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PROCESSING AND GRAPHING OF ELECTROMIOGRAPHIC SIGNALS WITH RASPBERRY-PI 2 FOR WRIST REHABILITATION

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Abstract: This job presents the design of a tool for wrist rehabilitation using a dynamic interface where the patient can carry out his therapy in a simple and entertaining way. This will help doctors to carry out the therapy more easily, since the values of the electromyographic signals (EMG) can be displayed in real time and they will have control over the information. In addition, the system allows to store the data of each session and can be graphed and compared with the data of previous sessions of a rehabilitation therapy. As an alternative to the common use of a computer as a processor, in this project a Raspberry-Pi 2 card is used as a hardware platform as a processor for specific use, accompanied by an Arduino-Uno card for interaction with sensors of the type *"sensor muscle V3"*.

Keywords: Arduino, Raspberry-Pi, wrist rehabilitation.

INTRODUCTION

The daily exercise of human activities directly involves the mobility of the wrist as a result of the movement of the upper extremities. This mobility represents 60% of the function of these extremities [Coll and Cladera, 2012], one of the main functions being flexion of the wrist. Because of this, there is always a risk of deterioration due to injury or disease presenting the need for medical treatment and rehabilitation to restore its original function. Thus, the use of rehabilitation and the techniques that accompany it become very relevant as a solution for the restoration of a damaged wrist [Hernández, 2018].

One of the most widely used techniques currently to address this problem consists of the acquisition of electromyographic (EMG) signals as an indicator of the healthy behavior of movement in the human body. These signals are produced in response to muscle movement, where the level of effort is determined by the number of muscle fibers activated during contraction by a neuron. The electrical potential of a motor unit can be measured using needle or surface electrodes [Orozco, 2005; Massin, 2016].

There are various proposals in the state of the art for the acquisition and processing of EMG signals in different parts of the body and that generally use a general purpose processor such as a computer as a hardware platform [Sánches, 2007; Maier, 2008; Jamal, 2011; Chain, 2015]. An implementation using a Raspberry-Pi card for this purpose has been reported in Rangel (2017) and has been used as an important reference for this work. Compared to most applications that use a general-purpose processor, this project proposes the use of a specific-use processor such as the Raspberry-Pi 2 card for processing EMG signals. The use of this card has become popular in recent years due to its important features, such as its processing speed, physical ports, size, cost, and the possibility of accessing a variety of open source libraries in the state of the art.

The design of a tool for wrist rehabilitation using a dynamic interface where the patient can carry out his therapy in a simple and entertaining way is presented in this paper. This will help doctors to carry out the therapy more easily, since the values of the electromyographic signals (EMG) can be displayed in real time and they will have control over the information.

DEVELOPMENT

For the acquisition of the signals in the present work, surface electrodes connected to the sensor were used *"muscle v3"* along with an Arduino one's card for its control. The operating system was used as the software platform *Raspbian* and the language *Python 2.7. Ruscitti (2018) and Pastorini (2012) have designed a dynamic and interactive interface* *for the processing and manipulation of EMG signals acquired during a rehabilitation session using the software Pygame* [Norris, 2014; Rossum, 2019]. Next, the development process is thoroughly reviewed.

HARDWARE DESCRIPTION

Figure 1 presents the methodology of this project. For the acquisition of the EMG signals, the tools provided by the Arduino uno card were used; this allows a direct acquisition of the signals produced by a simple movement of the wrist, which can be measured in real time and graphed in each session carried out with the patient. In this acquisition process, an electromyographic sensor from the *Maker Studio* brand was used, shown in figure 2. This sensor detects muscle movement by electrode reading methods for different muscles of the body. In addition, this sensor has the necessary filtering and amplification stage to be able to obtain the visualization of the signals directly with a microcontroller or development card.

As a first stage of the work, the electromyographic signals were obtained, for which an Electromyographic sensor of the Maker Studio brand was used, which detects muscle movement by electrode reading methods for different muscles of the body, in this case, arm muscles. This sensor has the necessary filtering and amplification stage to be able to obtain the visualization of the signals directly with a microcontroller or development card.

