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Myo Armband for Upper-Limb Prosthesis Control

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***Abstract*— This article presents a compact myoelectric bracelet incorporating eight surface sensors for upper limb prosthesis control. It outlines the fundamental anatomical and physiological principles underlying surface electromyography. The operating principles and optimal placement of the Myo Armband are described in detail. The hardware platform for signal acquisition and analysis, along with its components, is presented and illustrated. The selection of the Myo Armband as a suitable instrument for myoelectric signal studies is justified through comparison with related devices. An interactive interface was developed using an existing MATLAB library. This interface enables real-time signal visualization and the application of various filtering techniques. The updated system provides a foundation for further research on surface electromyographic signal processing and analysis. It also supports the development of an experimental framework for evaluating the reliability of surface electromyographic measurements.**

***Keywords*—Myo Armband, upper limb prosthesis, surface electromyography, MATLAB interface**

I. INTRODUCTION

With the development of biomedical technology and neuroengineering, the control of prosthetic devices by myoelectric signals (EMG) has established itself as one of the most promising areas for restoring muscle function in human amputees. EMG signals reflect the electrical activity of muscles and can be used as a reliable source of information about the user's intentions. This enables control of artificial limbs in a way that is both intuitive and adaptive.

The Myo Armband is a compact and affordable device equipped with eight surface EMG sensors and an Inertial Measurement Unit (IMU) “Fig. 1”, which enables real-time capture of muscle activity [1]. It remains widely used in research practice thanks to its open software interfaces and easy integration with programming environments such as MATLAB [2–5].

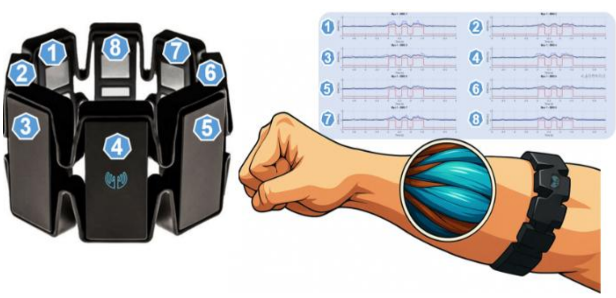

Fig. 1. Myo Armband myographic bracelet and principle of operation.

The aim of this study is to provide a theoretical framework of the use of upper limb prosthesis devices using myoelectric signals. The anatomy and physiology of the upper limb related to myoelectric signals are considered. The principle of operation and placement of such a concrete device - Myo Armband, are discussed. The main advantages and limitations of Myo Armband in comparison to other similar devices are outlined. The hardware components and technical specifications of this device are illustrated. The MATLAB software platform was used and further extended as a developed a custom interactive interface for monitoring and analysis of EMG.

II. THEORETICAL FRAMEWORKS OF THE USE OF UPPER LIMB PROSTHESIS DEVICES USING MYOELECTRIC SIGNALS

A. Anatomy and physiology of the upper limb related to EMG signals

The control of palm, wrist, and fingers movements is achieved through complex coordination among the central nervous system, motor neurons, and upper limb muscles. Of particular importance for surface electromyography (sEMG) are the superficial muscles of the forearm, as they generate measurable electrical signals used to control prostheses.

Among the main muscle groups that are innervated during wrist and fingers movement, the following stand out “Fig. 2”:

- Flexor carpi radialis and flexor carpi ulnaris – involved in wrist flexion;
- Extensor digitorum– a major muscle in fingers extension;
- Flexor digitorum superficialis – for fingers flexion;
- Brachioradialis – active in flexion of the elbow joint and stabilization of the wrist

These muscles are located relatively shallow under the skin, making them suitable for recording by surface EMG sensors such as those used by the Myo Armband.

Control is via motoneurons emanating from the spinal cord (C5-T1 segments) which transmit impulses to the corresponding muscle fibres. Depolarization results in the generation of myoelectric potentials that are sensed at the skin surface [1].

It is important to note that EMG signals measured at the surface are summed potentials from multiple motor units, making them relatively noisy and sensitive to electrode positioning [6].

