Demonstration Paper: bHealthy: A Physiological Feedback-based Mobile Wellness Application Suite

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ABSTRACT

We demonstrate bHealthy, a physiological feedback-based mobile wellness application suite. bHealthy, monitors physiological signals using electrocardiogram, electroencephalogram, and accelerometer sensors; uses a suite of assessment applications to detect mental state of the user; suggests apps to enhance wellbeing; and tracks the performance of the user in the suggested apps. bHealthy also provides wellness reports based on the user's activity in apps over a period of time.

1. INTRODUCTION

The smart phone is an important technological advance which enables several mobile applications such as Musical Heart [1], Transcend [2], and PETPeeves [3] which consider physiological feedback to encourage healthy behavior and hence promote wellbeing of users. The hypothesis is that physiological monitoring paired with capabilities of the smart phone can be combined with a deliberate audio-visual feedback to promote activities that augment user's health. In this regard, feedback from different parts of the body such as the heart, brain, as well as activity and environmental information have been considered. We demonstrate bHealthy application suite, which is a collection of physiological feedback-based mobile applications to assess mental and state of the user, suggest activities that promote user wellbeing, and compile a wellness report of the user. bHealthy consists of two types of applications: a) **assessment** and b) **training**. The assessment applications use feedback from activity, heart signals, and brainwaves to detect mental state of a user, such as frustration, relaxation, boredom, and excitement, and suggest activities. The training applications continuously monitor the activity performance and physiological signals of the user to compute the effectiveness of the wellness application.

2. ARCHITECTURE

Figure 1 shows the architecture of bHealthy, which has five components: a) a set of physiological sensors such as electro-cardiogram (ECG), electroencephalogram (EEG), and accelerometer, b) assessment application to determine the mental and physical health of the user, c) an activity suggestion module, which takes the assessment and suggests training applications that are shown to be effective in changing mental state, and d) training applications, and e) generation of a wellness report. In our implementation, we use Emotiv's Affectiv algorithms, which derive mental state from EEG signals, and two training applications—PETPeeves and BrainHealth. PETPeeves uses accelerometer or ECG signals to determine the heart rate and exercise patterns. BrainHealth uses neurofeedback to aid the user in manipulating mental state while PETPeeves makes use of a virtual pet's mood to keep the user engaged in exercise. The wellness report generator queries each activity app for data regarding how often the user used as well as health data. The data is then compiled and scored to a range between 1 and 10, where 10 is the highest. This score indicates the wellbeing of the user with regard to these apps. The higher the score, the more engaged a user is.

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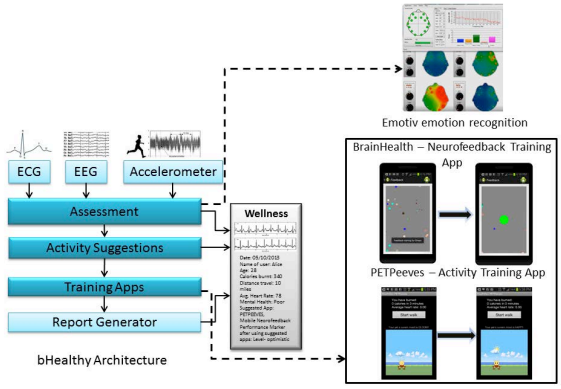

Figure 1: bHealthy Application Architecture.

3. THE APPLICATION SUITE

The application suite consists of a suggestion app which performs mental and physical assessment on the user and makes suggestions of other suite apps to use. The suggestion application also hosts the wellness report generation tool which a user can query training app activity over a period of time and view the report.

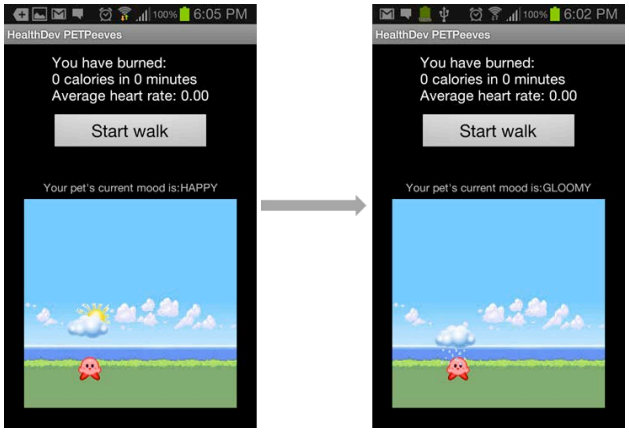

Figure 2: A user about to walk in PETPeeves.

