INNOVATIVE DESIGN OF INSOLE SHOES FOR ORTHOTIC PATIENTS WITH CLUBFOOT OR ANKLE DISPLACEMENT

A PROJECT REPORT

Submitted by

JYOTSANA K B	**[412419205034]**
HARINI G	**[412419205028]**
KAVITHAZRI G	**[412419205038]**

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BONAFIDE CERTIFICATE

Certified that this project report **“Innovative design of insole shoes for orthotic patients with clubfoot or ankle displacement."** is the Bonafide work of **“JYOTSANA KB (412419205034), HARINI G(412419205028), KAVITHAZRI G(412419205038)”,** who carried out the project work under my supervision.

SUPERVISOR	PROJECT COORDINATOR	HEAD OF THE DEPARTMENT
Ms. P SHARMILA **ASSISTANT PROFESSOR** Department of Information Technology	**Ms. P SHARMILA** **ASSISTANT PROFESSOR** Department of Information Technology	**Dr. V. BRINDHA DEVI** **PROFESSOR** Department of Information Technology

Submitted for the Project VIVA-VOCE Examination held on ……………….at Sri Sai Ram Institute of Technology, Chennai -6000 44.

INTERNAL EXAMINER **EXTERNAL EXAMINER**

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Such a successful personality is our beloved founder Chairman, **Thiru.MJF.Ln. LEO MUTHU.** At first, we express our sincere gratitude to our beloved Chairman through prayers, who is the guiding star who has spread his wings of external support with immortal blessings.

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We thank all the teaching and non-teaching staff members of the Department of Information Technology and all others who contributed directly or indirectly for the successful completion of the project.

ABSTRACT

The Internet of Things (IoT) is a promising technology for automation in both industries and commercial applications. Orthotic patients are the one who suffers a lot in regular life due to the impact of club foot disorder. The major problem is dealt with the physical imbalance which we are trying to fix in our project by counterbalancing. The existing system used for this purpose is a semi-automized system that properly supports only a few patients. The objective of this research is to create counterbalance support with the magnitude changes and export data logs to our server base for real-time improved fabrication of shoes based on their physical practice. In the proposed work we create a cloud system that tracks their body movements based on a six-axis accelerometer and three-axis gyroscopic modules. This data log will be saved on the cloud web server for our future study to develop the required counterbalance formula for the individuals.

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CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Clubfoot or club foot is an abnormality or disability in the shape of the foot that occurs from birth but is not yet known the exact cause of it. Early prevention of this disorder is very difficult because it is a congenital or genetic disorder. However, this disorder can be known early so that further treatment can be done.

FIGURE 1.1 PATIENT CLUB FOOT SHAPES

Club foot occurs because of the stiffness of the muscles and tendons of the inside of the foot so that the tendon becomes short and pulls the foot inward. Someone who has the shape of a foot like this will feel discomfort when doing daily activities so that every work or activity carried out runs poorly and not optimally. The development of the existing shoe industry is indeed running very fast and rapidly both in terms of design and fabrication offered.

However, this cannot be enjoyed by some people who have deformity feet like club foot. This happens because the shape of the foot that is owned is not in accordance with the form of footwear that is mass-fabricated and spread on the market. The shape of the foot like this if forced to use mass-fabricated footwear will eliminate the feeling of comfort and it will actually injure the foot. Shoes consist of insole, shoe last, upper shoe and outsole. The insole is the inside of the shoe which will that is in direct contact with the ground when people are on the move.

FIGURE 1.2 TRADITIONAL MOULDING PROCESS

Upper shoe is a blanket part of the shoe that covers the back of the foot, while shoe last is the core that forms the shoe that determines the final shape and is an important factor in determining the quality of shoes. The shoe last design and manufacturing process can be done in two methods, namely the manual process and using CARE System as in the journal reported by In general, the shoe fabrication process is largely determined by the form of shoe last, this is reported by However, one of the factors supporting the comfort offootwear lies in the insole that is in direct contact with the sole of the foot.

This condition has been reported by in his paper stating that one of the factors in the comfort of footwear, when used for daily activities, lies in insoles that are designed and manufactured according to the shape and size of the soles of the feet.

