Live Demonstration: A Wearable Armband for Real-Time Control of Multi-DOF Robotic Actuators

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Andrea Mongardi, Fabio Rossi, Andrea Prestia, Danilo Demarchi, Paolo Motto Ros
Department of Electronics and Telecommunications, Politecnico di Torino, Torino, Italy, Email: andrea.mongardi@polito.it

***Abstract*—This demonstration presents a smart wearable armband for hand gesture recognition interfaced with a 6-DOF robotic arm which actuates the user's movements. The armband is composed of seven modules which detect the muscular activity beneath them, fuse the data together, predict the performed gesture, and transmit the high-level information to an external computer via a Bluetooth Low Energy (BLE) communication. There, a software module transforms the sequence of gestures into consistent commands for the robotic arm. The observed responsiveness and accuracy make this armband suitable for the real-time control of robotic limbs in mixed reality scenarios.**

***Index Terms*—Embedded Systems, Event-driven, Gesture Recognition, Human-machine Interfaces, Real-time Control**

I. Overview

In the last decade, the use-case for the majority of devices involving bio-signals acquisition has moved from the simplest monitoring task (either long or short term) to the more complex and diversified world of Human-Machine Interfaces (HMI). Indeed, researchers focused their effort towards smart solutions to increasingly connect human beings to their surrounding environment, allowing them to interact with technology in the easiest way possible. In this scenario, the human hand grabbed the spotlight as the most natural controller and many different techniques are still competing to be selected as the most efficient at extracting hand gestures data while being non-invasive and promoting devices wearability [1].

In this demonstration[1] we present an application use-case of a recently prototyped armband for hand gesture recognition [2], involved as the interface between the human forearm and the 6-DOF Tinkerkit Braccio by Arduino®, here used to prove the responsiveness and accuracy of the implementation. The modular armband is made of 7 identical devices [3] interfaced with each other by an I^{2}C daisy-chain loop. The common role of each device is the event-driven processing of the underlying muscle activity, and the communication of the extracted feature to the next device in the loop. The master board, aligned on the *extensor digitorum* muscle, is wirelessly connected with a laptop to exchange user commands and acquired data. The last slave of the loop is equipped with a shallow Artificial Neural Network (ANN), able to recognize up to 8 movements and the idle state with average prediction accuracy and latency equal to 91.9 % and 1.34 ms, respectively.

Fig. 1 represents the demonstrative scenario, which involves the wearable armband, Braccio (with its Arduino® shield), the dedicated Graphical User Interface (GUI), and the target object (e.g., a bottle) to be moved. The armband must be placed at the proximal 1/3 of the user's forearm, to maximize the detection of muscular activity. Then, the GUI is run to let the user control the system: the armband and Braccio are connected and configured; after that, the transmission between the two can be started or stopped anytime. To ensure an effective and smooth operation of Braccio, with a latency within 300 ms, a trajectory planning/control software module, integrated in the overall GUI application, generates low-level actuation commands from received gesture predictions.

[1]A preview is available at https://youtu.be/B7kBvCXB1rY.

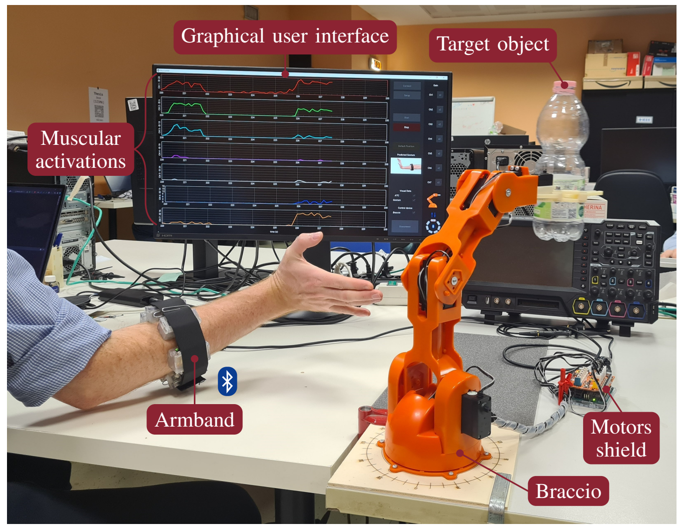

Fig. 1. System setup while performing wrist extension to control the clockwise rotation of Braccio.

II. Visitor Experience

The visitor can view and eventually participate to the control of Braccio to feel the effective responsiveness of the hand gesture recognition. The armband is totally non-invasive and its dry electrodes do not require any conductive gel.

References

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