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Posture Guardian With Smart Muscle Strain Detection And Correction Using TINYML

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Abstract— Millions of dollars are spent in the healthcare business on muscle strain-related illnesses, notably low back pain. Inadequate posture is typically the cause of lower back discomfort, especially in the transverse abdominal muscle. Intelligent monitoring systems encourage proper posture and exercise on a global scale to improve quality of life and treat this frequent issue. As pervasive intelligent technology emerges, medical equipment such as pulse monitors, hearing aids, and health monitors are being developed. This research discusses the design, development, and testing of a tiny wearable interface that uses an array of sensors to monitor and notify a person's back position in real time. A good posture helps to alleviate muscle stress during physical exertion and promotes general health. As a result, a gadget capable of detecting and correcting improper posture has become important. We created a wearable electromyography (EMG) sensor and flex sensor. EMG and flex sensors are used in our technology to monitor human posture and decide if it is right or improper. TinyML (Tiny Machine Learning) is used by our technology to assess and categorize posture data in real time, offering quick feedback and remedial help. Our TinyML-powered Smart Posture technology helps people improve their posture, reduce muscle discomfort, and improve their overall health and quality of life.
Index Terms— EMG, Health, MUSCLE, Smart monitoring, TINYML

1. Introduction

Muscle strains are a common occurrence in sports and physical fitness that, if left untreated, may impair an athlete's performance and result in long-term problems [1]. These injuries are typically caused by overexertion, poor technique, or insufficient warm-up measures [2]. Recognizing the importance of avoiding and controlling muscular strains, scientists and engineers have devised novel methods for detecting and correcting these abnormalities in real time [3]. One such achievement is the creation of sophisticated muscular strain detection and correction devices [4]. These cutting-edge technologies, which use a mix of sensors, data processing algorithms, and biofeedback mechanisms, give athletes and fitness enthusiasts with instant insights on their muscle performance, allowing them to make changes and lessen the danger of strains and injuries [5-7].

Posture refers to how individuals position themselves in terms of how they stand, sit, walk, and conduct tasks, and it has a big influence on their health [8]. Maintaining excellent posture allows the vertebrae of the spine to be correctly positioned [9].

It will posture has been linked to ill health as well as poor performance. According to one research, slouching has an effect on the transverses abdominis muscle [10-16]. The width of the transverse abdominis muscle has reduced significantly when a person maintains a slouched posture. Intransitive abdominis dysfunction has been linked to low back discomfort. Low back pain is one of the leading causes of disability globally, affecting an estimated 80% of the population. It is estimated that 80 percent of the population will be affected at some time [17]. Back discomfort is reported by 62 percent of the young population [18]. Ordinary acts, such as hunching over on a chair, may cause back pain [19]. People who were made to sit in a slumped posture had higher tension and so performed worse. Staying in the same position for a lengthy amount of time, even with excellent posture, is a bad postural habit because the muscles in the spine might cease generating chemicals needed for proper biological function [20]. As a consequence, excellent posture and changing postures on a regular basis are seen as vital, if not necessary, for overall health.

This technology was created to identify the region of stress and the length of time a person sits in the same position. The technology detects the proper or wrong posture by monitoring changes in human posture.

The LCD displays an indication of poor posture to the user.

1.1 Motivation of the paper

The study's objective is to address the high healthcare expenses associated with muscular strain-related illnesses, notably lower back pain, which affects a big segment of the population. Poor posture, particularly in the transverse abdominal muscle, is a frequent source of lower back pain and may have a negative impact on a person's quality of life. With the fast growth of wearable smart technology and the growing demand for medical equipment, there is a chance to build a solution that encourages good posture and improves health results. It is now feasible to monitor an individual's back posture in real time and send warnings for incorrect posture by developing a small wearable interface packed with sensors. This method has the ability to minimize muscular tension during physical exercise and everyday living, lowering the risk of muscle strain and boosting general well-being. This technology's advancement is in line with the expanding trend of preventative healthcare and individualized wellness solutions. The wearable gadget can accurately detect human posture and identify it as proper or wrong by using electromyography (EMG) and flex sensors. Real-time posture data analysis utilizing Tiny Machine Learning (TinyML) algorithms provides fast feedback and remedial aid.

