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System for identification of the muscle activation level in patients under rehabilitation using EMG, EDGE computing and IOHT techniques

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ABSTRACT
Electromyography, the concepts of data transmission, reading, analysis and other tools used in this work are already known and explored worldwide. Electromyography has been used in cases of lesion evaluation for decades, as pointed out in Kugelberg's article (KUGELBERG, 1949). A few decades later, with the advancement of computing, driven by the third industrial revolution (SALESFORCE, 2021), articles were seen incorporating EMG readings into computers, as shown by Hodges (1996) and opened the field for other research (DE LUCA, 1997), until they began to treat the read signals more intelligently, implementing digital signal processing techniques and thus allowing the classification of the signals (CHOWDHURY, 2013). The novelty of this solution is the use of robust, current, low-cost technologies to facilitate the follow-up of patients who are undergoing muscle rehabilitation. There is no study focused on this niche or market equipment that fills this gap. The technique used to analyze EMG signals and integrate the result of a reading that the patient took at home in real time with the physician who can be anywhere in the world at any time, is the differential and is on the rise with the emergence of devices and research in IoHT and IoMT (RANI, 2020), (IANCULESCU, 2019) and (DOURADO, 2020). Thus, it was possible to achieve a low-cost and modern solution, which can become an off-the-shelf device or help doctors with their patients, generating engagement, health, safety, and technological evolution.

Keywords: Muscle activation, Rehabilitation, IoHT.

1 INTRODUCTION

Electromyography, the concepts of data transmission, reading, analysis and other tools used in this work are already known and explored worldwide. Electromyography has been used in cases of lesion evaluation for decades, as pointed out in Kugelberg's article (KUGELBERG, 1949). A few decades later, with the advancement of computing, driven by the third industrial revolution (SALESFORCE, 2021), articles were seen incorporating EMG readings into computers, as shown by Hodges (1996) and opened the field for other research (DE LUCA, 1997), until they began to treat the read signals more intelligently, implementing digital signal processing techniques and thus allowing the classification of the signals (CHOWDHURY, 2013). The novelty of this solution is the use of robust, current, low-cost technologies in order to facilitate the follow-up of patients who are undergoing muscle

rehabilitation. There is no study focused on this niche or market equipment that fills this gap. The technique used to analyze EMG signals and integrate the result of a reading that the patient took at home in real time with the physician who can be anywhere in the world at any time, is the differential and is on the rise with the emergence of devices and research in IoHT and IoMT (RANI, 2020), (IANCULESCU, 2019) and (DOURADO, 2020). Thus, it was possible to achieve a low-cost and modern solution, which can become an off-the-shelf device or help doctors with their patients, generating engagement, health, safety, and technological evolution.

The proposed solution fills numerous gaps at the same time. By proposing a low-cost system, with processing at the edge of the cloud, with data being sent remotely to the doctor, remote support with scientific data to support clinical decision-making, accessibility, connectivity, etc.

Some factors served as motivational triggers for the definition of the characteristics of the solution. SARS-CoV-2 pandemic, a factor that hinders safe doctor-patient interaction. Social isolation, which makes it impossible to continuously monitor the patient in person. Difficulty of safe Doctor-Patient integration due to exposure factors, difficulty in locomotion of patients under motor rehabilitation. Decrease in the purchasing power of Brazilians (GEMAQUE, 2021) Difficulty in monitoring and consistent progress of patients with difficulty in traveling.

2 OBJECTIVES

Integrate emerging technologies and develop a system that has decentralized processing (EDGE Computing) and traffics important data, reducing the need for computational load. Process signals locally in an embedded system. To design a low-cost and accurate solution for use in medicine. Promote accessibility of effective treatment to patients under rehabilitation.

3 METHODOLOGY

The equipment is composed of a processing unit, called M5StickC®, which takes EMG readings from an electromyographic signal reader sensor installed in the target muscle. By pressing the start button, the equipment reads the signals generated by the muscle contraction and integrates the signal into an integer value, this value is constantly updated to the best performance value and at the end of the session, the patient presses the button again and confirms the sending to the doctor. At this point, the equipment requests the patient to authorize access to the Wi-Fi network through their Smartphone and then the equipment connects to the internet through the user's router and sends two requests, an HTTP GET so that the doctor receives a notification on his WhatsApp© and a POST HTTPS request to Google Sheets©, The patient's progress history and graph will be saved for medical monitoring and patient instruction assistance.