3.1 Assessment Application

The assessment app makes use two physiological signals—EEG and ECG. Using Emotiv's Affectiv algorithm suite [4], boredom, excitement, meditation, and frustration can be extracted and used in assessment. The app also makes use of BSNBench [5], a

physiological processing algorithms benchmark suite, which provides algorithms to extract heart rate, heart rate variability, and low frequency to high frequency ratio from ECG signals. These are parameters used to assess the wellbeing of the user and suggest activities and apps that might enhance their wellbeing.

3.2 Training Applications

3.2.2 PETPeeves: Activity training

PETPeeves is an app aimed to help a user alter their lifestyle to be healthier by presenting the user with a virtual pet whose mood changes based on the amount of exercise the user performs a week. The app makes use of accelerometer, GPS and ECG sensors to monitor the user's heart, calculate calories burned and distance traveled (Figure 2). A user can select different activities, such as walking, running, or bicycling. These activities affect the calculations which determine calories burned. Several surveys have shown the effectiveness of virtual pets in encouraging positive mental state in children [7].

3.2.3 BrainHealth: Mobile neurofeedback training

Neurofeedback has been found to be an effective method for encouraging healthy behavior [6]. This app consists of three feedback activities—focus, mood change, and relaxation. Focus is aimed towards users who suffer from learning disabilities and need a boost in mental performance, motivation, and focus. Mood change is aimed towards users whom are not satisfied with their mood and want to achieve a more positive mood. Lastly, relaxation is aimed at any user who wants to learn how to relax in any situation. The app consists of a visual feedback system which uses particles spread out on the screen. When the user is performing well, the particles are attracted towards the center and combine with each other. However, when the user's performance degrades, the particles begin to split and move towards the edges of the screen. The particle system is manipulated by a single ratio, which is calculated by filtering one second of data, removing the DC offset and channels which are not relevant for the selected feedback activity. The data is then passed through a Hamming Window and each chunk has power spectral density (PSD) estimator ran on it. A ratio based on two bands is calculated from the PSD. The bands consist of one or more ranges of frequencies the user should excite or inhibit. To calculate the ratio the PSD of the excitement band is taken over the PSD of the inhibit band.

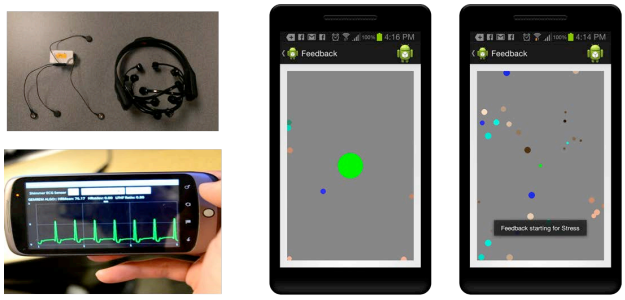

Figure 3: a) Sensor hardware and smart phone; b) particles solidifying and breaking with user's state of mind.

4. IMPLEMENTATION

The assessment and training applications in bHealthy require sensed physiological signals as input. This requires programming a sensor and interfacing it with a smartphone. bHealthy uses Health-Dev [3], an automatic code generator for programming sensors and developing a basic sensor interface application in the smartphone. The sensor interfacing application creates a database for each physiological signal, which any assessment, training and performance monitoring application can read. The assessment app can either be implemented in the sensors or in the smartphone. The activity assessment application is a combination of both smartphone and sensor application. The sensor calculates the heart rate obtained from ECG and the smartphone uses this data to make an assessment. Assessment is performed by either monitoring mental state for a period of time and making a recommendation or by measuring the user's ECG signals for a period of time then instructing the user to perform some form of exercise for a second period of time. The difference in heart rate between the baseline and the exercise state is used to determine if the user should make use of the PETPeeves app. The two training applications interact by sharing a physiological database that is created by the sensor interface obtained from Health-Dev. The training applications also store information about the app in their own database, which can later be queried by the wellness report generator. The information ranges from PETPeeves' pet mood, average heart rate during app usage, to the processed mental state ratio from BrainHealth.

5. Demonstration

The demonstration setup will include Shimmer ECG sensors and Emotiv EEG sensors, a laptop and an Android smart phone. The presenter will wear the ECG sensor while the viewers can try out the EEG sensor. Viewers will be able to see the effect of using the BrainHealth application with their own EEG signals. The EEG sensor will be connected to a laptop which will log the EEG signal and push it to the phone via Wi-Fi or 4G connections.

6. CONCLUSION

In this paper, we demonstrate a wellness suite which uses physiological feedback and generates wellness reports for the user. The wellness suite consists of an assessment and suggestion app as well as training applications such as PETPeeves and BrainHealth. This project is partly funded by NSF grants CNS #0831544 and IIS #1116385. Special thanks to Google for Android phones.

7. REFERENCES

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