International Research Journal of Innovations in Engineering and Technology (IRJIET)

ISSN (online): 2581-3048

Volume 8, Issue 11, pp 54-57, November-2024

https://doi.org/10.47001/IRJIET/2024.811007

Muscle Strain Mapping Using Arduino and IoT

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***Abstract* - Muscles are an important organ in the movement of the body's skeleton to carry out sports activities. Measurement of muscle activity during the exercise process can be done using electromyography (EMG). This research uses muscle sensor (AT-04-001) which is integrated with ATMEGA 328 SMD. This project presents a wearable, real-time muscle strain mapping system using Arduino and IoT technologies. The system utilizes electromyography (EMG) sensors to detect muscle activity and strain levels. Data is transmitted wirelessly to a cloud-based platform for analysis and visualization. Wearable monitoring devices are in demand in recent times for monitoring daily activities including exercise. Moreover, it is widely utilizing for preventing injuries of athletes during a practice session and in few cases, it leads to muscle fatigue. At present, emerging technology like the internet of things (IoT) and sensors is empowering to monitor and visualize the physical data from any remote location through internet connectivity. In this study, an IoT-enabled wearable device is proposing for monitoring and identifying the muscle fatigue condition using a surface electromyogram (sEMG) sensor. Normally, the EMG signal is utilized to display muscle activity. Arduino controller, Wi-Fi module, and EMG sensor are utilized in developing the wearable device. The Time-frequency domain spectrum technique is employed for classifying the three muscle fatigue conditions including mean RMS, mean frequency, etc. A real-time experiment is realized on six different individuals with developed wearable devices and the average RMS value assists to determine the average threshold of recorded data.**

Keywords: Muscle Strain, Arduino, IoT, Electromyography, EMG, Surface electromyogram.

I. INTRODUCTION

The Muscle Strain Mapping Using Arduino and IoT project aims to create an affordable, real-time muscle monitoring system that combines Arduino microcontrollers with Internet of Things (IoT) technology. By utilizing EMG sensors to detect muscle strain and transmitting this data wirelessly to a cloud-based platform, this system offers an accessible solution for users to monitor their muscle activity in real time. The system can be used by athletes to optimize performance, by physiotherapists to track rehabilitation progress, or by individuals and workers to prevent overuse injuries. This project leverages the power of IoT for seamless data transmission, Arduino for lowcost processing, and cloud computing for real-time data analysis and visualization, offering a scalable, user-friendly tool for muscle health monitoring. However, current muscle monitoring solutions, such as electromyography (EMG) machines, cumbersome, and limited to clinical environments.

II. LITERATURE SURVEY

In [1] Dr. M. Manoj Prabu1, Mr. D. Yugeanthiran , Ms. A. Vaishnavee3, Mr. R. Sunil4 Wireless Muscle Monitoring and Cramp Detection System with RealTime Alerts. This project presents a Muscle Cramp Detection System employing a Node MCU microcontroller with a DHT11 temperature and humidity sensor and a flex sensor for real-time muscle health and environmental monitoring. The system aims to promptly identify muscle fatigue and cramps by processing data from both sensors. It transmits this data to Thing Speak, an IOT platform, via Wi-Fi for remote access and analysis. Healthcare professionals and individuals can proactively manage muscle health and detect potential issues. This system enables early detection of muscle fatigue and cramps and offers insights into related environmental factors, showcasing the practical application of IOT and sensors in healthcare.

In [2] Fouad Jameel Ibrahim Alazzawia, Marwa Azzawib, Madiha Fouad Jameelc, and Yurii Khlaponind IoT-based Pain Monitoring and Management System Patient suffering from pain is in need for an immediate medical intervention, however in some cases self-pain assessment is not available due to unconsciousness or prone to errors due to observer's biases. Therefore, automated pain assessment and management is needed. The internet of things (IoT) revolution along with biosensor technology could be convenient for pain assessment and management application. Therefore, this paper is a mini-survey of the literatures in this field published in six years (2016–2021) was conducted in three online databases. Hundreds of papers were found, however after title, abstract and contents screening only 13 papers were included. This paper is aimed to review the papers that suggest a pain assessment model in a IoT philosophy, in order to summarize the present work and propose new suggestions for future work. Research with different pain levels, in a bigger and real

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patient population with different diseases were suggested in the conclusion for future work.

