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EMG MUSCLE FATIGUE DETECTION

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Abstract: Muscle fatigue and injuries are extremely common and may have a profound effect on the individual presenting with them. They are not restricted to professional athletes or indeed athletes at all but may occur commonly in people who have physically demanding jobs. The most important step to successful treatment is accurate diagnosis and sound professional advice, one that involves physiotherapists and other specialists. If well diagnosed and monitored, it would allow a healthier life for people suffering from injuries and those undergoing rehabilitation sessions. This project is based on the principle of Electromyography using a Myoware muscle sensor. The sensor can be fixed to any standard and can be positioned on the desired body part of the individual and can measure the Fatigue experienced by the specific muscle groups simultaneously with greater precision. The device gives us real time data of the muscle groups by measuring the EMG potential, voltage, and sensor values, which would also be the basis for different types of muscle injuries, their diagnosis, monitoring and severity classification. The aim is to develop a NodeMcu ESP8266 based IOT EMG monitoring device, which will analyze the EMG signal, generated from various muscle groups to check the performance of fatigue in that muscle.

I. INTRODUCTION

Muscle strains occur when tendons or muscles are injured. Localized muscle fatigue is usually harmful, causing serious injuries when the level of fatigue is high. EMG is a biomedical signal used to measure muscle activity. Muscle tissue is a conductor of electrical potentials like the way nerves do and the name given to these electrical signals is the muscle action potential. Surface EMG is a method of recording this electrical information present in these muscle action potentials.

The EMG measures the electrical currents that are generated in muscles when they contract, representing neuromuscular activities. Muscle activity that includes relaxation and contraction is controlled by the nervous system and depends on the anatomical and physiological properties of muscles. Given that the muscle characteristics differ from person to person there isn't one simple function of muscle load and timing that can define a precise muscle fatigue threshold, this is the significant reason that interest is taken in EMG signal analysis in Clinical diagnosis as well as biomedical applications. When muscle activation occurs, to lift a load, the muscle shortens and contracts [2] Concentric contraction (i.e., shortening of the muscle) will only occur if the load on the muscle is less than the tetanic tension that the muscle produces. Isometric contraction includes activation of the muscles but the muscle length remains the same. When muscles are exercised, they are sometimes active while lengthening; this is called an eccentric contraction, and it occurs when the subject walks or places an object on the floor. In the latter, when the object falls, it is being controlled by the active arm flexors. When dynamic or non-isometric contractions are said to be performed it means: dynamic exercise is being performed, where all of the three above mentioned contractions are taking place. This means that the muscles are constantly lengthening and shortening as the exercise is carried out. A researcher claims that's a weakening of muscle strength can be treated by intents use of active movement involving repetitive task, task-oriented and task-variation [3], but the others claim that the repetitive task produces muscle fatigue [4-5, 7]. There has been extensive evidence concerning the relationship between repetitive tasks and muscle fatigue in numerous studies [5-6]. The loss of muscle strength is caused by muscle fatigue, which is the breakdown of muscle tissue as a result of exercise. Muscle fatigue can occur when someone does exercise without rest. This condition