The software was designed to solve the problem of locomotion and safety that patients who are undergoing motor rehabilitation suffer as a result of the intrinsic effects of their neuro/muscular diseases. In order to improve the quality of life and safety of these people, a system was proposed to measure the electromyographic signals emitted by the muscle contraction of the limb that is under reconditioning. These signals, which can also be called EMG, would be collected by low-cost, embedded hardware to promote portability and accessibility to low-income families. After collecting this data, the equipment would process these signals and send the results to the doctor or physiotherapist responsible for the recovery treatment. With the data from the results of the exercises and other forms of treatment, it would be possible to verify the progress or setback of this patient in his motor rehabilitation process, so that the person responsible for the treatment could make adjustments, recommendations and assist the patient remotely, with greater quality and frequency, being able to analyze the patient's history. Thus, the system would also serve as a tool to support medical decision-making.

The technologies used that have been incorporated into the SOFTWARE are:

- Wi-Fi communication;
- Reading of EMG signals;
- Digital signal processing;
- Development techniques for embedded systems;
- Moving average filters;
- Communication with cloud servers (Google Sheets® and WhatsApp®);

4 RESULTS AND DISCUSSION

After positioning the sensors on the patient and feeding the equipment, it exempts an operating screen and instructs them to press the button to start the exercise. After pressing the button, the patient will perform their exercise normally while the equipment registers and displays dimensionless values on its display, for patient follow-up. At this point the software begins to read the patient's EMG signals, treat these signals and save the average value measured at the end of each minute of exercise, At the end of the exercise, the patient presses the button again that stops the capture and treatment of the signals and asks the patient to synchronize the device with his shartphone, so that it is possible to access a 2.4 Ghz Wi-Fi network, thus making it possible to send the results to Google Sheets® and a notification on WhatsApp® from your doctor or therapist, notifying you that the patient has just finished a session and the data is available for consultation.

System Functions:

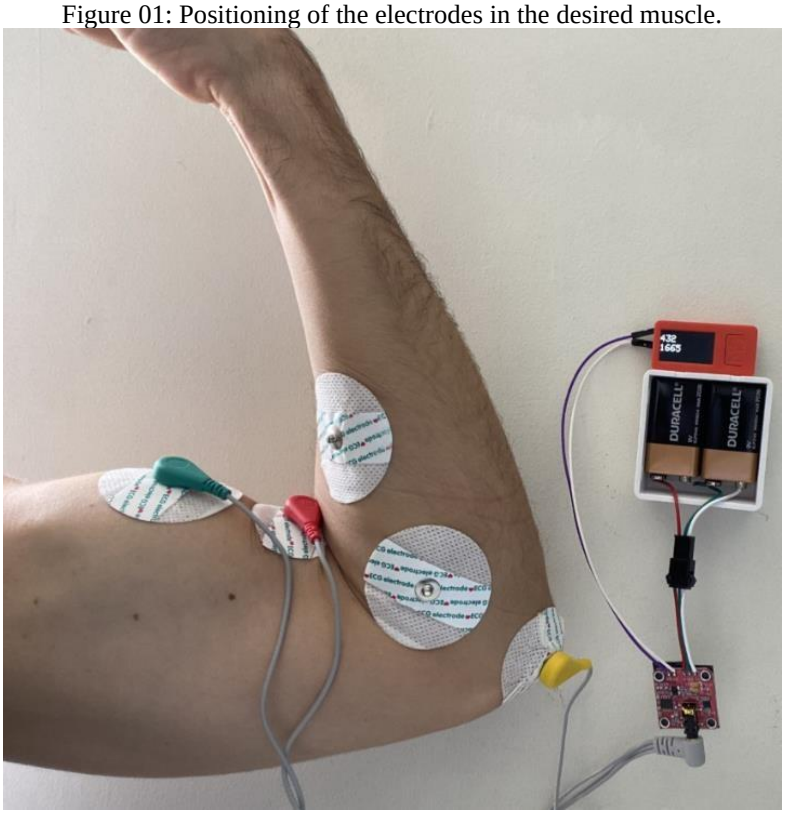
- To measure the EMG signals generated by the muscle of patients;
- Sensor interface;

- Process signals locally and handle errors;
- Promote human-machine interface;
- Indicate the measured signal;
- Communicate with Google Sheets®;
- Make a request to WhatsApp®.

To operate the equipment, the first step is to glue the electrodes to the desired muscle group. A green electrode should be attached to the middle of the muscle to be measured, a yellow electrode should be placed at the end of the target muscle, and the yellow electrode should be placed in a non-muscle part. As depicted in the image below.

After positioning the electrodes, dispose of the equipment. A welcome screen will be presented, as exemplified in Figure 01.

Figure 01: Positioning of the electrodes in the desired muscle.



