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Sensors for stress detection: first analysis

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Abstract. Since 2020, due to the pandemic caused by the COVID-19 virus, the world has come to a standstill, causing the isolation of the population. The vulnerability perceived by the population, as well as the lock-down, have wreaked havoc on the physical and emotional health of most people. One of the main conditions has been stress, which can trigger other conditions such as heart issues, anger, depression, among others. Therefore, at the Autonomous University of Hidalgo State, in the Software Engineering degree program and in collaboration with institutes as the Technologic Institute of Zacatepec, we have proposed to implement a development based on Arduino and biometric sensors which allow monitoring bio-signals to determine the user's perceived level of stress, through connection with a mobile application. For this reason, this document is based on researching, comparing, and analyzing the sensors to be applied to the final project.

Keywords: Stress; Covid-19, EMG, EEG, ECG, Galvanic skin response.

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1 Introduction

The objective of detecting and mitigating stress immediately to avoid the problems caused by the disease, gives a place to the importance of medical technology that is present from diagnosis to treatment. To carry out measurements and detections in patients, the main characteristics of the physiological systems of the organism must be considered, such as the cardiovascular system, the nervous system, and the respiratory system.

That is why this research seeks to carry out a non-invasive detection of these physiological data, in a simple way and without the need for an expert doctor, but using electronic instruments, artificial intelligence and data analysis with the use of mobile devices and applications.

On the other hand, it should be noted that from the analysis of the sensors to be used, the creation of a bracelet device has begun, which will allow the interconnection of the sensors and components to be carried by the user during the acquisition of bioelectric signals.

For this reason and as the beginning of this research, this document focuses on describing some of the sensors and devices that can be used, as well as the description of the signals that can be obtained from them.

2 Bio signals

The term 'Bio signal' is applied to all types of signals that can be continuously measured and controlled in biological entities and refers to electrical and non-electrical bio signals. A signal is defined as an information transmission channel whose acquisition allows obtaining information about the source that generated it. In the case of bio signals, the sources are the different physiological systems of the organism.

The capture of bio signals allows obtaining data to be processed and analyzed to find the association of an event to a particular situation.
To determine what type of bio signals could indicate the existence of stress, this research is based on studies such as the one published by [1] y [2], for which has determined the type of bioelectrical signals described below.

2.1 Electroencephalogram

The recording of the bioelectric potentials generated by the neuronal activity of the brain is called an electroencephalogram, which has waveforms that vary according to the location of the measuring electrodes on the surface of the head [3].

EEG bio signals represent the combined effect of neuronal potentials from a wide region of the cortex and from different points within. An awake or attentive person presents an asynchronous high-frequency EEG. On the other hand, a fatigued person produces a rhythmic activity around 8-13 Hz.

The EEG frequency is affected by a person's mental activity. Another type of EEG measurement is the evoked response, which is a measure of the alteration of the EEG signal produced by an easily repeatable external stimulus. Table 1 describes some of the EEG sensors that have been analyzed.

Table 1. EEG sensors analyzed.

Name	Application	Description
Electroencephalography Sensor (EEG) PLUXSKU: RB-Plu-47 Manufacturer number: SENSPRO-EEG [4]	Evoked potential analysis Neurofeedback Sleep studies Human-computer interaction Neurophysiology studies Psychophysiology	Single channel differential sensor With two measuring electrodes and an elastic headband For classic and localized EEG measurement Gain: 40000 / Range: ±37.5µV (with VCC = 3V) Bandwidth: 0.8-49Hz / Input Impedance: >100GOhm Pre-conditioned analog and medical grade raw data outputs Specifications Gain: 40000 Range: ±37.5µV (with VCC = 3V) Bandwidth: 0.8-49Hz Consumption: ~3mA Input impedance: >100GOhm CMRR: 100dB
Cyton Wireless EEG Module [5]	The OpenBCI Cyton plate allows obtaining electroencephalogram, electromyogram, and electrocardiogram type bio signals.	The OpenBCI Cyton board is an Arduino-compatible 8-channel interface with a 32-bit processor. The OpenBCI Cyton board implements the PIC32MX250F128B microcontroller, giving it large local memory and fast processing speeds. The board comes pre-flashed with the chipKIT™Bootloader and the latest OpenBCI firmware. Data is displayed at 250Hz on each of the eight channels. The OpenBCI Cyton board can be used to test brain activity (EEG), muscle activity (EMG) and cardiac activity (ECG). The board communicates wirelessly to a computer via the OpenBCI USB dongle using RFDuino radio modules. You can also communicate wirelessly with any Bluetooth Low Energy (BLE) compatible

mobile device or tablet.

