Integration of a recording and BLE transmission system for brain bioelectrical activity based on IoT devices

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***Abstract*—Thanks to IoT applications, it is possible to offer people with disabilities the help and support they need to achieve a good quality of life and enable them to integrate into social and economic life. This document will focus on the integration of IoT devices with an EEG sensor using a Bluetooth Low Energy (BLE) connection to design and implement an HW / SW platform which allows people with disabilities to interact with the environment by recording their brain bioelectrical activity and further processing it.**

Keywords: *IoT, BLE, EEG, Eye blinking.*

I. Introduction

In recent years, the continuous transformation of Information and Communication Technologies (ICT) has drastically changed the way we live. One of the key aspects in which this fact is reflected is in human interactions through Internet. The increase in the number of devices connected to the network and the possibility of exchanging information between them has led to an evolution of the use of the Internet.

At this point, the concept of *Internet of Things (IoT)* arises. The basis of this concept is the use of Internet to interconnect objects with each other, creating an intelligent and easily accessible environment [1]. The IoT model contemplates an interaction based on ubiquitous computing, understood as the integration of common devices, with which they can interact to perform daily activities [2].

It is expected that, thanks to IoT technologies, it will be feasible to develop devices with very low cost that guarantee a more independent life for users with disabilities. In this field, several manufacturers have developed electroencephalogram (EEG) sensors that can be integrated with different platforms, in most cases through proprietary solutions, based on the use of wireless technologies, which allows transmitting, especially in the case of people with physical disabilities, neurophysiological signals from the brain [3].

II. TGAM Module

The device used to record the EEG waves is the Mindflex product, that is based on the *ThinkGear ASIC* chip (ThinkGear ASIC Module, TGAM), shown in Fig.1. This chip is not compatible with Bluetooth nor with BLE. Therefore, the first step is to modify the hardware of the TGAM module in the Mindflex device to access the information recorded by it, and send it through a serial TTL link to an IoT device, through a connection to the RX / TX pins [4].

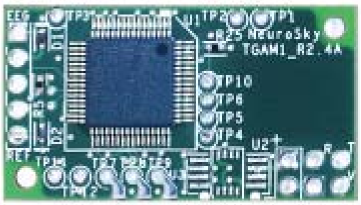

Fig. 1 -TGAM Module

III. ThinkGear Data Packets

The TGAM module is able to send signals collected by the EEG sensor in two modes: NORMAL mode and RAW mode. In NORMAL mode, the data contained in a ThinkGear packet are: Signal Quality Value, Attention level, Meditation level, and values from the 8 power bands of EEG. Otherwise, in RAW mode, the TGAM module provides a value of 16 bits (2 bytes) representing the value of each sample in the decimal range from -2048 to 2047.

IV. IoT Devices Integration

The devices chosen for the development of the proposed platform have been the Bluz DK device [5], shown in Fig. 2, and the RedBear Duo device [6], shown in Fig.3, due to its low cost, its programmability, its open source utilization, and the connectivity requirements to carry out the proposed objective.

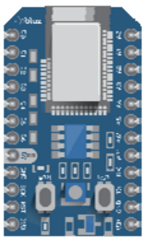

Fig. 2 - Bluz DK

Fig.3 - RedBear Duo

The RedBear Duo device will act as *Central* and detect the blink of the eyes from the value of the RAW samples transferred in BLE packets from the Mindflex device connected directly through the serial interface to the Bluz DK device, acting as *Peripheral*, to emulate a capable device to record the EEG information and transmit it via a BLE connection, as schematically shown in Fig. 4, which represents the target scenario.

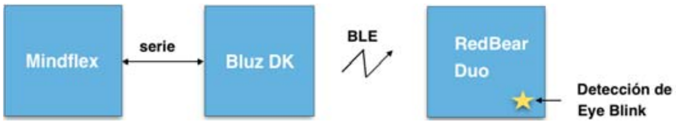

Fig. 4 - HW/SW Platform

V. EEG Signal Processing For Eyeblink Detection

The proposed algorithm for eye blinking detection is based on the EEG signal shown in Fig. 5. Thus, about the duration of the signal observed in the EEG when blinking eyes in various sources, it is stated that its duration is generally in the range of 200 milliseconds to 400 milliseconds, initially presenting a positive peak in its amplitude, followed by a negative peak of smaller amplitude [7].

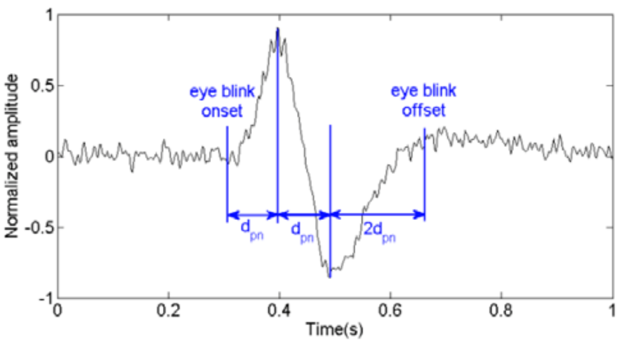

Fig. 5 – EEG signal characteristics for eye blinking

Taking this behavior as a reference, an algorithm to detect eye blinking was developed, and the IoT devices of the BLE platform were programmed, giving as a result the experimental detection of eye blinks on the RedBear Duo from the RWA samples received via BLE from the Bluz DK device connected to the TGAM module integrated in the Mindflex product, as shown in Fig. 6.

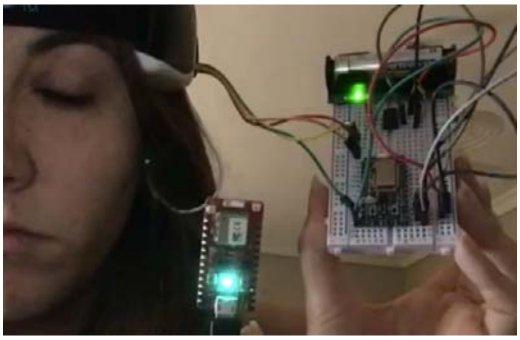

Fig. 6 – Final system used to detect eye blinking

VI. Conclusions

The platform developed in this Master's Degree Project, based on the use of IoT devices, aims to allow people with physical disabilities to interact with the environment around them from the recording of brain bioelectrical activity and its subsequent processing.

This work has led to the identification of a problem in the firmware of the Bluz DK device, related to CCCD reading, which was communicated to the developers forum, recognized and corrected in the 2.1.50 release.

In addition, a limitation related to the number of packets sent per connection interval by the RedBear Duo device as *Central*, related to the Broadcom BCM43438 chip integrated into the RedBear Duo device was also detected. This limitation is under study by Cypress, the developer of the device.

References

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