Subsequently, the EMG signals obtained from the muscles were analyzed, for this the Electromyograph sensor was connected to the Arduino board as shown in the connection diagram represented in figure 3. Once the signals were acquired, we worked with the connection between the Arduino and the Raspberry-Pi 2 board as shown in figure 4. The Arduino IDE (Integrated Development Environment) was downloaded and installed on the Raspberry-Pi to make communication easier and analog signals acquired [Bate, 2018].

SOFTWARE DESCRIPTION

For the process of acquiring the EMG signals, a dynamic interface was created as can be seen in figure 5. For this, the *Pygame* library in *Python* language was used, which allowed acquiring and processing one or two signals from two different sensors; however, for the purposes of this project, only one signal was used. Subsequently, basic processing was done through an averager to obtain a smoother sensor response.

This signal or impulse was used to move an object, in order to facilitate rehabilitation therapy. The interface is used for a type of rehabilitation therapy, which is the "empowerment of the hand" which, in order to gain strength again, must slowly close as much as possible until "making a fist" [Wichmann, 2016].

Another functionality that was added to the programming code is to have control over the information received, for which we sought to save the sessions in a format that would allow their access without requiring specialized software. For this, it was decided to save each rehabilitation session in files with .txt format, this allows the person who requires it to graph the information from different sessions in general-use software such as Excel. The code flowchart is shown in Figure 6.

TESTS AND RESULTS

Continuous exercise with the visual interface helps to detect the variation of force through the sensor to make a range from which some element of the interface can be activated and display the values obtained in real time, as can be seen in figure 7. Each time the interface was used, the data obtained from the signals was saved, as shown in Figure 8;

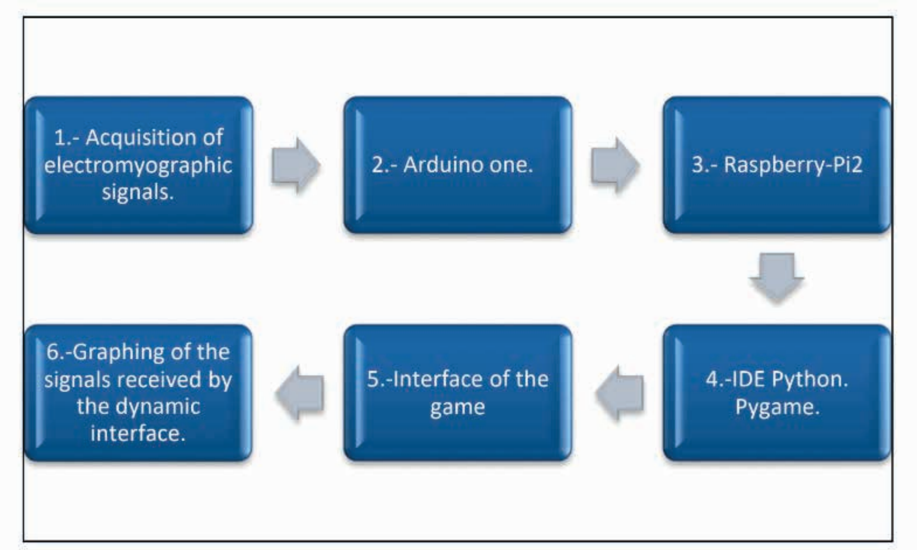

Figure 1 .- Project methodology.

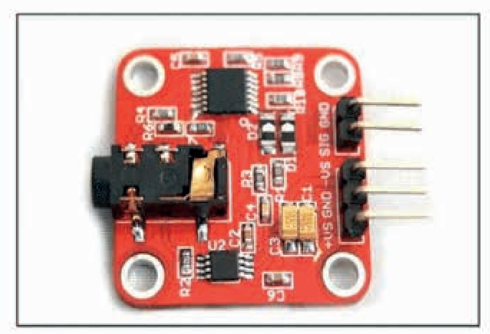

Figure 2. Sensor

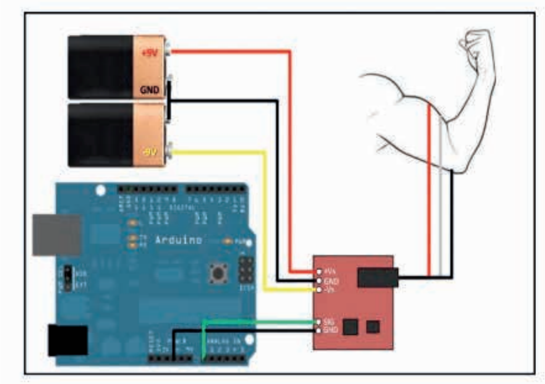

Figure 3. v3 muscle sensor connections.