2.2 Electromyogram

Bioelectric potentials associated with muscle activity constitute the electromyogram (EMG). They can be measured on the body surface near the muscle of interest or directly into the muscle by piercing the skin with needle electrodes. Since most EMG measurements obtain the activity of one or more muscles, rather than an individual muscle fiber, the signal is a sum of individual action potentials of the fibers that make up the muscle or muscles where it is measured [6].

EMG electrodes collect potentials from all the muscles in their range. This means that potentials from nearby large muscles can interfere with attempts to measure the EMG of small muscles, even when the electrodes are placed directly over the small muscles. The amplitude of the measured EMG waveform is the instantaneous sum of all potentials generated at the same instant. Since these action potentials occur with both positive and negative polarities at a given pair of electrodes, they sometimes add up and sometimes cancel out. Thus, the EMG signal resembles random noise, the energy of the signal being a function of the amount of muscle activity and the placement of the electrodes [7]. Table 2 describes the EMG sensors that have been analyzed.

Table 2. EMG sensors analyzed.

Name	Application	Description
Electromyography Sensor EMG [8]	The EMG Electromyography Sensor detects small muscle signals, amplifies, and filters them so that the resulting signal can be read by a processor such as Arduino or similar.	3.5mm jack 6 disposable electrodes Supply voltage: 3.3V-5V 1m cable Does not require additional voltage supply Range: ±37.5μV (with VCC = 3V) Bandwidth: 0.8-49Hz Consumption: ~3mA Input impedance: >100GOhm CMRR: 100dB
EMG Hessenboom	Electromyographic sensor module	Compatible with Arduino Uno
Electromyography Sensor Muscle V3 Sensor [9]	1. The EMG sensor is used to measure muscle activity by detecting the electromyogram (EMG). 2. The muscle signal sensor is traditionally used in medical research. 3. Electromyography circuit and sensor can be used in a variety of control systems. 4. EMG power supply continues to emerge with smaller but more powerful microcontrollers and ICs. 5. This muscle signal sensor is specifically designed for microcontrollers, convenient to use.	Compatible with Arduino Uno Condition: 100% New Item Type: EMG Sensor Material: semiconductor Send data: Compatible for breadboard Voltage: + -9V dual power supply, minimum + -3.5V Product Size: Approx. 25 x 26 x 10mm/0.98 x 1.02 x 0.39in Weight: Approx. 40g/1.4oz

a. Galvanic Skin Response

The function of the eccrine sweat glands is linked to the regulation of body temperature. The afferent pathway originates from various thermoreceptors (cutaneous and hypothalamic) that emit impulses through the spinal cord and thalamus to the hypothalamus, where sensory signals are integrated. Sweating also has an emotional control component (emotional sweating) regulated by the anterior cingulate cortex and the limbic system [10].

When a small voltage is applied to a superficial area of the sweat glands through a stainless-steel sensor, an electric current is created due to the electrochemical reaction.
Due to this low voltage, the stratum corneum acts as a capacitor and only allows the transmission of sweat ions. This ensures that the measured electrical current (conductance) corresponds exclusively to the sweating function. This measure is also called Galvanic Skin Response and is measured in micro siemens μS [11]. Table 3 describes some of the GSR sensors that have been analyzed.

Table 3. GSR sensors analyzed.