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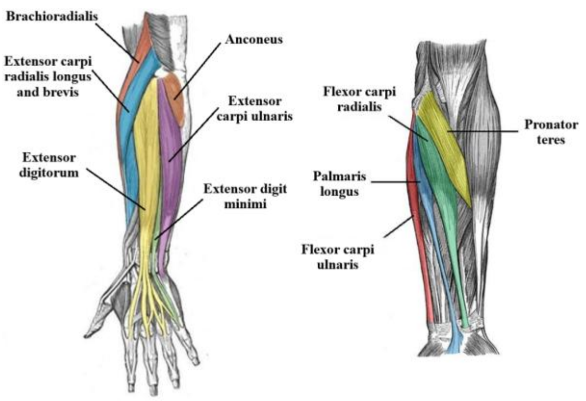

Fig. 2. Posterior and anterior forearm musculature [9].

According to studies, to achieve effective control of a prosthesis by sEMG, not only correct positioning of the sensors, but also temporal stability of muscle activation as well as clearly distinguishable signals in different gestures and movements are required [7].

B. *Principles of Myo Armband operation and placement*

The Myo Armband is a wearable, non-invasive device for sensing muscle electrical activity via sEMG. It is used for upper limb gesture recognition and finds applications in various fields including prosthesis control, robotics and interactive interfaces [8].

The device features eight dry electrodes, spaced evenly around the inner circumference of the strip, which register sEMG signals generated by muscle contraction. In addition to the EMG, an inertial measurement unit provides information on the movement and orientation of the limb using a 9-axis sensor including an accelerometer, gyroscope and magnetometer [9].

Table 1 presents the location of Myo Armband sensors relative to activated muscles and movements. Data processing is performed by a microcontroller and communication with external devices is implemented via a Bluetooth Low Energy (BLE), allowing real-time transmission of signals to a computer or mobile device. Proper positioning of the device on the forearm is critical to ensure stable and repeatable signals. It is recommended that the Myo Armband be placed just below the elbow, on the most prominent part of the musculature, with the central electrode pointing up - towards the upper arm.

This configuration ensures maximum contact resistance and coverage of the major muscle groups [8, 9].

However, the quality of the EMG signal can be influenced by a number of factors - such as the position of the limb (the so-called "limb position effect"), sweating, changes in skin-electrode impedance, cross-talk from adjacent muscles, and individual anatomical features. Limb position effect represents a change in EMG signal characteristics when the position of the limb relative to the body changes due to stretching or shortening of muscle fibres, resulting in difficulty in classification of gestures in real use [9].

The main advantages of the device include its wireless operation, compactness, cross-platform compatibility and low cost. However, it also has some limitations - low sampling rate (200 Hz), limited number of channels (8 electrodes), sensitivity to motion and interference, and the need for periodic battery charging [9].

TABLE I. LOCATION OF MYO ARMBAND SENSORS RELATIVE TO ACTIVATED MUSCLES AND MOVEMENTS

Name (medical term)	**Function / Movement**	**Myo Armband sensor**
Brachioradialis (m. brachioradialis)	Flexion of the forearm in the semi-supine position	Sensor 1
Anconeus (m. anconeus)	Elbow joint extension	Sensor 8
Long and short radial extension of the wrist (m. extensor carpi radialis longus et brevis)	Wrist extension and abduction	Sensor 2
Wrist extensor to ulna (m. extensor carpi ulnaris)	Wrist extension and adduction	Sensor 3
Finger extensor (m. extensor digitorum)	Extension of the fingers of the hand (II-V)	Sensor 4
Little finger extensor (m. extensor digiti minimi)	Extension of the little finger (digit V)	Sensor 5
Wrist flexor to radius (m. flexor carpi radialis)	Flexion and abduction of the wrist	Sensor 6
Long palmar muscle (m. palmaris longus)	Flexion of the wrist, stretching of the palmar aponeurosis	Sensor 6
Wrist flexor to ulna (m. flexor carpi ulnaris)	Flexion and adduction of the wrist	Sensor 7
Pronator muscle (m. pronator teres)	Pronation of the forearm (inward rotation)	Sensor 5

In view of these characteristics, the Myo Armband appears to be a good choice for prototyping and research purposes, but in real applications especially in clinical environments, additional assurance of reliability and robustness of measurements is needed.

C. *Hardware: Myo Armband, technical specifications*

The Myo Armband uses an ARM Cortex-M4 microcontroller with a clock frequency of 120 MHz and embedded memory, which allows local real-time signal processing.