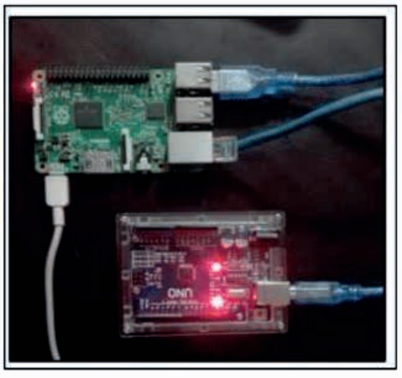

Figure 4. Arduino and Raspberry-Pi connection

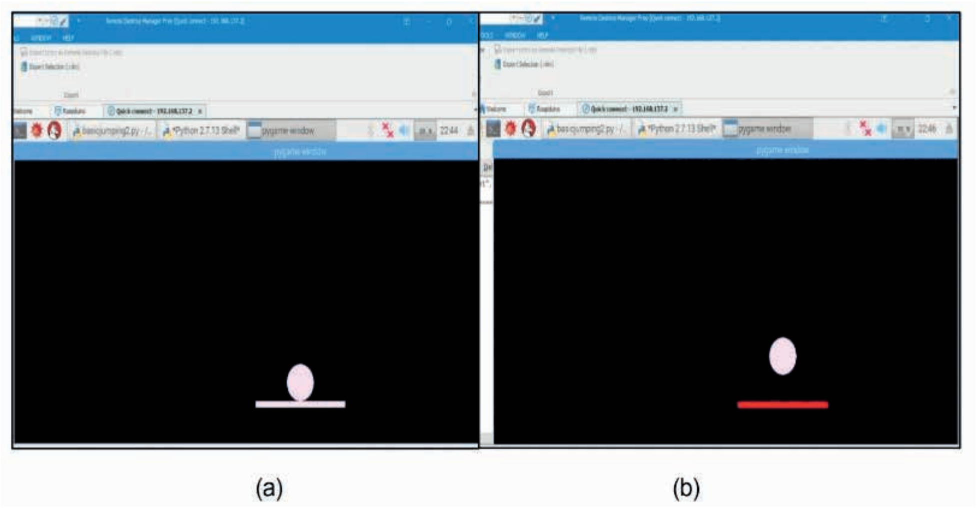

Figure 5. Dynamic interface: a) The ball is not activated by any signal. b) The ball is activated because the signal exceeds the established range.