also has an impact on stroke patients if they do the repetitive task in a long period [8]. ‖ The detection and classification of muscle fatigue adds important information to the fields of human-computer interactions, sports injuries and performance of sports players, ergonomics and prosthetics. An automated system that will help in predicting and detecting when muscle fatigue occurs will be a boon in sports related scenarios, where fatigue can/may lead to injury. This system can be applied in occupational health and ergonomics, where there is a risk of work-related musculoskeletal disorders. If localized muscle fatigue occurs in the workplace it may cause injury, for example, if a task or activity causes elevated static muscle activity [1]. An automated system can determine when the muscle is fatiguing and hence avoid injury. The existence of muscle fatigue during arm movements done for stroke rehabilitation can be determined by using an EMG signal [5]. The most significant part in signal processing to eliminate the affected noise or undesired part and to obtain the useful information in the EMG signals is Feature extraction. The extraction of features can be classified into three types: time domain (TD), frequency domain (TF), and time-frequency domain (TFD). Previous studies have mentioned that a stationary or steady sEMG signal depends on many factors such as the contraction of the muscle when a constant force is applied, where the sEMG signal would be considered as stationary, which is a TD feature [9]. In the meantime, the sEMG signal is also considered as non-stationary because it is contained in various frequency components [10]. Thus, wavelet trans-form, as a TFD feature, is the best feature extraction technique for analyzing the sEMG in both the time and frequency domains. 8 Several authors have described the EMG signal analysis performance and their validation of the biceps brachia muscle with different ranges of age, protocols, and electrode placements on the desired muscle. For example, when monitoring an athlete's performance in muscle strength exercises, the use of a dumbbell as a resistance to muscle contraction is considered[11] in order to increase the strength of the biceps brachii muscle. A previous study documented and compared the effect of EMG on the biceps brachii muscles of male and female subjects. The comparisons were based on the mean values and root mean values[12]. Many Studies shows the comparison of the electromyography biceps brachii muscle activity which was based on differences in the root mean square (RMS) and mean absolute value (MAV), which are the two most commonly accepted features that define the amplitude of electromyography signals[13,14]. Some studies suggest the biceps brachii muscle to be the site of placement of electrodes during the EMG measurement. The best location for the EMG electrodes is in the area between the innervation zone(IZ) and the tendon to obtain high-quality and stable sEMG signals[15, 16]. To obtain comparable results in EMG based muscle fatigue research, selection of volunteer subjects may be based on a set of criteria. Several health factors greatly influence the outcome, and it is therefore important that the participating subjects are healthy. Muscle performance can be affected by preexisting conditions or diseases, resulting in inconsistent results. Smoking and alcohol consumption are other factors that could influence results. [7] A typical experiment in muscle Fatigue research involves a subject performing a task that is a fixed activity such as moving a given limb in a specified manner. The changes in signal acquired from muscle movement is detected by the sensor attached to the skin. After recording and processing the acquired signal, the characteristics of the muscle are revealed. Normally healthy volunteers give informed consent to participate in the research study after being explained the experiment to them by an ethics committee. They are then approved by the ethics committee to participate in the study.