Number of Measure	The Measure of Actual Foot from Patient with Club Foot		The Measure of 3D Replika Foot from Patient Club Foot		Error	
	Right Foot (mm)	Left Foot (mm)	Right Foot (mm)	Left Foot (mm)	Right Foot (mm)	Left Foot (mm)
1	179.50	224.70	179.40	224.60	0.06	0.09
2	134.50	160.10	134.50	160.00	0.08	0.08
3	155.90	104.40	155.80	104.30	0.07	0.08
4	89.52	81.06	89.45	80.99	0.07	0.07
5	101.10	196.70	101.00	196.60	0.05	0.08
6	84.23	87.47	84.15	87.41	0.08	0.06

FIGURE 1.3 TRADITIONAL ERROR RATE STUDY

The process of making insoles with designs that fit the shape and size of the soles of the feet needs to be used Reverse Engineering (RE) technology on a CAD, CAE, and CNC / RP basis that is reliable and this is often referred to as a Computer Aided Reverse Engineering System (CARE System)

1.2 SDG GOALS

- Design of Perfect Orthotic Shoe
- Free Energy Transmission and Charging
- Cloud Server Data Log from Real-time

1.3 OBJECTIVE

- Create Counter balance support with magnitude changes
- Export data log to our server base for real-time improved fabrication of shoes based on their physical practice
- Recharge the system hardware with a free energy rack and pinion mechanism
- Here we implement piezoelectric sensors to generate the variable voltage for data a transmission
- DC Buck booster will stabilize the ramping voltage which is gained from foot pressure
- Future prediction of supportive design on fabrication will be extracted from our real-time server data logs

1.4 PROBLEM STATEMENT

Orthotic patients are the one who suffers a lot in regular life due to the impact of Club foot disorder. This is a genetic imbalance disease that sounds to nearly 12.8% of thetotal population in India. Nearly 21% of the world's population suffers from genetic, accidental, and explosive impacts. The major problem is dealt with the physical imbalance which we are trying to fix in our project by counterbalancing. We gather the information based on precise six-axis Accelerometer and Three-Axis Gyroscope magnitude variations.

1.5 EXISTING SYSTEM

Counterbalance support was derived with general assumptions. A common semi-automized system that supports only few patients properly. Robotic an ankle landlibs are controlled with a counterbalance weight. There is no presence of muscle contraction study analysis. The free energy rack and pinon concept is still imbalance which can generate power

CHAPTER 2

LITERATURE SURVEY

A.A. Anthony et al.(2020)[1] author discussed a Club foot as one of the foot deformities caused by genetic factors. Patients with this characteristic have abnormal foot shapes most important difficulty is finding shoes with the right footwear, precisely and comfortable to use. The number of patients who are not small in Indonesia is an important topic discussed in this paper. The semi-Reverse innovative design (RID) is a Reverse Engineering application with 3D mesh data and is able to get the precise and accurate surface contours of the club foot patient. Computer-Aided Design (CAD) Power Shape 2019 was used in this paper to get a variation of the design of an orthotic ankle-foot insole that fits the club foot patient's foot. The resulting output is in the form of three types of insole designs with a geometric error toleranceof 0.08 mm.

Luis I.Lugo Villeda et al.(2020)[2] authors have discussed The analysis, synthesis, and mechanical design of a wearable biomechanical device for treating the club–foot children malformation is presented in this paper. This system serves as a non-invasive alternative method for correctingthis congenital malformation in 0–1 1-year-old children. Robot kinematics and constrained Euler-Lagrange dynamics tools are employed to analyze this malformation, altogether with a quasi-static computational method, and to assess the normal children's feet, in order to design a robotic prototype. The 8-month clinical case presented in this paper establishes a preliminary club–foot correction angle of 90%, without typical patient complaints, such as those coming from conventional methods, either because of uneasiness and unrest of long–time cast or invasive clinical surgery. The proposed passive noninvasive robotic prototype allows to analyze and to assess the real progress over time and spatial coordinates, which record real data of the betterment of the club–foot malformation

Yohanes EkaAnggraita putra et al.(2020)[3] the author have discussed shoe selection as the right footwear is veryrelated to the feet comfort, especially in the selection of shoe materials. The shoe consists of three parts: insole, outsole, and upper shoe. The right outsole material will affect the comfort of feet during activity. This paper demonstrates a mechanical testing method for the optimization of outsole material base computer-aided engineering (CAE). The outsole design on minutes diabetic patients in previous studies were used as the basic design for mechanical testing at CAE. The test results showed that the material EVA rubber type declared with optimum characteristics of the von Misses stress 0.0013 MPa, maximum principal stress 0.0036 MPa, and features shock absorption of 5.01562MJ. This data can serve as a basic reference for the process of manufacturing the outsole of the shoe on CNC machines.