Name	Application	Description
GSR Galvanic Skin Resistance Sensor [12]	The GSR Sensor allows you to detect emotions by placing electrodes on two fingers on one hand. It is an interesting option to create projects related to emotions, such as sleep quality monitoring.	finger straps for electrodes Input voltage 5V / 3.3V Output analog signal Adjustable sensitivity via a potentiometer
EMG Hessenboom	Electromyographic sensor module	Compatible with Arduino Uno
Grove - GSR V1.2 Electrical Conductance Sensor [13]	Grove - GSR allows you to detect such strong emotions simply by placing two electrodes on two fingers of one hand. It is interesting to create projects related to emotions such as the sleep quality monitor. This version V1.2 the change of this sensor is the following, add C3 100nf between M324PW-TSSOP14 and GND. The sensor works with Arduino and Raspberry.	Operating voltage: 3.3V / 5V Sensitivity: Adjustable by means of a potentiometer Input signal: Resistance, NO conductivity Output signal: Voltage, analog reading Finger Contact Material: Nickel

3 Results

a. Interconnection design of bracelet sensors

From the analysis of some sensors to be used, the creation of the design of a bracelet device has begun, which will allow the interconnection of the sensors and components to be carried by the user during the acquisition of bioelectric signals.

Fig. 1 shows the proposed diagram of the first structure of the device under development in its beta version. This device will be controlled by the mobile app which is also under development.

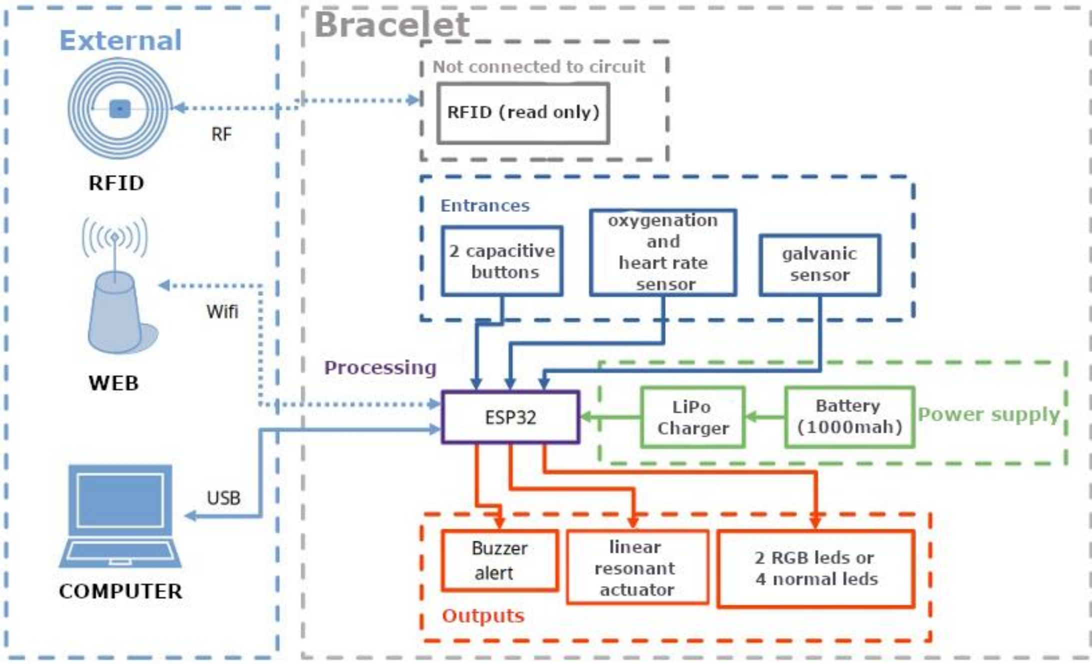

Fig. 1. Bioelectric signal acquisition device box diagram (produced by ITZ 2023).

4 Conclusions

Through this analysis ‘it has been possible to identify some of the low-cost sensors necessary to detect the existence of stress in users and although the experimentation has not yet begun, it has given the preamble to know the basic electronic requirements that are needed to develop this closed-loop system.

On the other hand, and although this document does not mention it, the filtering and interpretation system for the acquisition of bioelectrical signals is in its initial phase, as well as the study and analysis for the generation of user interfaces that will be implemented for the control of the closed-loop system that will allow the user to mitigate perceived stress.

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