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# Study Muscle Movements with Arduino

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***Abstract:*** Electromyography (EMG) devices are well-suited for measuring the behaviour of muscles during an exercise or a task, and are widely used in many different research areas. Their disadvantage is that commercial systems are expensive. We designed a low-cost EMG system with enough accuracy to be used in a wide range of possible ways. The present research focuses on the validation of the low-cost system we designed, which is compared with a commercially available, accurate device. The evaluation was done by means of a set of experiments, in which volunteers performed isometric and dynamic exercises while EMG signals from the hand were registered by both the proposed low-cost system and a commercial system simultaneously. Analysis and assessment of two indicators to estimate the similarity between both signals were developed. These indicated a very good result.

## Introduction

Electromyography (EMG) provides information related to muscle activity[1][2]. For that reason, EMG devices are used in many research fields, such as biomedical, ergonomics, physiotherapy or sports performance applications, where it is very important to assess the behaviour of the muscles throughout the task [4] based on the changes in the electrical signal [4–5]. Moreover, this kind of technology can be used to improve other studies [6]. One of the main problems of existing EMG technology is the high cost of commercial devices. Although EMG signal acquisition can be done in different ways, nowadays one of the most used methods is by means of superficial electromyography (sEMG), because in comparison with other methods, e.g., needles, it is one of the less invasive methods. Some researchers [7] consider that sEMG is as valid as other methods, taking into account that the acquired signal must be denoised.

Several researchers have tried to build or implement low-cost EMG systems. Supuk et al. [8] designed, developed and evaluated a low-cost EMG system, which can be used to measure the muscle activity during human motion, focused on the design of a cascade bio-amplifier that reduces the noise of the signal as a first step. Later they used different approaches to denoise the output signal. Validation was only centred on the gait analysis, where researchers measured the activity of six main muscles. Another example is the manuscript of Sophia Heywood et al. [9], where the authors compared the signal from a low-cost EMG system and a wire-commercial device. The evaluation consisted of the acquisition of the Vastus Lateralis signal while volunteers executed different exercises. After the authors denoised the signal using a few filters, they carried out an evaluation by means of the Teager–Kaiser energy operator (TKEO) and the maximal voluntary contraction (MVC) of the muscle, with good results. A third example is the work undertaken by Cheney et al. [10] where the authors developed the ability to adjust diverse variables, such as the gain, attenuation or offset. For that reason, they developed a 2-channel EMG board to gather a signal that later was filtered by lowpass filter. Unfortunately, the authors did not explain how the validation test was

## Material and method

Design of Low-Cost Electromyography will be executed in following stepsIdentification of input and output parameters. The front panel will be designed according to the input and output required.

Appropriate block will be developed according to the output required. After completion of designing, it will be tested for accuracy.

**Table 1. shows the hardware used in this study**

| NO. | Description |
|---|---|
| 1 | Arduino Uno R3 |
| 2 | EMG Sensor Module Kit |
| 3 | Lcd Display |
| 4 | 5mm LED |
| 5 | Electrode Pad & Cable |
| 6 | Battery 18V |
| 7 | Jumper Wire |

**Arduino Uno R3**

The Arduino Uno R3 is an upgraded and enhanced version of the popular Arduino Uno board. It is based on the ATmega328P microcontroller and offers 14 digital input/output (I/O) pins, which can be used to interface with various digital devices and components. Additionally, it provides 6 analog input pins, allowing for the measurement of analog voltage levels. With a clock speed of 16MHz, the Arduino Uno R3 ensures efficient and fast execution of instructions, enabling responsive and real-time applications. The board can be powered either through a USB connection or by an external power supply connected to the power jack. This flexibility allows for easy integration into different power setups and environments. One of the notable features of the Arduino Uno R3 is its compatibility with a wide range of shields. Shields are add-on boards that expand the capabilities of the Arduino Uno R3, providing additional functionalities such as wireless communication, motor control, and display capabilities. This expandability makes the Arduino Uno R3 suitable for a diverse range of projects and applications.

