Live Demonstration: Event-Driven Hand Gesture Recognition for Wearable Human-Machine Interface

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***Abstract*—The demonstration presents a wireless system to control video games with user hand movements. Muscles activity is detected by applying the Average Threshold Crossing (ATC) technique to the surface ElectroMyoGraphic (sEMG) signals acquired from two sets of electrodes on the user forearm. Three hand movements and an idle state are classified in real-time on a computer by implementing a Neural Network (NN) feeded with the acquired ATC values, with accuracies above 97 %. Recognized gestures are then mapped to keyboard inputs to control the maneuvers of a game character.**

***Index Terms*—Surface ElectroMyoGraphy, Event-Based, Neural Networks, Gesture Recognition, Human-Machine Interfaces**

I. Overview

Human motion recognition is currently a widely studied topic in the research for biomedical applications and Human-Machine Interfaces (HMI) [1]. Within the most widespread approaches, the surface ElectroMyoGraphy (sEMG) is employed to acquire muscle activity information through non-invasive electrodes placed directly on the skin.

In our research, we applied the Average Threshold Crossing (ATC) technique on board, thus avoiding the use of the Analog to Digital Converter (ADC) to fully and continuously digitize the signal and minimizing the data throughput for wireless communication [2]. This event-driven approach consists in comparing the sEMG signal with a suitable threshold and generating an event each time the threshold is crossed. The TC events are then counted in a time frame (e.g., 130 ms), resulting in a value highly correlated with the muscle activation [2].

Based on our recent work [3], the ATC values of two acquisition devices, placed on *Extensor Carpi Ulnaris* and *Palmaris Longus*, are transmitted to a computer via a Bluetooth Low Energy (BLE) communication. Three movements (wrist extension, wrist flexion, grasp) and an idle state are classified in real-time by a fully connected Neural Network (NN) followed by a robustness routine (taking as input two or more consecutive NN outputs).

The experimental setup, including the two acquisition channels and the gaming application, is shown in Fig. 1. Both the NN implementation and the Graphical User Interface (GUI) for system control, including the keyboard emulation, have been developed in the Python programming language. The recognized movement is used to directly control the Space Invaders cannon making it go right, go left, fire, or stay still.

System testing has shown good classifier performance, obtaining an accuracy of 97.89 %. Moreover, the very low current absorption of 0.48 mA brings each device to run for about 230 h (considering a 110 mAh small battery), making it a promising solution in different fields, from the interactivity in gaming to the control of body prostheses.

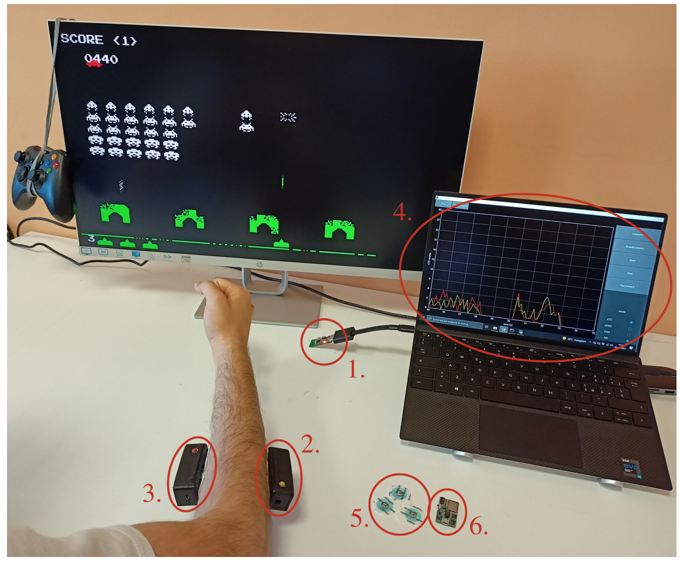

Fig. 1. System setup: 1) Bluetooth receiver; 2) Acquisition device on *Extensor Carpi Ulnaris*; 3) Acquisition device on *Palmaris Longus*; 4) System GUI while plotting ATC values; 5) Employed electrodes; 6) Involved PCB.

II. Visitor experience

Visitors can participate in a multi-game session by experiencing the wearable hand gesture recognition system. A brief setup phase will be required to find the proper position for the two sets of electrodes.

The employed electrodes are standard medical disposable ones, which could leave the forearm a bit sticky afterwards but ensure proper sterilization according to Covid-19 regulations.

References

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