2. Materials and Methods

This technology was created to identify the region of stress and the length of time a person sits in the same position. The technology detects the proper or wrong posture by monitoring changes in human posture. The LCD displays an indication of poor posture to the user. The device is intended for human comfort and appropriate body posture, both of which are necessary to keep the body and mind healthy.

2.1 Block Diagram

- Itcanidentifyourpostureifwearenotslouchinginthechair anditcanalsodetectourposturewhilewearedoingany activity.
- Itissuitablefortravellingpurpose.

The Arduino UNO is a small, inexpensive, and easily programmed microcontroller board that has many potential uses in the realm of electronics. Deflection or bending may be measured using a flex sensor, also known as a bend sensor. To assess and record the electrical activity produced by skeletal muscles, electrodiagnostic medicine makes use of electromyography (EMG) sensors. Liquid Crystal Display is shortened to LCD. Multi-segment light-emitting diode and seven-segment displays are the most common applications for these types of screens.

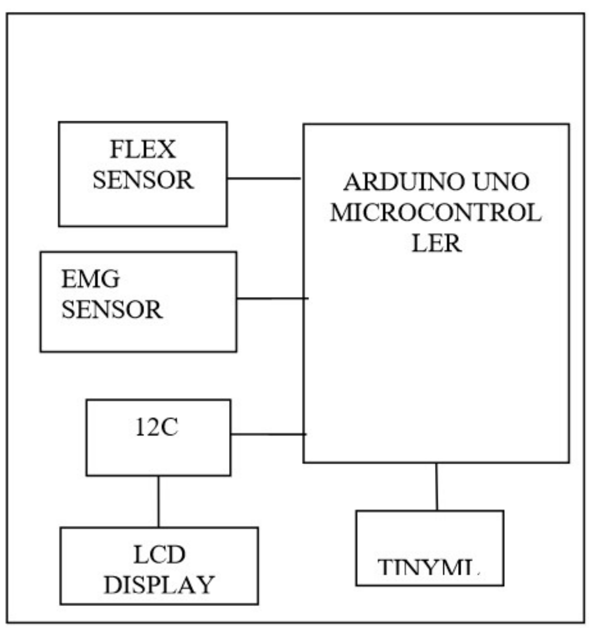

Fig 1: Block Diagram

2.2 Circuit Diagram

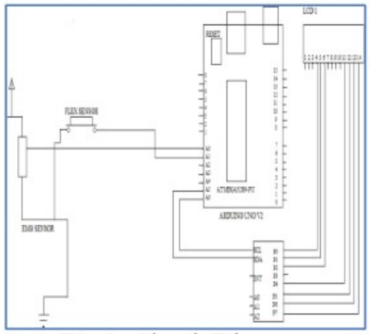

Fig 2: Circuit Diagram

The ARDUINO UNO Microcontroller was used in the circuit's development. The ARDUINO IDE is used to merge the code and hardware before feeding it to the Microcontroller. The Flex Sensor and Electromyography (EMG) sensor can measure muscle tension and body alignment. The outcome is shown on a 16-by-2-inch LCD screen. The LCD display's 16-pin connection to the microcontroller is reduced to a 4-pin interface through the I2C interface. Analog pins on the microcontroller receive data from the Flex sensor and the EMG sensor. The LCD Display receives the data from the microcontroller through the I2C Interface pins.

2.3 ArduinoUNOMicrocontroller

The ATmega328P is the basis of the Arduino Uno microcontroller board. There are 14 digital I/O pins, six of which are PWM outputs, a reset button, and a USB port. It contains a reset button, six analog inputs, and a 16 MHz ceramic resonator (CSTCE16M0V53-R0). The microcontroller may be powered via a computer's USB port, or an AC-to-DC converter or battery can be used to get things going.

Since "UNO" means "one" in Italian, it was selected to commemorate the launch of Arduino Software (IDE) 1.0. In the years since the first Uno board and version 1.0 of the Arduino Software (IDE) were released, the Arduino platform has seen a number of revisions and improvements. The Arduino Uno board is the foundation of the Arduino platform and the first of a line of USB development boards.

Fig 3: ARDUINOUNO

2.4 FlexSensor

A flex sensor, sometimes known as a bend sensor, is a sensor that detects and records mechanical deformation. Bending the surface, which is normally attached to the item being monitored, adjusts the resistance of the sensor element. A goniometer's resistance, also known as a flexible potentiometer, changes directly with the bending radius.