K.Beau Freckleton et al.(2019)[4] the author have discussed the Exploration of an “Intelligent” orthotic shoe sole to negate, or minimize, longitudinal slip by momentarily increasing friction force is presented. The conceptual device takes the form of a rubberized shoe sole containing pockets of air that can be released via valves controlled by a microprocessor. During a slip event, the values would be opened and the bladders would be collapsed by the weight of theuser, which modulates contact and friction forces In this process, by creating an Impact forcebetween the user and the ground surface, with the potential to increase friction and mitigate slip. Simulations of bladder walls were modeled and combined into a lumped parameter model to pre-device behavior Prototype so the type of the device is created and evaluated to validatemodels and slip-mitigating potential.

Foad Dabiri et al.(2020)[5]the author have discussed The improvement in processor performance through continuous breakthroughs in transistor technology has resulted in the proliferation of lightweight embedded systems. Advances in wireless technology and embedded systems have enabled remote healthcare and telemedicine. Continuous and real-time monitoring can discretely analyze how a patient's lifestyle affects his/her physiological conditions and if additional symptoms occur under various stimuli. We have developed a wireless electronic orthotics composed of lightweight embedded systems and non-invasive sensors which can be used by diabetic patients suffering from peripheral neuropathy. Our proposed system monitors feet motion and pressure distribution beneath the feet in real-time and classifies the state of the patient. This system enables a continuous feedback mechanism for instance in case of an undesired behavior or condition a preemptive message is wirelessly to the patient and the patient's caregiver.

Pitchaya Rayothee et al.(2019)[6] the author have discussed a successful orthotic prescription hastwo important factors that influence fitting, the accuracy of the patient's assessmentand the ability of the device to fulfill the impairments of patient. From orthotic clinical experience, clinicians are often faced with some difficulties during prescription because of the large variety of pathologies. An orthosis which does not meet precise patient needs will ultimately affect the initial fitting as the orthosis might be inappropriate with the patient's condition. Currently, there are not that many tools or equipment to assist in making the precise and suitable prescription for each individual patient. Instead, the prescription is dependent upon the skill or experience of the clinician. Therefore, the purpose of this study was to develop a mechanical ankle joint called the SSPO temporary mechanical ankle joint or SSPO-TMAJ 1 which could adjust in three planes (sagittal, coronal and transverse) in order to be fit initially during assessment and orthotic prescription. This device could assist orthotists in during assessment and prescription by properly positioning the foot and ankle alignment in each plane following the patient conditions. There were 3 phases of the study; design and stress-strain distribution testing with the SolidWorks program; simulation task with participants; clinical trial with an able-bodied participant. The results of mechanical property testing enough during force application. SSPO-TMAJ 1 was firstly fabricated by 3D printing with plastic ABS and secondly machined and milled with Aluminum. As a result, a satisfactory score was given to the adjustability level and satisfaction level for adjustment. However, a score of 2.6/4 marks was observed in satisfaction level for appearance due to bulkiness, un-cosmetic, and non- labeled number of angles on the joint surface. These were issues which need to be too reconsidered for further studies. During sitting, standing, and walking, SSPO-TMAJ 1 is able to adjust, fix, or allow a desirable angle, range of movement and position.

Nikalo Lukic et al.(2019)[7] the author have discussed a deformed footprint was performed in the case when an anatomical customized insole is used and in the case when an anatomical customized insole is not used. Solid models of the foot and insole, which are necessary for creating finite element models, were obtained by scanning the physical objects of the footprint and insole, and by their reconstruction and optimization in Geomatics software. Stress analysis was performed in Catia V5 R21 software for the case of a neutral standing position on the ground. Results show maximum values of the pressures in the medial region of the foot and to region in the case when an anatomical customized insole is not used. With the use of the customized insole, pressures are significantly reduced.

CHAPTER 3

SYSTEM ANALYSIS

3.1 EXISTING SYSTEM:

Counterbalance support was derived with general assumptions. Common semi-automized system that support only few patients properly. Robotic ankle and libs are controlled with counterbalance weight. There is no presence of muscle contraction study analysis. Free energy rack and pinon concept is still imbalance which can generate power.