Data is transmitted via Bluetooth Low Energy (BLE), which provides wireless communication and low power consumption. Power is supplied by two built-in 260 mAh lithium-ion batteries that support the operation for several hours under standard use. In “Fig. 3”, the components of the Myo bracelet are presented.

The IMU module is based on the InvenSense MPU-9150 and includes an accelerometer, gyroscope and magnetometer. This combination enables the recognition of hand orientation and dynamics, particularly useful in combined gesture recognition algorithms.

The sampling rate of the device is 200 Hz, which is sufficient for basic EMG applications, but is significantly lower compared to professional systems e.g., Delsys or OT Bioelettronica (reaching over 1000 Hz). Signal resolution is also limited due to the small number of channels and fixed hardware design, which limits the ability to differentiate individual fingers in detail [9]. In “Fig. 4”, the lower side of the Myo wristband control board is shown.

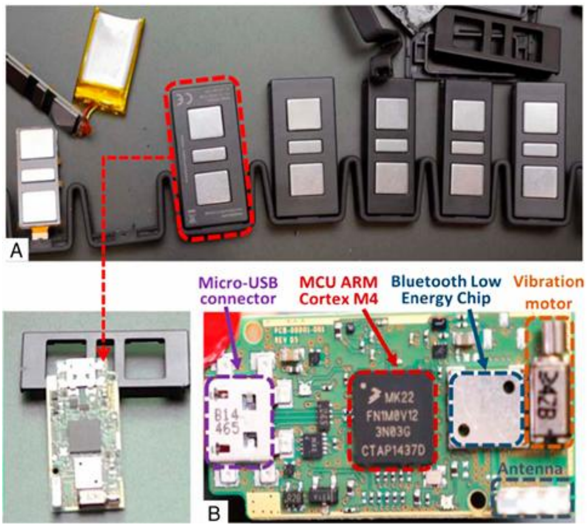

Fig. 3. View of Myo bracelet components (A) and main module control board (B); micro-USB (purple), ARM Cortex M4 MCU (red), BLE chip (blue), vibration motor (brown), antenna (grey) [8].

Despite these limitations, the Myo Armband features a quick and easy setup process, universal size, ease of use, and low cost, making it a preferred tool in educational and experimental settings. Through its compatibility with various software platforms (e.g., Python, Unity, MATLAB) and the availability of a Software Development Kit (SDK), the device enables rapid prototyping for controlling prostheses or human-computer interfaces.

D. Advantages of the Myo Armband over similar devices

In the field of sensor-based prosthesis control, several compact wearable devices have been developed to capture muscle activity using various biosignal modalities. Although the Myo Armband remains one of the most widely used systems, new alternatives have emerged, such as Force Myography (FMG), Tactile Myography (TMG), and high-density surface electromyography (HD-sEMG).

Force Myography (FMG) devices, such as those proposed by Zhou et al. (2019) [12], measure volumetric changes in forearm muscles using pressure sensors. They are less affected by skin impedance variations and electrical noise compared to EMG. FMG systems are characterized by low complexity and energy efficiency but offer lower temporal resolution.

Tactile Myography (TMG)**,** explored by Geng et al. (2012) [13], employs tactile sensors to detect muscle shape deformation and provides spatial information on muscle activation. These systems are less sensitive to electrode placement and maintain stable performance under motion. For example, the TMG-based tactile bracelet developed by Waichal (2020) [9] utilizes foam-based tactile sensors with up to 320 channels, enabling deep learning–based classification “Fig. 5”.

High-density EMG (HD-EMG) systems, such as Delsys Trigno™ and OT Bioelettronica Quattrocento, described by Farina et al. (2014) [14], provide superior signal resolution and spatial discrimination. However, they are larger, more complex, and more expensive, with sampling rates exceeding 2000 Hz, making them suitable primarily for laboratory or clinical applications.

Emerging hybrid systems that combine multiple sensing modalities (e.g., EMG + IMU or EMG + FMG), as reported by Young et al. (2012) [15], can further improve gesture classification accuracy. Nevertheless, these systems often compromise portability and power efficiency.