Flex sensors are used in a variety of studies, including those involving computers, rehabilitation, security systems, and even musical instrument interfaces. It is also popular among students and hobbyists. A flex sensor may be used to measure the amount of deformation or bending. This sensor might be made from materials such as plastic and carbon. When the carbon surface on a plastic strip is spun, the resistance of the sensor changes. A strain gauge is what a bend sensor is. It may also be used as a goniometer since the amount of turn is directly connected to the resistance change. This sensor operates on the bending strip principle, which means that when the strip is bent, its resistance changes. This may be monitored with any controller.

Fig 4: FLEXSENSOR

2.5 EMGSensor

Muscle electrical activity after nerve stimulation may be measured by electromyography (EMG). Neuromuscular disorders may be better pinpointed with the use of this testing. One or more small needles (electrodes) will be placed beneath the skin and into a muscle during the test. A monitor called an oscilloscope shows the electrical activity captured by the electrodes as waves. The volume of the sound is amplified so that it may be heard. At rest, during mild contraction, and during vigorous contraction, EMG records the electrical activity of the muscle. During a typical resting state, muscle tissue does not generate electrical impulses. There should be a short period of activity on the oscilloscope once an electrode is inserted, but then no signal at all.

Following electrode placement, you could be asked to raise or bend your leg to contract the muscle. Oscilloscope readings of the action potential (wave's amplitude and morphology) this produces reveal the muscle's responsiveness to electrical stimulation. More and more muscle fibers are engaged and action potentials are generated when the muscle is flexed more vigorously. In certain cases, a nerve conduction study (NCS) may be necessary. How much and how quickly an electrical impulse travels along a nerve is quantified by the nerve conduction speed, or NCS. In conjunction with EMG, NCS can assess nerve injury and destruction. Diseases that cause damage to nerves and muscles may be diagnosed, localized, and assessed with the use of both diagnostic methods.

Fig 5: EMGSENSOR

2.6 LCDDisplay

The abbreviation for "Liquid Crystal Display" is "LCD." It's a kind of electronic display module found in many different circuits and gadgets (such phones, calculators, PCs, TVs, etc.). Multi-segment Light Emitting Diodes and seven-segment displays are the most common uses for these types of monitors. A flat-panel Liquid Crystal Display, like those seen in computer and television displays, mobile devices, etc. LCD and CRT screens may seem identical, yet their functions are quite different. A liquid crystal display uses a backlight to illuminate each pixel in a rectangular array, rather than electrons diffracting through glass.

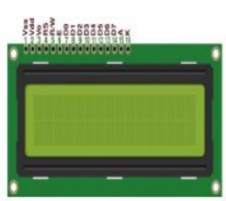

Fig 6: LCDDISPLAY

2.7 JumperWire

Jump wires (also known as jumpers, jumper wires, and DuPont wire) are electrical wires (or groups of wires in a cable) that have a connector or pin at each end (or sometimes do not have them at all and are simply "tinned") and are typically used to connect the components of a breadboard or other prototype or test circuit, either among themselves or to external equipment and components. The "end connectors" of individual jump wires are inserted into corresponding slots on a breadboard, a circuit board's header, or a piece of testing equipment. In the world of printed circuit boards, a "jumper wire" is an electrical line used to link far-flung electrical circuits. The electric circuit may be jumped to by using a jumper wire to create a short circuit. A jumper wire is a short length of wire that has already been cut and stripped for use in various electrical circuits. Jumper wire may be either bare or tinned and can have a single core (solid wire) or several strands (stranded wire).

Fig 7: JUMPERWIRE

2.8 LCDI2C16x2

The 16-by-2-character LCD can show up 16 ASCII characters across both rows. This I2C-interface LCD module cuts down on the usual seven digital pins required by conventional 16x2 character displays. The display's brightness may be modified using a built-in potentiometer. These LCDs find widespread usage, showing up in anything from photocopiers and fax machines to laser printers and industrial testing equipment.Thissensorhas 4pins:

- **VCC**:Modulepower supply –5V
- **GND**:Ground
- **SDA:**I2CData
- **SCL**:I2CClock