3.2 PROPOSED SYSTEM:

Our system is broadly divided into two phases of work. The primary phase is regarding the creation of a dataset that would reliably differ from multiple people who suffer from this genetic disorder. The traditional method of cloning the structure of the shoe via waxing mount no not way related to supporting their counterbalance operation. Here in our proposed model, we create the data set for people who suffer from this kind of genetic disorder problem.

3.2.1 PHASE 1 OF OUR PROPOSED MODEL:

- We design an IoT-based system that supports orthotic patients based on their regularuse
- We create a cloud system that tracks their body movements based on a six-axisaccelerometer and 3 Axis Gyroscopic modules
- Based on the pre-fixed modules we gather the magnitude difference in their range
- This data log will be saved on the cloud web server for our future study to developthe required counterbalance formula for the individuals.

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- This in turn helps to create a gadget in the universal mode of operation.

CHAPTER 4

TECHNICAL DESCRIPTION

4 DOMAIN SPECIFICATION

4.1 EMBEDDED SYSTEM

An embedded system is a combination of computer hardware and software designed for a specific function. Embedded systems may also function within a larger system. The systems can be programmable or have a fixed functionality. Industrial machines, consumer electronics, agricultural and processing industry devices, automobiles, medical equipment, cameras, digital watches, household appliances, airplanes, vending machines and toys, as well as mobile devices, are possible locations for an embedded system.

While embedded systems are computing systems, they can range from having no user interface (UI) -- for example, on devices designed to perform a single task -- to complex graphical user interfaces (GUIs), such as in mobile devices. User interfaces can include buttons, LEDs (light-emitting diodes) and touchscreen sensing. Some systems use remote user interfaces as well.

Markets and Markets, a business-to-business (B2B) research firm, predicted that the embedded market will be worth $116.2 billion by 2025. Chip manufacturers for embedded systems include many well-known technology companies, such as Apple, IBM, Intel and Texas Instruments. The expected growth is partially due to the continued investment in artificial intelligence (AI), mobile computing and the need for chips designed for high-level processing.

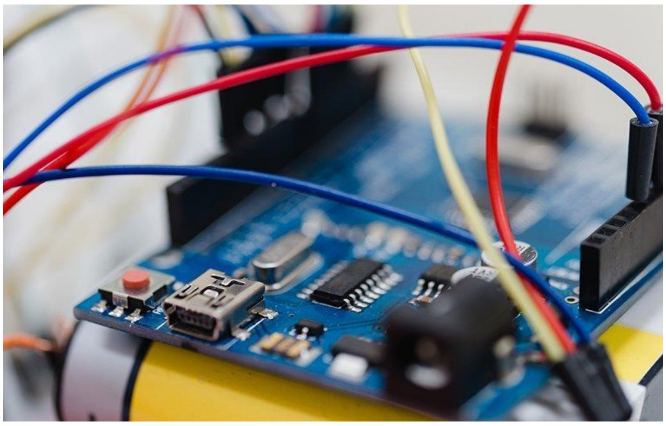

FIGURE 4.1 EMBEDDED SYSTEM

4.1.2 BLYNK WEB SERVER

The BLYNK application was designed for the primary purpose of the Internet of Things. **BLYNK** is a platform with IOS and Android apps to control Arduino, Raspberry Pi, and the likes over the Internet. It's a digital dashboard where a graphic interface for a prototype can be built by simply dragging and dropping widgets. It can control hardware remotely it can display sensor data, can store and visualize data, and possessed a lotmore functionality. There are three major components of the platform:

BLYNK APPLICATION: Allows to you create amazing interfaces for your projects using various widgets we provide.

BLYNK SERVER: responsible for all the communications between the smartphone and hardware. You use our BLYNK Cloud or run your private BLYNK serverlocally. It's open-source could easily handle thousands of devices, and can even be launched on a Raspberry Pi.

BLYNK LIBRARIES: For all the popular hardware platforms–enable communication with the server and process all the incoming and outgoing commands. Every time a radio button is accessed in the BLYNK application, the message travels to the BLYNK Cloud, where it finds the specific hardware by the uniquely generated authentication token. It works in the same way in the opposite direction.