In [3] Rui Qin1 and Hongying Meng Continuous Pain Related Behavior Recognition from Muscle Activity and Body Movements Chronic pain is a disease that the patients suffers a lot in their daily life and it is difficult to be released completely. It is difficult to manage because pain can come anytime and it is unpredictable. However, the pain can be represented by the pain related behaviors such as guiding and abrupt actions. In this paper, we will develop a machine learning based system that can detect the pain related behaviors from patient's Electromyography (EMG) signals and body movements continuously. The system includes data collection, feature extraction, modeling and classification. The data were collected using biosensor sensor for EMG and motion capture for body movement. Specific features are extracted from the body movement data. Then Random Forest and a Two Stage Classification (TSC) scheme (KNN coupled with Hidden Markov Model (HMM)) were used for pain related behavior detection in a continuous manner. The proposed method was tested on EmoPain corpus dataset provided by UCL and experimental results demonstrate the efficiency of the proposed method.

In [4] mohammed aledhari1, (senior member, ieee), rehma razzak1, basheer qolomany2, (member, ieee), ala al-fuqaha3, (senior member, ieee), and fahad saeed 4, (senior member, ieee)] Biomedical IoT: Enabling Technologies, Architectural Elements, Challenges, and Future Directions This paper provides a comprehensive literature review of various technologies and protocols used for medical Internet of Things (IoT) with a thorough examination of current enabling technologies, use cases, applications, and challenges. Despite recent advances, medical IoT is still not considered a routine practice. Due to regulation, ethical, and technological challenges of biomedical hardware, the growth of medical IoT is inhibited. Medical IoT continues to advance in terms of biomedical hardware, and monitoring figures like vital signs, temperature, electrical signals, oxygen levels, cancer indicators, glucose levels, and other bodily levels. In the upcoming years, medical IoT is expected replace old healthcare systems. In comparison to other survey papers on this topic, our paper provides a thorough summary of the most relevant protocols and technologies specifically for medical IoT as well as the challenges. Our paper also contains several proposed frameworks and use cases of medical IoT in hospital settings as well as a comprehensive overview of previous architectures of IoT regarding the strengths and weaknesses. We hope to enable researchers of multiple disciplines, developers, and biomedical engineers to quickly become knowledgeable on how various technologies cooperate and how current frameworks can be modified for new use cases, thus inspiring more growth in medical IoT.

III. PROPOSED SYSTEM

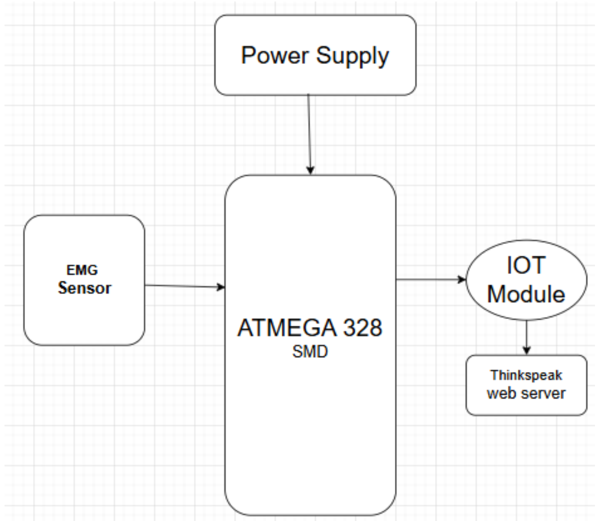

Figure 1: Proposed Methodology

Block Diagram description:

There are two parts to the proposed system. The first is software, and the second is hardware, for monitoring in normal and abnormal situations utilizing sensors and IoT. The data from the various sensors is delivered to the controlling device, which is microcontroller, under the hardware section. The data processing Programme is programmed into the microcontroller. ATMEGA 328 used as a main controller which controls all the operations. Connect to a Microcontroller (e.g. Arduino) a. Connect the SIG pin of your sensor to an analog pin on the Arduino (e.g. A0) b. Connect the GND pin of your sensor to a GND pin on the Arduino. If any Mussale pain is there then sensor goes above Threshold value. Then update data on web server thinkspeak and recommend patient doctor for treatment. Graphically we can monitor the data on web.