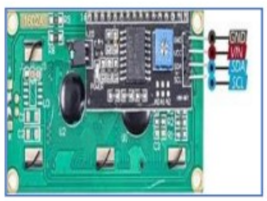

Fig 8: LCDI2C16x2

2.9 TinyML

In the context of muscle strain detection, TinyML frameworks offer valuable capabilities for implementing machine learning algorithms on constrained platforms. These frameworks enable the development of efficient and lightweight models that can be deployed directly on wearable devices or embedded systems for real-time muscle strain detection. One approach within the TinyML ecosystem involves converting pre-trained models from popular ML libraries such as TensorFlow, Scikit-Learn, or PyTorch. By leveraging tools like TensorFlow Lite, these models can be optimized and adapted to run efficiently on resource-constrained platforms. This allows for the deployment of muscle strain detection models directly on wearable devices, providing real-time feedback and alerts to users during physical activities. Another approach is to integrate ML libraries within the microcontroller units themselves. This enables on-device training and analysis, empowering the device to generate models from data collected during muscle strain monitoring. By incorporating unsupervised learning algorithms, these models can adapt to individual users' patterns and improve the accuracy of strain detection over time.

2.10 Importance of IoT

The term "Internet of things" (IoT) refers to a network in which everyday items are embedded with sensors, processors, software, and other technologies that allow them to communicate and share data with other devices and systems. Some have argued that the term "Internet of Things" is misleading since it implies that all linked gadgets must communicate via the public internet rather than just one private network.

The area has progressed as a result of the integration of several technologies, including as cheap sensors, sophisticated embedded systems, the Internet of Things, and machine learning. Independently and together, the Internet of Things enables the traditional domains of embedded systems, wireless sensor networks, control systems, automation (including home and building automation).The Internet of Things, or IoT for short, is a rapidly developing area of computer science that may increase the intelligence of any electronic device. Many sectors are integrating this technology into their processes in an effort to boost output and cut waste. Many commonplace items, from washing machines to home garages, are getting a digital makeover thanks to the Internet of Things. It's also clear that the Internet of Things will rapidly develop into a multi-trillion dollar market.

This cutting-edge technology does more than just link the device to the internet; it also gives the user access to a host of additional benefits, including as real-time analytics, a platform for analyzing the data acquired, cloud data storage, the ability to remotely initiate an action, remote alerts, and so on. This technology has so many potential uses that it can be used in almost any market.

3. Results and Discussion

In this section, we present the results and discuss the findings of our study on the development and testing of a tiny wearable interface for real-time posture monitoring. The goal of our research was to create a technology that utilizes electromyography (EMG) and flex sensors to monitor human posture and classify it as correct or incorrect. By leveraging Tiny Machine Learning (TinyML) algorithms, we aimed to provide quick feedback and remedial assistance to help individuals improve their posture, reduce muscular strain, and enhance their general well-being and quality of life.

Fig 9: Hardware Diagram

The hardware is seen in figure 9. In the field of information technology, the term "hardware" refers to the myriad of tangible components that are necessary for the operation of computer systems, devices, and networks.

Fig 10: Correct Posture

The figure 10 shows LCDdisplayingthe“correctposture”,whenthesystemdetectsthatthehumanholdsthegoodposture.

Fig 11: FLEX value

Fig 12: EMG value

The figure 11 and 12 shows the EMG VALUE and FLEX VALUE that is detected by the system when thehumanholds thecorrectposture.

4. Conclusion

The purpose of our system is to provide individuals with a comprehensive solution for monitoring their posture, detecting areas of stress, and identifying how long they have been sitting in the same position. Tiny ML (Tiny Machine Learning) is used by our technology to assess and categorize posture data in real time, offering quick feedback and remedial help. By accurately detecting changes in posture, our system can determine whether a person is in the right or wrong posture. To achieve this, our system incorporates an LCD display that serves as a user interface. The LCD provides real-time feedback and alerts the user when they are in the wrong position. This visual indication allows individuals to become aware of their posture and make the necessary adjustments to maintain a correct posture. The primary goal of our gadget is to prioritize human comfort and encourage proper body posture. Maintaining good posture not only supports physical health but also contributes to overall mental well-being. By helping individuals maintain proper body alignment, our system aims to alleviate muscular strain, reduce discomfort, and promote a healthier and more comfortable lifestyle. By utilizing our wearable interface with its posture monitoring capabilities, individuals can gain insights into their posture habits and make informed decisions to improve their body alignment. With regular use, this technology can help individuals develop healthier posture habits and minimize the negative effects of prolonged sitting or incorrect postures, ultimately contributing to their overall well-being and quality of life.

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