Kalpa Publications in Computing

Volume 14, 2023, Pages 88–91

Proceedings of V XoveTIC Conference. XoveTIC 2022

Smart bracelet for anxiety

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Abstract

This paper introduces a novel non-invasive wearable device that can infer whether people are suffering from anxiety or not. The device allows capturing physiological signals such as: electrodermal activity (EDA), skin temperature (ST), electrocardiography (ECG) and photoplethysmography (PPG), and provides an estimation of blood pressure -through the pulse transit time (PTT) technique- and breathing rate (BR) -by analyzing the heart rate variability-. The hardware also includes an SD card to store the signals for offline processing in laboratory tests.

1 Introduction

Nowadays, anxiety is the leading mental disorder that affects up to a 3.4% of the population. It has been estimated that, in the following ten years, as a consequence of the anxiety or the emotional stress, the depression will dramatically increase, becoming the main cause of mental disorder [8]. Anxiety and stress are very common in our society and we need to deal with it to keep a healthy mental state.

Anxiety is a psycho-physiological response characterized by continuous fear, apprehension and increased vigilance in situations of danger or potential threats to the integrity of the organism. The American Psychological Association (APA) defines anxiety as '*an emotion characterized by feelings of tension, worried thoughts and physical changes like increased blood pressure (BP)*'. Anxiety occurs when the amygdala is electrically stimulated [2]; this brain area is capable of recognizing dangerous situations and initiating a physiological response through the activation of the sympathetic nervous system. Anxiety may be physically manifested through eye movements -greater number of fixations and avoidance of gaze-, facial expressions, and an increase in BP and sweating [6, 1] among other variables. We prefer to analyze biosignals for anxiety detection because facial gestures may be hidden by certain level of self-control [1].

The emotional activation triggers a physiological response that encompasses an increase in the body temperature, sweating, BR, tachycardia, dry mouth, high BP or low skin impedance, among others. These involuntary responses will be more intense if the subject cannot cope with object that provoked the emotional response [1, 10].

This contribution proposes the design of a wearable that can measure electrodermal activity (EDA), skin temperature (ST), electrocardiography (ECG) and photoplethysmography (PPG) to detect the changes that the anxiety causes on them.

2 Material and methods

The wearable is based on the Arduino Pro Mini and fulfills the terms of Open Source Hardware. The design includes the same ECG, EDA and ST modules as in [4], and an adapted version of the PPG circuit shown in [7] so that it can operate correctly on the wrist.

The Arduino was programmed with the BSP library [9]. All of the physiological signals were sampled at a 256-Hz rate and stored on an SD card through the OpenLog module. Figure 1 Left shows the system interconnection scheme. Unlike other wearable devices that use Bluetooth for continuous data transmission, we decided to use the SD card to reduce power consumption and extend the battery lifetime.

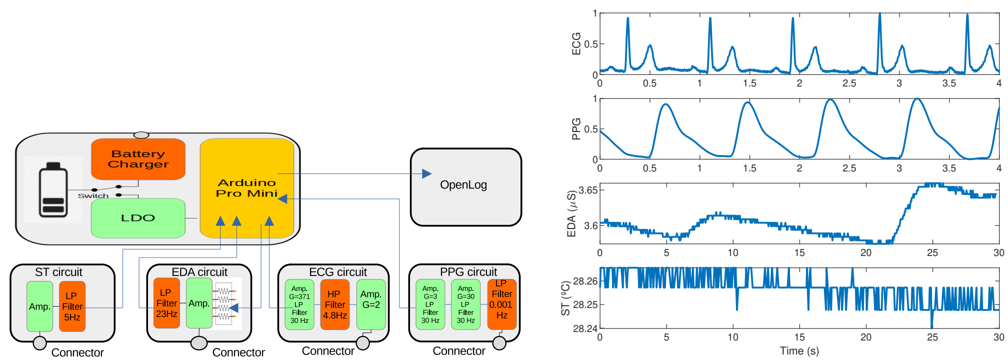

Figure 1: Left: Block diagram of our design, which contains a battery charger, a LDO, a battery checker, an Arduinio Pro Mini, an OpenLog module, and modules for the measurement of ST, EDA, ECG, and PPG. Right: captured signals, ECG and PPG are normalized.

Since the modules used for phyisiological signals were tested in [4, 7], there is no need to conduct a similar analysis in this work. We performed a test for the OpenLog module to check missing data. To do that, we connected an FTDI module, in parallel to the USART used by the OpenLog module, to send the data to the computer at the same time that they are stored in the SD card. The experiment took one hour.

3 Results and discussion

The data integrity test showed no data loss during the storage. Therefore, the use of an SD card is a feasible alternative for long-duration experiments when no near-real-time data is needed. OpenLog consumes a maximum of 23 mA according to the manufacturer, while the Bluetooth HC-05 module consumes about 40 mA. This results in an energy saving of near 50%. Although no new quality tests have been performed on the signals obtained, it has been verified that the device was within the levels of the previous works.

Even though it may seem redundant to have include ECG and PPG in the design, they were included to estimate the blood pressure through pulse transit time (PTT) [7, 3]; i. e., the elapsed time for the blood to travel from the heart to the wrist. The respiratory rhythm can also be derived from the ECG or PPG using spectral analysis [5].

At the current stage of development, the signal processing is performed off-line. We are now developing the algorithms that the wearable processor will execute. That algorithm computes the signal's variability and sets a warning indicator so that the user can activate her/his self-regulation mechanisms.

4 Conclusions and future works

The selected physiological signals are effective anxiety markers and can be detected by sensors efficiently, non-invasively and inexpensively. Health monitoring helps people gain control over their health, improve significantly their quality of life and prevent anxiety attacks.

5 Acknowledgments

This research was funded by: (a) project AAI, Grant PID2019-104323RB-C32 funded by MCIN/AEI/ 10.13039/501100011033, (b) project AIRPLANE, with reference PID2019-104323RB-C31, of Spain's Ministry of Science and Innovation; and (c) project CM/JIN/2019-022 of the University of Alcalá.

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