II. METHODOLOGY

The microcontroller is supplied with 5V of Voltage supply. The code which has been uploaded onto the microcontroller board starts to execute itself upon receiving voltage supply. Surface electrodes and Myoware Muscle Sensor are interfaced with the microcontroller. The EMG muscle sensor measures the electrical impulses and voltages of the muscle group under examination. It monitors the parameters from different positions as the surface electrodes are placed on specified locations of the muscle group under examination. The microcontroller will read the voltage and sensor data from the Analog muscle sensor data pin and send that information to the screen. Data is generated on the basis of voltage values to sensor values. We record this data using an external application to read values of the serial monitor. This data is now uploaded and analyzed using signal processing techniques like RMS values, FFT (Fast Fourier Transform) and mean frequency over time on Python.

If the wires are having a lose connection or if the electrode placement is misplaced by mistake while performing the analysis ,the code designed is efficient enough to detect and display these errors on to the screen ,thus maintaining the efficiency of the system.

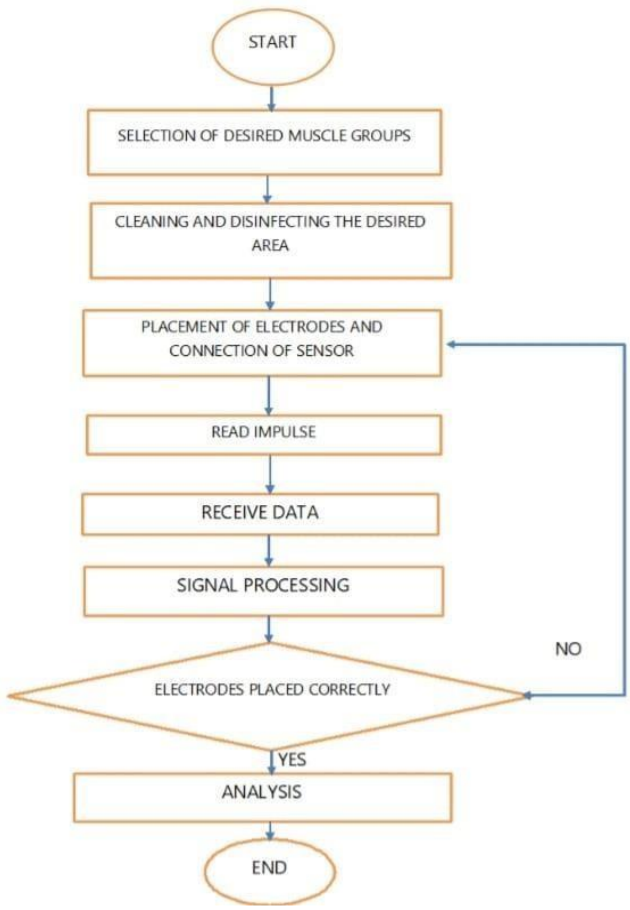

Fig.1: - Flow chart of the system

III. HARDWARE AND SOFTWARE REQUIREMENTS

1) Myoware Muscle Sensor (AT-04-001)

Fig. 2: - Myoware

Muscle Sensor Features and specifications: -

This muscle detector from Advancer Technologies measures a muscle's exertion by covering the electric implicit generated by muscle cells. An analog-to-digital converter (ADC) on every microcontroller can fluently read the simple analog signal generated by the detector which amplifies and processes the complex electrical exertion of a muscle. As the target muscle group flexes, the detector's affair voltage increases. An on-board gain potentiometer can be used to fine-tune the voltage-muscle activity relationship. In addition, the new model has a raw EMG output, reverse power protection, a power switch, as well as LED indicators. In order to attach to skin, the sensor requires three electrodes that snap into the sensor's snap-style connectors, which make it easy to attach and detach electrodes. An additional connector is located at the end of the reference electrode cable, and two are located directly on the PCB. There is a 0.1" pitch on the pins, and the board works with both male and female headers 0.1".

Technical Details: -

- Single Supply
- 2.9V to +5.7V
- Polarity reversal protection
- Two Output Modes
- EMG Envelope
- Raw EMG
- Expandable via Shields
- NEW – LED Indicators
- Specially Designed for Microcontrollers
- Adjustable Gain Applications

2) EMG Electrodes

Fig 3: - Electrodes

Features: -

Excellent electrical characteristics are showcased by the product
The base material, size, and connection types are varied
The monitoring electrode is attached to the monitor with foam tape and equipped with a radiolucent stud.
A convenient abrader is included with the ECG electrode.
A high-adherence ECG electrode is recommended for monitoring applications that require a high level of adhesion.
Featuring a foam tape back and proprietary sticky gel, the product ensures excellent skin contact