In summary, the Myo Armband offers a balanced combination of simplicity, affordability, and cross-platform compatibility. Other systems may outperform it in signal fidelity, spatial resolution, or robustness, depending on the intended use. A thorough evaluation of parameters such as accuracy, sampling rate, cost, and usability is crucial when selecting a system for upper-limb prosthesis research or development.

The advantages of the Myo Armband make it a preferred choice for research and prototyping, though it is less suitable for clinical applications that demand higher signal precision and reliability.

Comparative studies have shown that integrating EMG sensors (e.g., Myo) with visual or motion sensors (IMUs, accelerometers) can improve gesture recognition accuracy, albeit at the cost of greater system complexity and size [9].

Ultimately, choosing an appropriate sensor system requires balancing functionality, energy efficiency, cost, portability, and accuracy.

For embedded implementations of prosthesis control, such as on Cortex-M microcontrollers, resource-efficient data processing is also critical — an area where simpler systems like the Myo Armband outperform more complex, high-resolution alternatives.

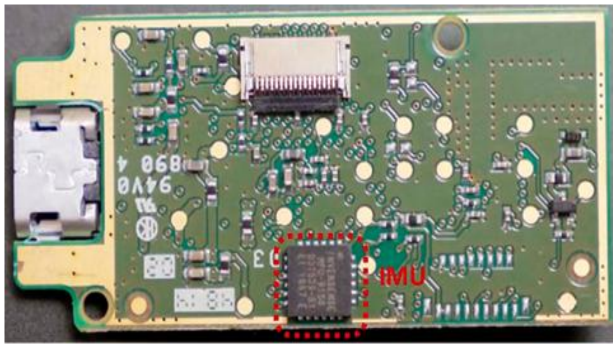

Fig. 4. Lower side of the Myo wristband control board: the MPU-9150 inertial module (IMU) is marked in red [8].

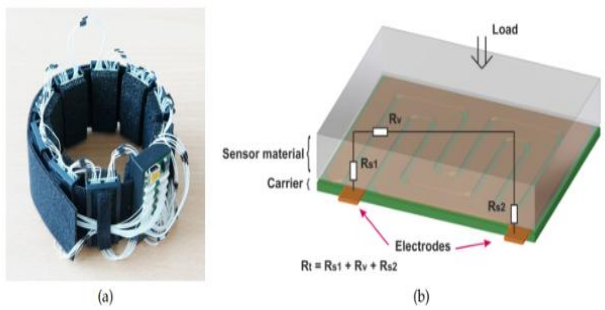

Fig. 5. (a) Prototype of a tactile bracelet with 10 sensory modules and conductive foam; (b) Operating principle – resistance changes based on pressure applied to the foam [9].

III. Software Platform and Interface

The software implementation is built in a MATLAB environment by building on the existing Myo SDK MATLAB MEX (MATLAB executable) Wrapper library. An intuitive graphical user interface (GUI) was developed to allow real-time monitoring, filtering, analysis and recording of EMG signals received from the Myo Armband.

A. *Software implementation: MATLAB and adapted MYO SDK*

To integrate the Myo Armband with the MATLAB platform and to provide a visual and functional interface for EMG signal processing, the above-mentioned Wrapper library [10] was used and further extended in this study. It provides a MATLAB wrapper to the official Thalmic Labs SDK and allows real-time access to sensor data via MEX functions written in C++.

B. *Graphical user interface and signal processing*

Based on this library, a custom interactive interface for monitoring and analysis of EMG signals was developed “Fig. 6”, which includes:

- Temporal visualizations of 8 EMG channels from the device;
- Real-time FFT analysis for frequency estimation;
- Heatmap chart for viewing total muscle activity;
- Ability to apply various digital filters (bandpass, notch, zero-phase, etc.);
- Data export functionalities in .mat, .csv and .txt formats;
- Buttons to pause/resume streaming, which is key when labeling or monitoring gestures.

The interface is built entirely using MATLAB GUI components (uicontrol, subplot, imagesc), and data is updated in real time every 50 milliseconds via a buffering mechanism and pause flag checking.

Buffers cover the last 5 seconds at a sampling rate of 200 Hz.