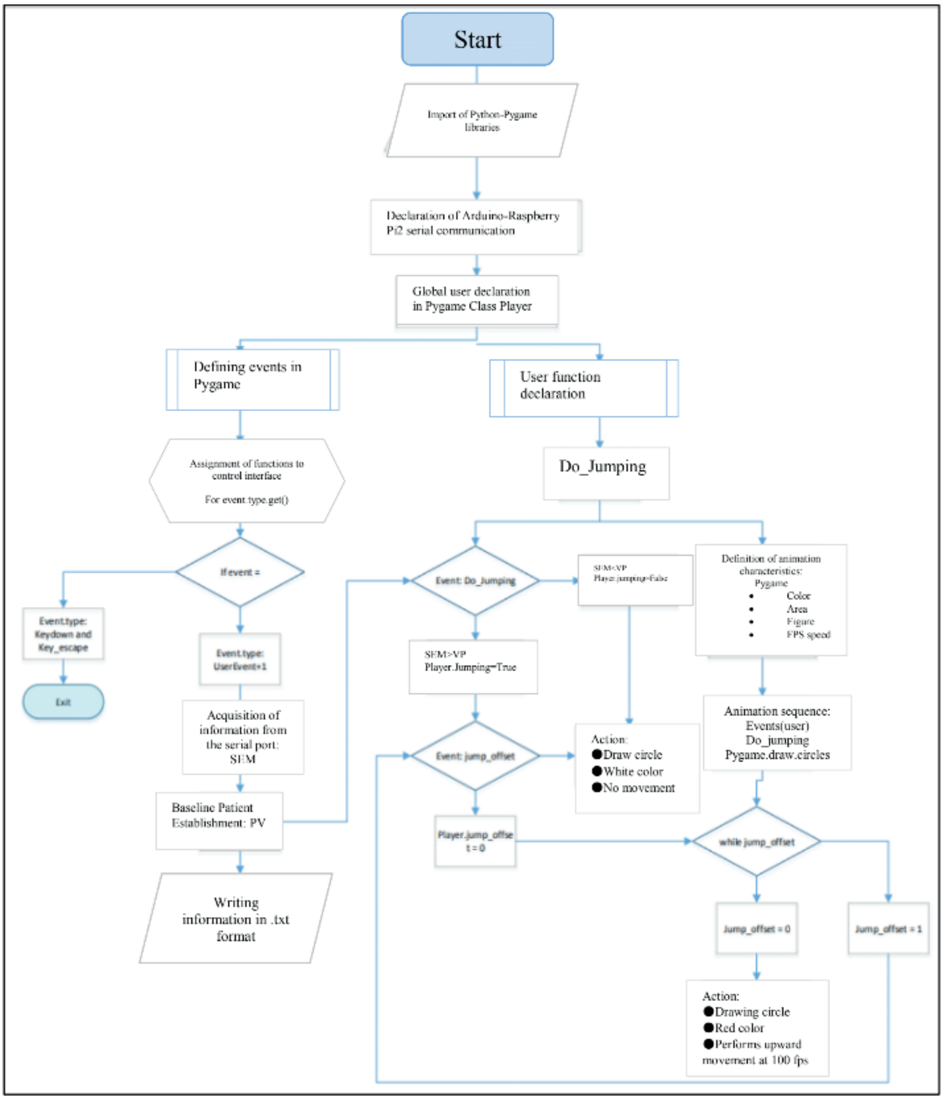

Figure 6. Code flowchart on the Raspberry-Pi

later, the doctors were able to use them in the comparison or graphing in a simple way and thus be able to keep a record of the sessions of each patient, as shown in figure 9.

The exercise continued with this tool. Figure 10 shows the exercise with the dynamic interface. As mentioned before, it has been developed using the Pygame library in Python language, which has made it possible to acquire and process one or two signals from two different sensors; however, for the purposes of this project, only one signal was used. Subsequently, basic processing was done through an averager to obtain a smoother sensor response, this signal or impulse was used to move an object, in order to facilitate rehabilitation therapy. Figure 11 shows the graphic record of two rehabilitation sessions for comparison.

CONCLUSIONS

In the present work, a tool for wrist rehabilitation was developed using a dynamic interface where the patient can carry out his therapy in a simple and entertaining way. In addition, as an alternative to the common use of a computer as a processor, in this project a Raspberry-Pi 2 card was used as a hardware platform as a processor for specific use, accompanied by an Arduino Uno card for interaction with sensors of the type " sensor muscle V3". The Raspberry-Pi 2 card offers a multiplatform system which could be adapted to the needs of this project. Not having analog ports, the use of an Arduino Uno card in slave mode was used, in order to carry out the transfer of information through serial communication. The programming code was compiled using different libraries integrated into the same language, which in this case was Python 2.7. It was possible to verify the transfer of information without alteration even at high speeds (>115200 bauds), however, depending on the graphical interface used, the generation of a buffer is required to display the data without delay. The development of the project was oriented towards the creation of an easy-to-manipulate interface, for which reason the means to be able to access the information without requiring specialized software was sought. The means through which it was possible to achieve this was through the generation of a .txt file compatible with conventional software. Taking advantage of the free access libraries in the state of the art, this tool has been implemented as a support for its application in the rehabilitation of patients with wrist injuries. Under the supervision of the therapist, this tool will allow the patient to have an indicator of her progress in restoring her wrist movements.

LIMITATIONS AND RECOMMENDATIONS

It is necessary to create a physical model that establishes a standard means for the acquisition of EMG signals. Due to the sensitivity of the reading on this tool, it varies depending on the position of the wrist. The dynamic interface can be integrated into a single executable file which has buttons to carry out the function of reading, graphing in real time and saving files independently.

