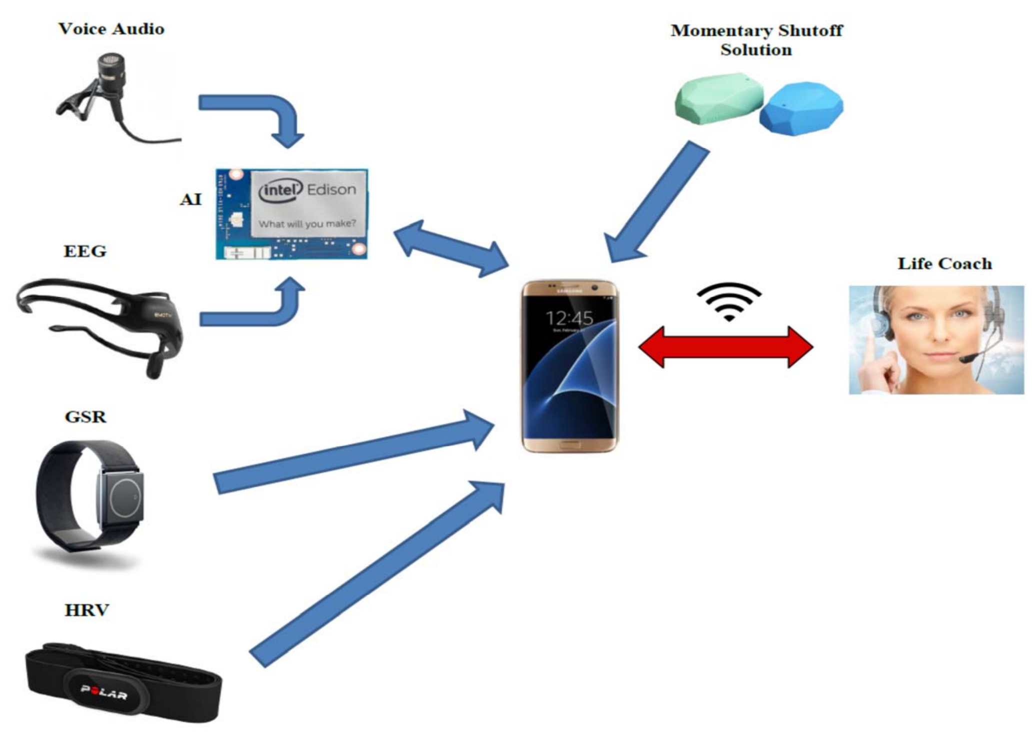

Figure 1. The Design of the WERC system

The bio-sensor element of the WERC system is intended to enable an automatic interventional call to the life coach triggered by the detection of elevated human stress. Galvanic Skin Response (GSR) was used in past years, but found unable to distinguish between positive and negative stress. The WERC team has identified and explored other negative stress measuring technologies to be used in conjunction with GSR: Voice Analysis (VA), Electroencephalography (EEG), and Heart Rate Variability (HRV).

Electroencephalography for Emotion Recognition

Electroencephalography (EEG) measures brainwave signal frequencies, typically using a headset with bio-potential sensors capable of detecting the electrical impulses of the brain. In the past year, the WERCware team used a 5-channel Emotiv headset along with processing metrics and a display tool that reveals levels of emotional states over time. Due to the complexity of data emitted from the headset, we hope to train an artificial neural network (ANN) to recognize human stress from these brainwave patterns, so as to monitor the stress status of a WERCware consumer during non-verbal moments, otherwise undetectable by our Voice Analysis subsystem.