3) NODEMCU-ESP8266

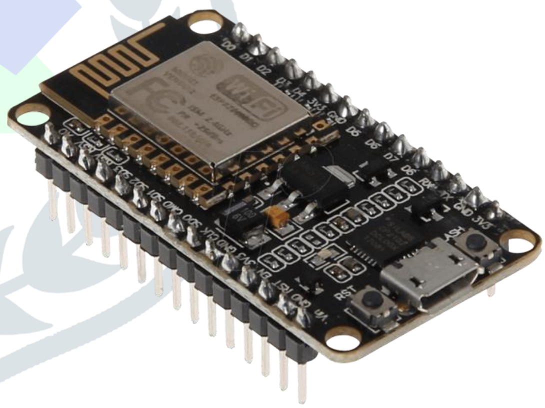

Fig 4: - NodeMcu-ESP826

It is possible to make prototyping boards based on NodeMCU's open-source firmware. The name "NodeMCU" was created by combining two other words "node" and "MCU" (micro¬controller unit). Firmware is what is meant by "NodeMCU," not the accompanying development kits. There is an open-source firmware design as well as a prototyping board design. Nodemcu ESP8266. It is common to use a DIP board, which consists of a USB controller and a smaller surface mount board that contains an antenna and the MCU, for prototyping. By using the DIP format, breadboard prototyping is made easy. Based on ESP-12, which is an IoT-recognized Wi-Fi module with a Tensilica Xtensa LX106 core, the original design relied on this module.

Nodemcu ESP8266 Specifications & Features: -

- A Tensilica 32-bit RISC CPU Xtensa LX106 is used as the microcontroller
- 3.3V is the operating voltage
- There is a voltage range of 7-12 volts for the input voltage
- There are 16 digital input/output (DIO) pins on this board
- There are 1 analog input pins (ADC) on the board
- There is one UART
- There are one SPI
- There are one I2C
- A 4 MB flash memory is included
- A 64 KB SRAM is provided
- There is an onboard USB-TTL module based on CP2102 that enables Plug & Play operation

4) Arduino UNO

Fig 5: - Arduino Uno

A microcontroller board based on the ATmega328P, Arduino UNO, is a board that uses the Arduino microcontroller. A 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header, a reset button, and 14 digital input/output pins (of which six can be used as PWM outputs) are all included. Getting started is as easy as connecting a USB cable to a computer or using an AC-to-DC adapter or battery to power the microcontroller.

Technical Specifications: -

- Microcontroller used is Microchip ATmega328P
- Operating Voltage is 5 Volts
- There is a voltage range of 7-12 volts for the input voltage
- There are 14 digital input/output (DIO) pins on this board of which 6 can provide PWM output
- There are 6 PWM Pins (Pin # 3, 5, 6, 9, 10 and 11)
- 50 mA is the DC current for 3.3V Pin
- Flash Memory: 32 KB of which 0.5 KB is is used by the boot loader A 2KB SRAM is provided
- There are 6 analog input pins
- DC Current per I/O Pin is 20 m
- 1 KB of EEPROM is available
- Clock speed is 16 MHz

5) PYTHON PROGRAMMING: -

Python is an interpreter, object-oriented, high-level programming language with dynamic semantics developed by Guido van Rossum. stem scripting, and is popular for Rapid Application Development and as a scripting or glue language to tie existing components because of its high-level, built-in data structures, dynamic typing, and dynamic binding and signal processing. Because Python is easy to learn and emphasizes readability, program maintenance costs are reduced. Additionally, Python's support of modules and packages facilitates modular programs and the reuse of code. Python is an open-source community language, so numerous independent programmers are continually building libraries and functionality for it

Python Use Cases: -

- Creating web applications on a server Building workflows that can be used in conjunction with software
- Connecting to database systems
- Reading and modifying files
- Performing complex mathematics
- Processing big data
- Fast prototyping
- Developing production-ready software

IV. RESULTS AND DISCUSSION

4.1 Results of Descriptive Statics of Study Variables

After the signal is acquired, it is processed on the Python application where Signal Processing techniques like RMS values, FFT and Mean frequency over time are performed in order to detect the fatigue muscle values. If the wires are having a lose connection or if the electrode placement is misplaced by mistake while performing the analysis, the system is designed efficiently to detect these issues.