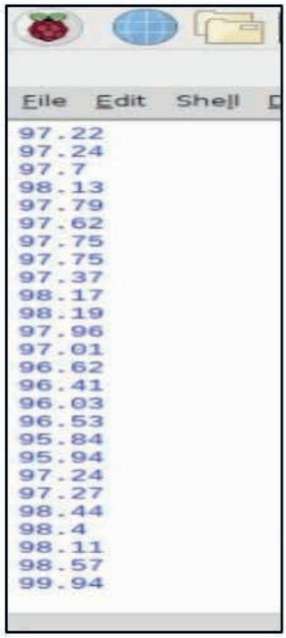

Figure7.Values obtained from already processed EMG signals

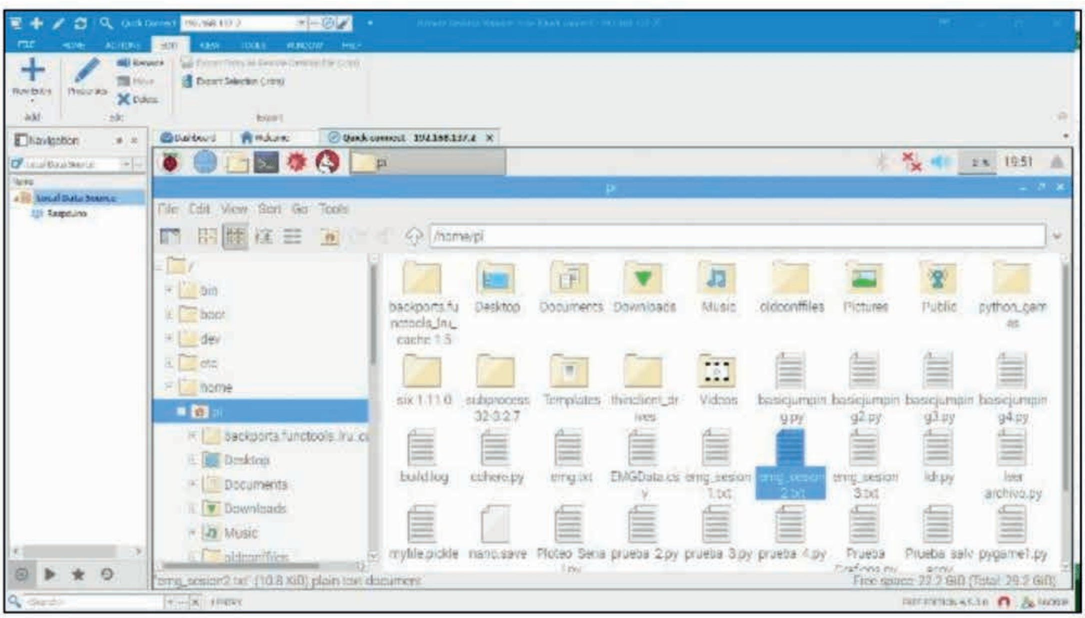

Figure 8. Saved file of the "EMG" rehabilitation session where the data captured by the video game is stored.