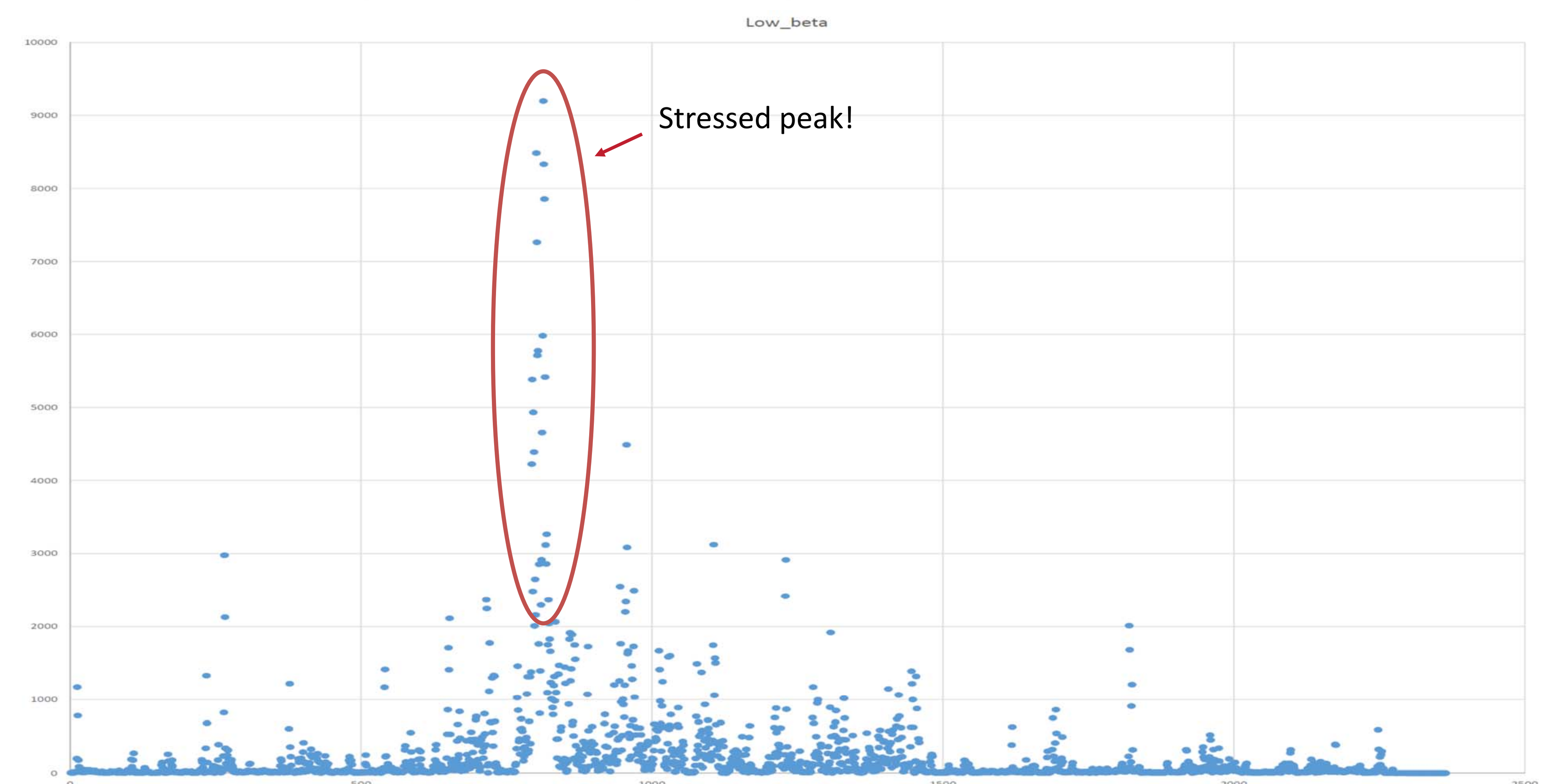

Figure 2. A graph depicting stressed brainwaves from f3 sensor in the low beta frequency band.

Figure 2 above shows what the output of an unprocessed EEG signal. We used a program developed by Emotiv to qualitatively test the headset for emotion detection. The application processes the raw frequency output waves, Theta, Gamma, Beta, and Alpha, in combination with the amplitude of each to determine an emotion state. Since Emotiv currently retains the proprietary rights to these emotion state algorithms, the WERCware team decided to develop an ANN for analysis instead. Some concerns with the current EEG headset include physical discomfort after long periods of use, and relatively short battery life. We expect Emotiv to address these concerns with improvements in their headset product going forward.

Detecting Stress Using EEG

WERC is developing an Artificial Neural Network (ANN) to analyze EEG data in order to detect stress in humans. The ANN is based off of one made in the previous year (see Figure 3) to analyze audio data. It takes raw data from the Emotiv EEG headset and stores it into a thirty second buffer. It processes the buffer every half second into a sum weighted average set of points. This keeps the scale of the data bounded between zero and one while preserving the relative amplitudes. This bounding allows a consistent scale for the ANN to process.

A Java program was written to collect the data emitted from the headset and to store it into a csv file. Data was recorded while the subject was doing six different tasks such as driving, playing guitar, and taking tests. The ANN will be created and trained on this data. After the ANN has been trained, it will use 1500 inputs to analyze a thirty second set of data from all of the sensors on the EEG headset in real time. It is hoped that this method of detecting stress will have results as successful as the voice analysis ANN (~80% accuracy), but initial testing has not yet been completed to determine the accuracy of the ANN.

Figure 3. An example of a 32-input Backpropagation ANN

Clients

The client for the Wireless Enabled Remote Co-presence (WERC) project is Dr. Nancy Patrick. Dr. Patrick is the director of the graduate program in education at Messiah College. She has been involved in advising the project for many years but only recently become the client.

Further Information

More information on Artificial Neural Networks:

Data Mining: Practical Machine Learning Tools and Techniques by Ian H. Witten & Eibe Frank

http://www.natureofcode.com/book/chapter-10-neural-networks/

More information on EEG:

https://emotiv.zendesk.com/hc/en-us/articles/208378593-Frequency-Bands-what-are-they-and-how-do-I-access-them-

Conclusions and Future Work

We have completed building and collecting EEG data to test an ANN for stress detection. Once the testing has been completed, we will be able to determine its accuracy. EEG will likely be used in some combination with Galvanic Skin Response (GSR), voice analysis (VA), and heart rate variability (HRV) so as to validate the detection of negative human stress more reliably and under different circumstances. Next steps will include writing any extra code necessary for these bio-sensors to determine stress from the bio-metric data and port the required code to the Intel Edison platform for analysis. Any stress detected will trigger an automatic call to the coach via the smartphone.

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