Signal processing includes optional steps on:

- Band-pass filtering (20-90 Hz), which suppresses low- and high-frequency noise [1];
- Notch filter at 50 Hz to eliminate electrical interference from the mains frequency [11];
- Rectification (absolute value) for unidirectional EMG;
- Root mean square (RMS) calculations for signal energy;
- Zero-phase processing implemented by a proprietary implementation via forward and backward symmetric filtering.

Also added functionality to visualize a pulse width modulation (PWM)-like output based on a threshold value, allowing easy adaptation for binary control (e.g. of a motor or classifier).

Such an approach, although informal, is favored in academic practice due to MATLAB's flexibility for digital signal processing (DSP) and ease of visualization, even in the absence of formal SDK support [9].

In conclusion, the interface created provides a real-time, extensible and easy-to-use environment for EMG analysis that can be used for both data recording and pre-processing, as well as visual signal quality checking prior to training models for gesture recognition or prosthesis control.

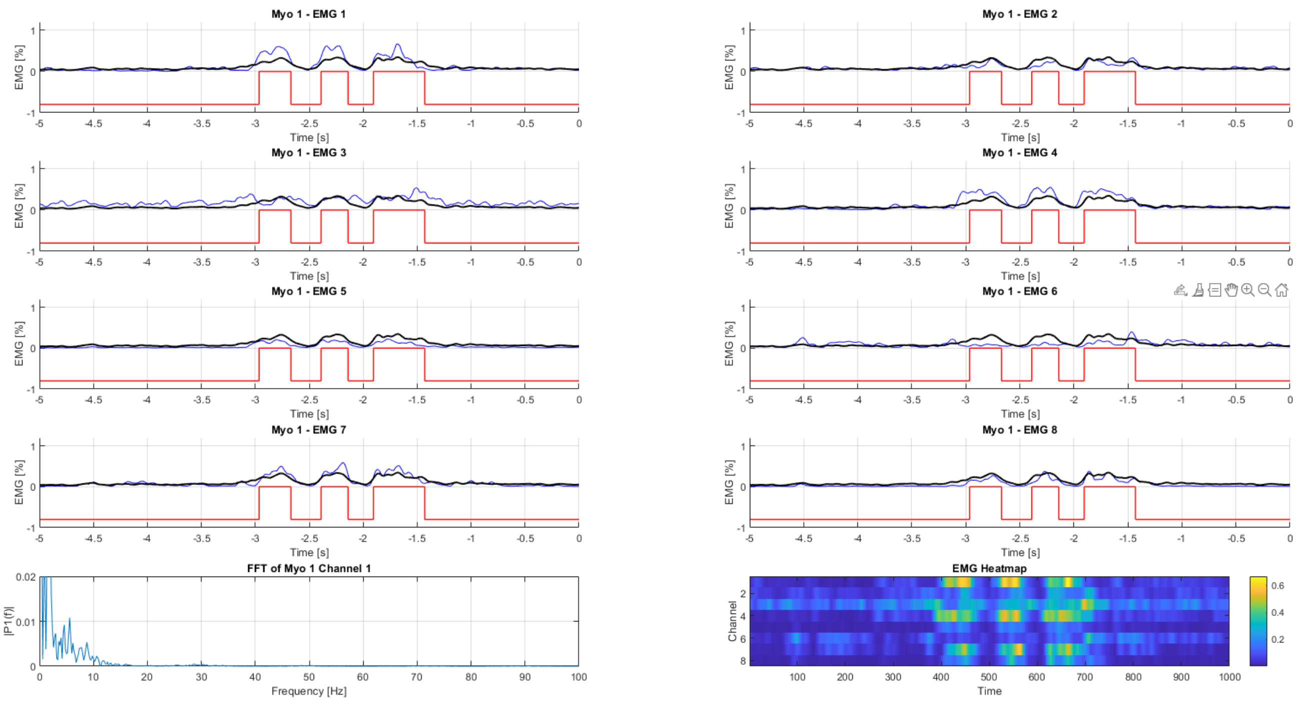

Fig. 6. Graphical interface developed in MATLAB based on the Myo SDK MATLAB MEX Wrapper.

IV. CONCLUSION

The analysis of the Myo Armband's characteristics in comparison with similar devices confirms its suitability as a reliable tool for studying myoelectric signals.