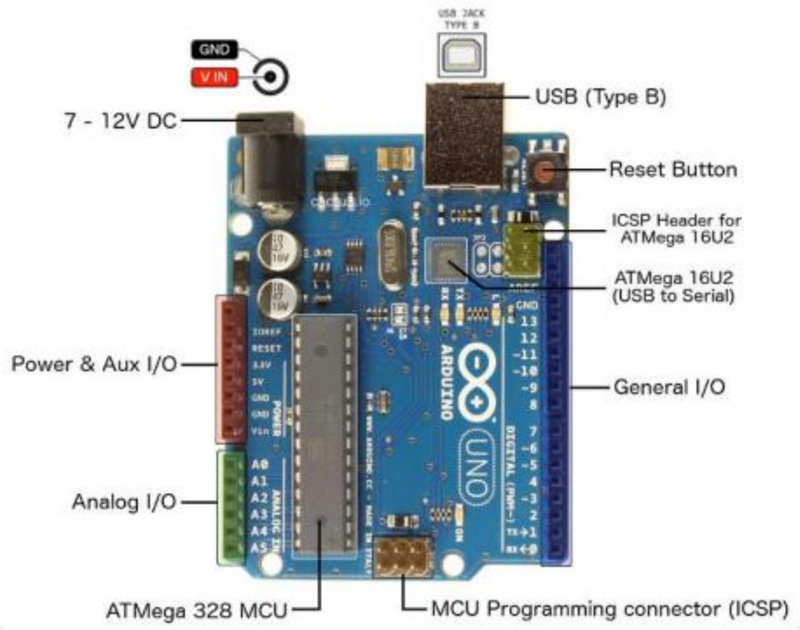


**Figure 1: Arduino Uno R3**

**Arduino IDE**

To upload the code to our microcontroller, we use an integrated development environment (IDE) that deals with AVR-type microcontrollers, including Arduino and Esp32, which work in the same environment using the Arduino IDE, which is a software available for various operating systems, Windows, Linux, and Mac. It can be downloaded from the official Arduino website. The code can upload from the Arduino Figure 3.9 : block diagram of EMG muscle sensor 24 IDE to our microcontroller by connecting the microcontroller to the PC, selecting the port on which the microcontroller is connected, and then uploading the code quickly

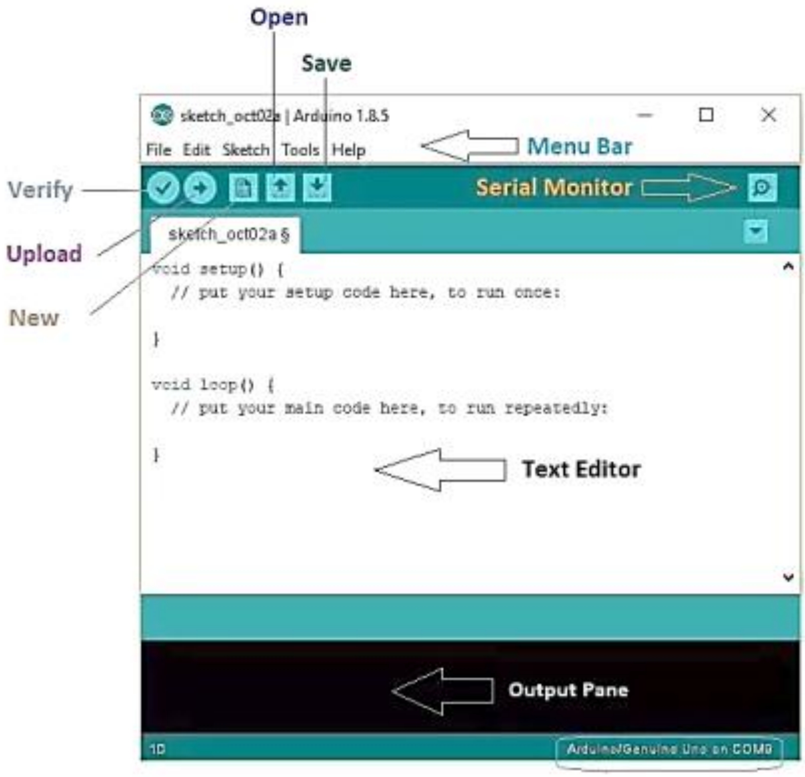


**Figure 2: Arduino Software (IDE)**

After uploading the code free in the wibsite, you can start testing the sensor and start observing the value. To test the sensor working, stretch your arm. Then you can contract or relax the muscle. This will produce an analog voltage, that can be observed on Serial Monitor.

**Result**

The two devices will be compared The testbed used was built using two different EMG systems. The first system comprised a set of low-cost elements, and the second system was a commercial solution He has confidence.

**Equipment**

Figure 3 shows how the testing equipment was installed, the low-cost system and itswire-connection with the computer and with the muscle by means of three electrodes. On the right side of Figure 3 is shown the commercial system. Commercial system electrodes only need to be placed on the muscle and aligned with the muscle fibres, and its communication with the computer is by means of a wireless connection.