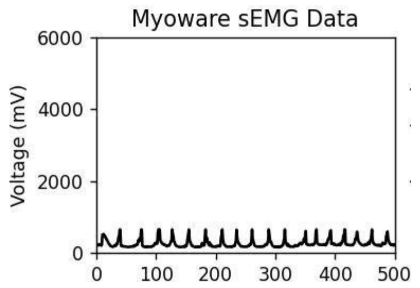

Fig 6: -Graph of Raw EMG data of sEMG data

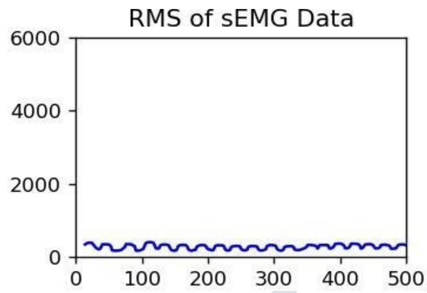

Fig 7: -Graph of RMS (Root Mean Square) of sEMG data

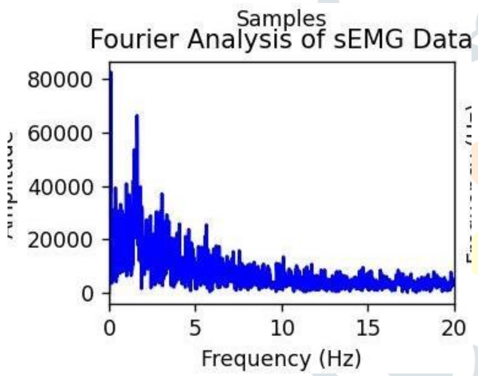

Fig 8: -Graph of Fourier Analysis of sEMG Data (Amplitude vs Frequency)

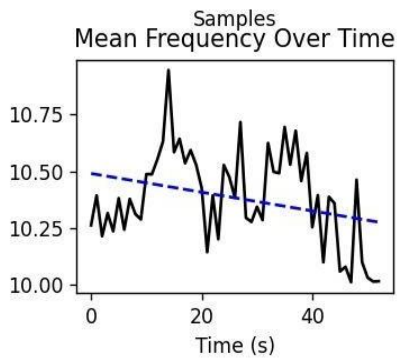

Fig 9: - Graph of Mean Frequency Over Time

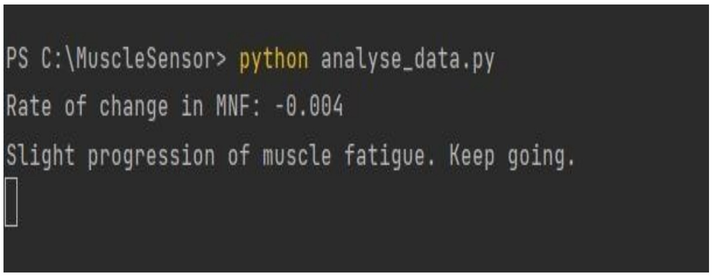

Fig 10: - Fatigue Muscle reading on Python Application**.**

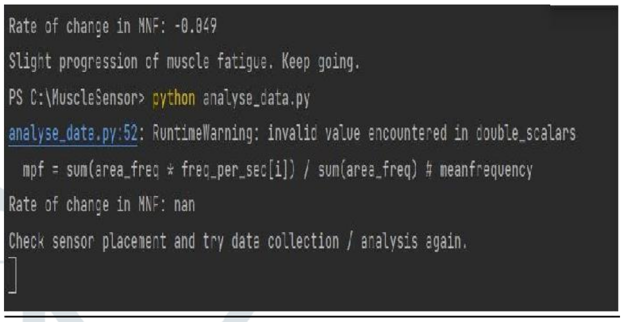

Fig.11: - Python Application showing error

V. CONCLUSION

Using this technique, the system will discover the electromyogram signals from different areas of body that will detect the strength of muscles and convert it in to measurable or understandable data or graphical format. This collected data from EMG module will help in conditional analysis of body muscle. With the help of this technology, we can identify the muscle reaction ability and capacity in the form of electric single from different area of body and can convert electromyogram signals in the form of values or codes and plot it over graphical tools. Apart from that there is possibility to store and manage all records for further analysis in biomedical sense

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