An interactive MATLAB interface was developed, based on an existing library, enabling real-time visualization and the application of various filtering techniques. This feature is essential, as the myoelectric signals recorded by the device are sensitive to different sources of noise and interference.

The updated interface provides a solid foundation for future research focused on the processing and analysis of surface electromyographic signals acquired with the Myo Armband. It also supports the development of an experimental platform for evaluating the accuracy and reliability of surface electromyographic measurements.

REFERENCES

[1] De Luca, C. J. (1997). The use of surface electromyography in biomechanics. Journal of applied biomechanics, 13(2), 135-163.

[2] J Zsoldos, P, B. Nagy, and F. Wijaya (2025) . Deep Learning-Based Implementation of Telerobotic Control with Gesture Recognition from EMG Signals. In 2025 11th International Conference on Automation, Robotics, and Applications (ICARA), pp. 6-10. IEEE.

[3] I Zhang, Z. ,Y. Ming, Q. Shen, Y. Wang and Y. Zhang (2025) An extended variational autoencoder for cross-subject electromyograph gesture recognition. Biomedical Signal Processing and Control, 99, p.106828.K. Elissa, "Title of paper if known," unpublished.

[4] Gomez-Correa M., J. Gallego-Londoño, A.Morin, and D. Cruz-Ortiz (2022) A Wearable Armband System for Multichannel Surface Electromyography Detection. In Latin American Conference on Biomedical Engineering, pp. 301-312. Cham: Springer Nature SwitzerlandY. Yorozu, M. Hirano, K. Oka, and Y. Tagawa, "Electron spectroscopy studies on magneto-optical media and plastic substrate interface," IEEE Transl. J. Magn. Japan, vol. 2, pp. 740–741, August 1987 [Digests 9th Annual Conf. Magnetics Japan, p. 301, 1982].

[5] Mehrabi A. and G. Gargiulo. (2025) Hardware-Based Spiking Neural Network for Real-Time Hand Gesture Recognition Using MYO Armband EMG sensor.

[6] Fougner A., E. Scheme, A. Chan., K. Englehart and Ø. Stavdahl (2012). Control of upper limb prostheses: terminology and proportional myoelectric control-A review. IEEE Transactions on Neural Systems and Rehabilitation Engineering, 20(5), pp.663-677.

[7] Khushaba, R., S. Kodagoda, M. Takruri and G. Dissanayake (2012). Toward improved control of prosthetic fingers using surface electromyogram (EMG) signals. Expert Systems with Applications, 39(12), 10731-10738.

[8] Visconti P., F. Gaetani, G. Zappatore and P. Primiceri (2018). Technical features and functionalities of Myo armband: An overview on related literature and advanced applications of myoelectric armbands mainly focused on arm prostheses. International Journal on Smart Sensing and Intelligent Systems, 11(1), 1.

[9] Waichal S. V. (2020). Comparison of Solutions for Efficient Implementation of Sensor based Hand Prosthesis Control on a Microcontroller using Regression based Machine Learning and Neural Networks (Doctoral dissertation, Technical University of Munich).

[10] Tomaszewski M. (2025). Myo SDK MATLAB MEX Wrapper(https://github.com/mark-toma/MyoMex), GitHub. Retrieved

[11] Merletti R. and P. Parker (2015). Surface electromyography: physiology, engineering, and applications. Hoboken, NJ: Wiley-IEEE Press.

[12] Zhou Y., Z. Yang and Z. Wang (2019). Wearable Force Myography for Muscle Activity Sensing Using Pressure Sensor Array. IEEE Sensors Journal, 19(3), 1164–1172.

[13] Geng Y., P. Zhou and G. Li (2012). Toward attenuating the impact of arm position variation on electromyography pattern-recognition based motion classification in transradial amputees. Journal of NeuroEngineering and Rehabilitation, 9(1), 1–11.

[14] Farina D., A. Holobar. R. Merletti and R. Enoka. (2014). Decoding the neural drive to muscles from the surface electromyogram. Clinical Neurophysiology, 125(11), 2151–2169.

[15] Young A., L. Hargrove and T. Kuiken (2012). The effects of electrode size and orientation on the sensitivity of myoelectric pattern recognition systems to electrode shift. IEEE Transactions on Biomedical Engineering, 58(9), 2537–2544.