Source: The author

After the welcome screen, the equipment will wait for the user to press the button to start reading the EMG signals, as shown in Figure 02 and Figure 03.

Figure 02: Image of M5StickC displaying the home screen.

Source: The author

Figure 03: Image of M5StickC displaying the waiting message.

Source: The author

After pressing the start button, the equipment begins to measure the signals coming from the patient's muscle contraction and display them on the display. At this point, the equipment processes the signals and saves them in the internal memory. When the user finishes their exercises, they must press the button again, so the equipment will understand that the session is over! As exemplified in Figure 04.

Figure 04: Image of the M5StickC displaying the measurement value.

Source: The author

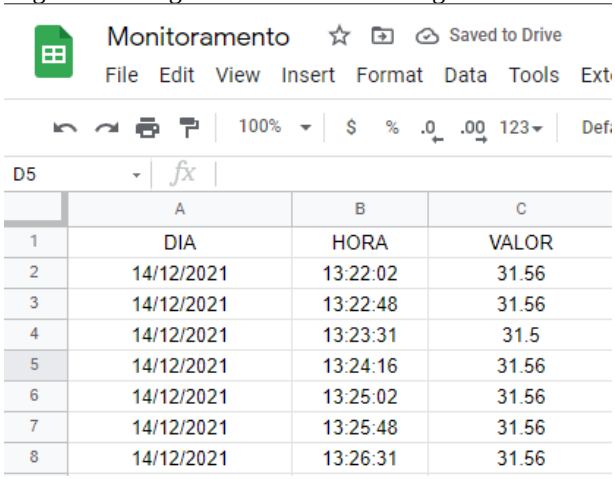
After finishing the session, the device asks the user to connect with the "ESP SmartConfig" application to enable internet access to the equipment, as can be seen in Figure 05.

Figure 05: Image of M5StickC displaying the request for connectivity to the Application.

Source: The author

After connecting the equipment, it will send the patient's data to Google's server, in a "Sheet" that the doctor or physiotherapist has access to. Like Figure 06.

Figure 06: Image of the data in the Google Sheets table.



	A	B	C
1	DIA	HORA	VALOR
2	14/12/2021	13:22:02	31.56
3	14/12/2021	13:22:48	31.56
4	14/12/2021	13:23:31	31.5
5	14/12/2021	13:24:16	31.56
6	14/12/2021	13:25:02	31.56
7	14/12/2021	13:25:48	31.56
8	14/12/2021	13:26:31	31.56

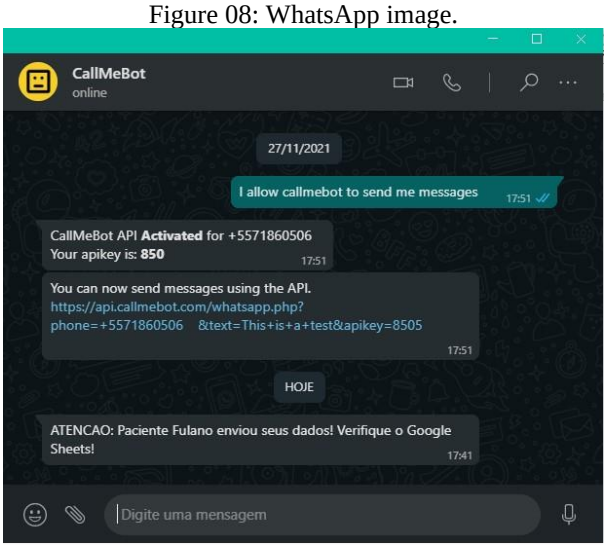
Source: The author

After successfully sending the data to the registered spreadsheet, the equipment deletes its internal memory and sends an HTTP request to CallMeBot, which generates a notification on WhatsApp from the professional accompanying the patient, as can be seen in the following two figures, Figure 07 and Figure 08.

Figure 07: WhatsApp Notification.

Source: The author

Figure 08: WhatsApp image.



Source: The author

Finally, after all communications are successfully made, the equipment issues a warning to the patient that the data has been sent and at this point the equipment can be turned off. As can be seen in Figure 09.

Figure 09: Image of the M5StickC displaying the checkout message.

Source: The author

5 CONCLUSIONS

This is a product of the biomedical industry that could revolutionize how medicine and motor rehabilitation is treated in the world, since it is not necessary for the patient to have physical contact with a health professional so that this professional can monitor their rehabilitation and physical reconditioning, protecting, ensuring accessibility, and promoting comfort to the patient. The entire system has already been built and tested, only the validation stage of the integration of the segmented EMG signals and constant updating of these values is missing, the other parts of the project are already developed and waiting for the completion of this stage to join and finalize the proposal.

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