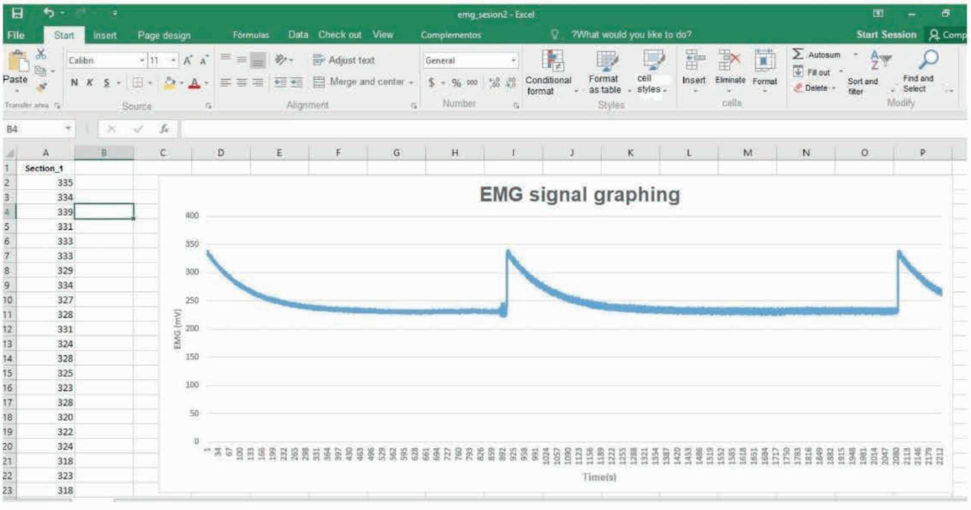

Figure 9. Graphing of rehabilitation session results

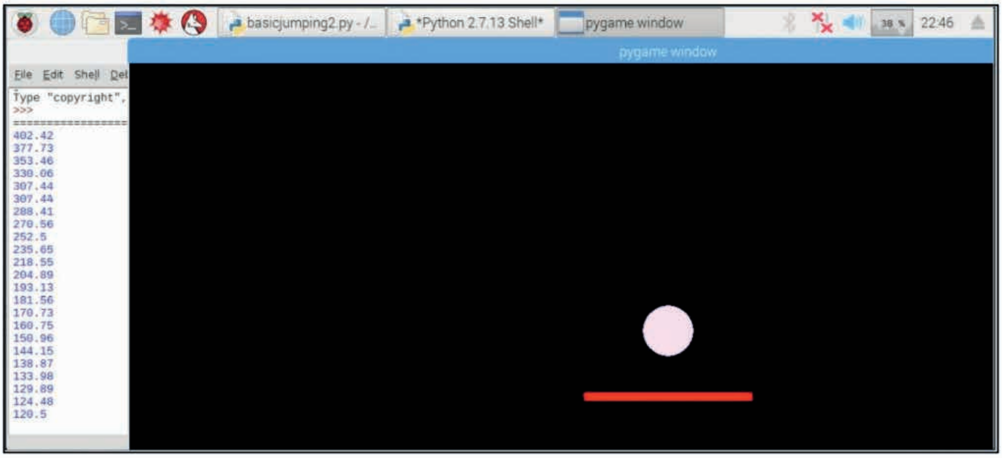

Figure 10. Exercise using the dynamic interface

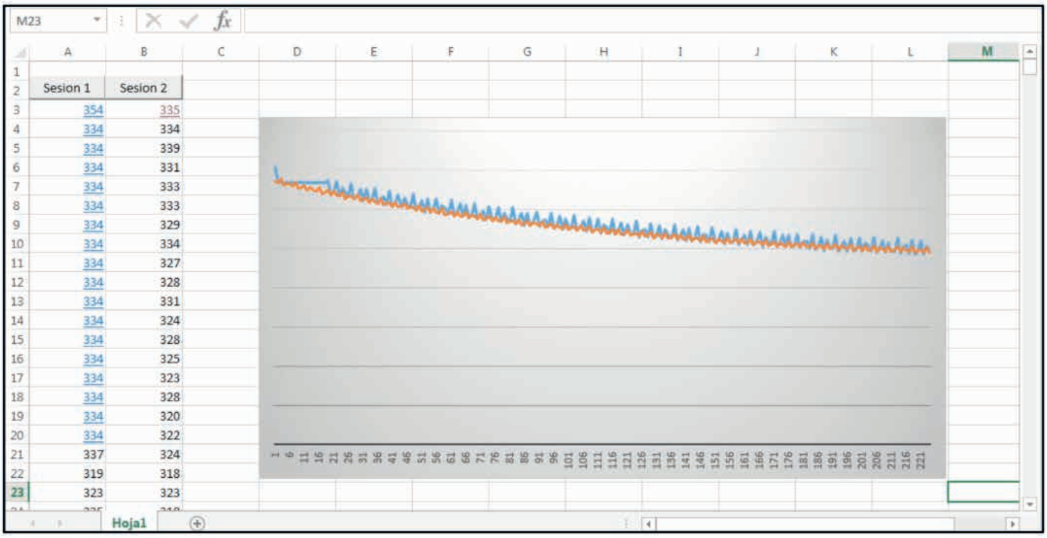

Figure 11. Graphing of two rehabilitation sessions.

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