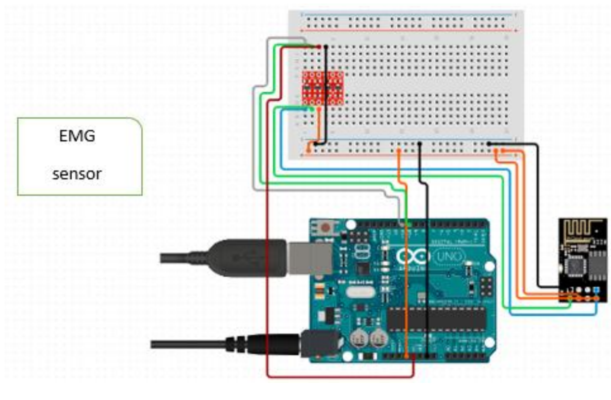

Figure 2: Proposed circuit diagram

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ATMEGA 328 SMD:

Arduino is a single-board microcontroller to make using electronics in multidisciplinary projects more accessible.

The hardware consists of a simple open source hardware board designed around an 8-bit Atmel AVR microcontroller, or a 32-bit Atmel ARM. The software consists of a standard programming language compiler and a bootloader that executes on the microcontroller.

EMG Muscle Sensor:

Figure 3: EMG Muscle Sensor

If you are wandering to make a device that is used to detect measure electrical activity on muscle, then you will need EMG sensor, EMG Muscle Sensor Module measure the filtered and rectified electrical activity of a muscle; outputting 0-Vs Volts depending the amount of activity in the selected muscle, where Vs signifies the voltage of the power source. Power supply voltage: min. +-3.5V.

By detecting the electromyogram (EMG), measuring muscle activity has traditionally been used in medical research, however with shrinking but more powerful microcontrollers and integrated circuits advent EMG power Road and sensors can be used for various control systems.

This Muscle EMG Sensor measures, filters, rectifies, and amplifies the electrical activity of a muscle and produces an analogue output signal that can easily be read by a microcontroller.

ESP8266 WiFi Module:

This module has a powerful enough on-board processing and storage capability that allows it to be integrated with the sensors and other application specific devices through its GPIOs with minimal development up-front and minimal loading during runtime. Its high degree of on-chip integration allows for minimal external circuitry, including the front-end module, is designed to occupy minimal PCB area.

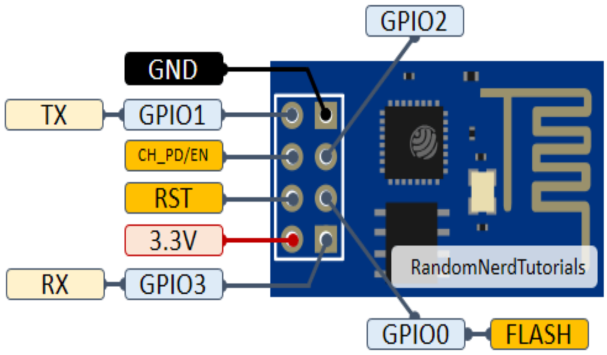

Figure 4: ESP8266 WiFi Module

a) Morphological Transform (Morphological Transform):

To produce an output image with a comparable size, morphological processes employ a structural feature on the input image. To find the value of each pixel in the output image, it compares the matching pixel in the input image with its neighbors. Morphological alterations come in two flavors: erosion and dilation.

b) Problem Definition:

Muscle strain, resulting from excessive muscle activity or overexertion, is a common issue in sports, manual labor, and rehabilitation settings. Existing muscle monitoring systems, such as electromyography (EMG) machines, are effective but often expensive, bulky, and not easily accessible for continuous, real-time use outside of clinical environments. This lack of affordable and portable muscle strain monitoring solutions hinders the ability of individuals to detect early signs of muscle fatigue or strain, leading to injuries, reduced performance, and prolonged recovery times.

IV. RESULTS AND DISCUSSIONS

Real-time muscle activity monitoring. Visual representation of muscle strain levels. Alert system for excessive strain detection. Multi-sensor fusion for comprehensive monitoring. Integration with physical therapy and rehabilitation platforms. Development of personalized muscle strain prediction models.

V. CONCLUSION

This project demonstrates the potential of Arduino and IoT technologies in monitoring muscle strain. The wearable system provides real-time insights, enabling individuals to take preventive measures and reduce injury risk.

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Citation of this Article:

Sanskruti Gaikwad, Aakanksha Khambayat, Pratik Waykar, Aryan Kasar, Prof. Sandhya. B. Thakare. (2024). Muscle Strain Mapping Using Arduino and IoT. *International Research Journal of Innovations in Engineering and Technology - IRJIET*, 8(11), 54-57. Article DOI https://doi.org/10.47001/IRJIET/2024.811007

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