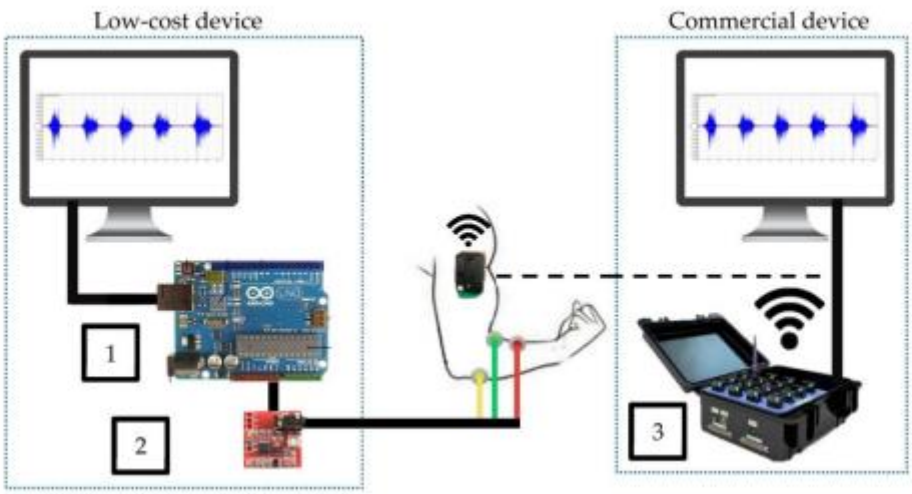


**Figure 3: Equipment of the testbed used in the experiments**

## Discussion

Indicators Assessment Results of the comparison between the commercial and low-cost system based on the indicators can be found below. These indicators provide information about the signal and its reliability when this system is used for simple exercises, as in the experiment. Table 2 show Three healthy and fit volunteers show results , Peak level muscle contraction range (ICC) is a measure of the variability in the amount of force that a muscle can generate. It is calculated by dividing the range of muscle contraction (the difference between the maximum and minimum force that a muscle can generate) by the mean muscle contraction force.

**Table 2: Peak level muscle contraction range (ICC) of Volunteers**

| Volunteer | Device | Peak level muscle contraction range (ICC) |
|---|---|---|
| Volunteer 1 | Myoware EMG+Arduino uno | 0.83 |
| Volunteer 1 | Delsys Trigno | 0.85 |
| Volunteer 2 | Myoware EMG+Arduino uno | 0.87 |
| Volunteer 2 | Delsys Trigno | 0.89 |
| Volunteer 3 | Myoware EMG+Arduino uno | 0.91 |
| Volunteer 3 | Delsys Trigno | 0.93 |

After the parts of the test, it was noted that there was some delay in the low cost signal, as it needed to filter the signal, and the results proved that the proposed project was able to provide good results, but rather for a low-cost device.

## Conclusion

The need to develop a muscle sensor at a low price is very much needed to provide assistance to people who do not have access to expensive devices, and on the other hand, to increase accuracy in applications such as control and even artificial limbs.

## REFERENCES


1. Hagberg, M. Work load and fatigue in repetitive arm elevations. Ergonomics 1981, 24, 543–555.
2. Cifrek, M.; Medved, V.; Tonkovic´, S.; Ostojic´, S. Surface EMG based muscle fatigue evaluation in biomechanics. Clin. Biomech. 2009, 24, 327–340. 3. Fuentes del Toro, S.; Santos-Cuadros, S.; Olmeda, E.; Álvarez-Caldas, C.; Díaz, ]V.; San Román, J.L. Is the Use of a Low-Cost sEMG Sensor Valid to Measure Muscle Fatigue? Sensors 2019, 19, 3204.
3. Farina, D.; Pozzo, M.; Merlo, E.; Bottin, A.; Merletti, R. Assessment of Average Muscle Fiber Conduction Velocity From Surface EMG Signals During Fatiguing Dynamic Contractions. IEEE Trans. Biomed. Eng. 2004, 51, 1383–1393.
4. Molinari, F.; Knaflitz, M.; Bonato, P.; Actis, M.V. Electrical Manifestations of Muscle Fatigue During Concentric and Eccentric Isokinetic Knee FlexionExtension Movements. IEEE Trans. Biomed. Eng. 2006, 53, 1309–1316.
5. Olmeda, E.; del Toro, S.F.; Garrosa, M.; Redondo, J.P.; Diaz, V. Clutch Pedal Sensorization and Evaluation of the Main Parameters Related to Driver Posture. Sensors 2018, 18, 2797.
6. Andrade, A.O.; Soares, A.B.; Nasuto, S.J.; Kyberd, P.J. EMG Decomposition and artefact removal. In Computational Intelligence in Electromyography Analysis—A Perspective on Current Applications and Future Challenges; InTech: London, UK, 2012; pp. 261–286.
7. Supuk, T.G.; Skelin, A.K.; Cic, M. Design, development and testing of a low-cost sEMG system and its use in recording muscle activity in human gait. Sensors (Switz.) 2014, 14, 8235–8258.
8. Heywood, S.; Pua, Y.H.; McClelland, J.; Geigle, P.; Rahmann, A.; Bower, K.; Clark, R. Low-cost electromyography—Validation against a commercial system using both manual and automated activation timing thresholds. J. Electromyogr. Kinesiol. 2018, 42, 74–80.
9. Cheney, P.D.; Kenton, J.D.; Thompson, R.W.; McKiernan, B.J.; Lininger, R.E.; Trank, J.W. A low-cost, multi-channel, EMG signal processing amplifier. J. Neurosci. Methods 1998, 79, 123–127.