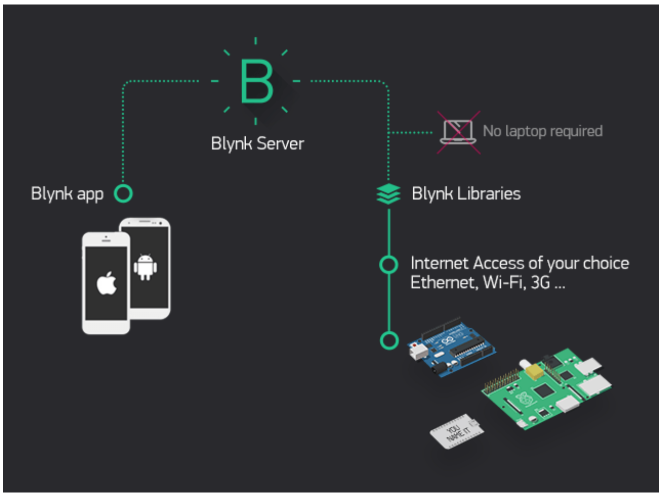

FIGURE 4.2 BLYNK SERVER

4.2 PROJECT REQUIREMENT

4.2.1 HARDWARE REQUIREMENT

- ESP8266 NodeMCU
- MPU6050 Module
- Piezo Electric Module
- Voltage Regulator 7805
- HLK5M05 SMPS

4.2.2 SOFTWARE REQUIREMENTS

- ARDUINO IDE
- PROTEUS SIMULATION SOFTWARE
- BLYNK WEB SERVER

4.2.1.1 ESP8266 NODEMCU

The NodeMCU (***N***ode ***M***icro***c***ontroller ***U***nit) is an open-source software and hardware development environment built around an inexpensive System-on-a-Chip (SoC) called the ESP8266. The ESP8266, designed and manufacture. Express if Systems contains the crucial elements of a computer: CPU, RAM, networking (Wi-Fi), and even a modern operating system and SDK. That makes it an excellent choice for Internet of Things (IoT) projects of all kinds

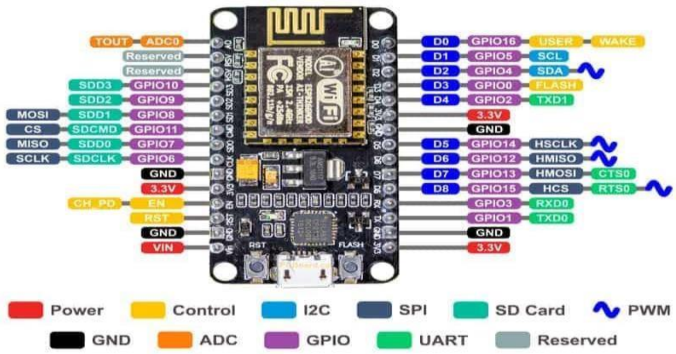

FIGURE 4.3 NODE MCU DEVELOPMENT BOARD

However, as a chip, the ESP8266 is also hard to access and use. You must solder wires, with the appropriate analog voltage, to its pins for the simplest tasks such as powering it on or sending a keystroke to the “computer” on the chip. You also have to program it in low-level machine instructions that can be interpreted by the chip hardware.This level of integration is not a problem using the ESP8266 as an embedded controller chip in mass-produced electronics. It is a huge burden for hobbyists, hackers, or students who want to experiment with it in their own IoT projects.

Similar to NodeMCU, the Arduino hardware is a microcontroller board with a USB connector, LED lights, and standard data pins. It also defines standard interfaces to interact with sensors or other boards. But unlike NodeMCU, the Arduino board can have different types of CPU chips (typically an ARM or Intel x86 chip) with memory chips, and a variety of programming environments. There is an Arduino reference design for the ESP8266 chip as well. However, the flexibility of Arduino also means significant variations across different vendors. For example, most Arduino boards do not have Wi-Fi capabilities, and some even have a serial data port instead of a USB port.

4.2.1.2 MPU6050 MODULE

The MPU6050 sensor module is a complete 6-axis Motion Tracking Device. It combines a 3-axis Gyroscope, 3-axis Accelerometer, and Digital Motion Processor all in a small package. Also, it has the addition of an on-chip Temperature sensor. It has an I2C bus interface to communicate with the microcontrollers. It has an Auxiliary I2C bus to communicate with other sensor devices like 3-a axis magnetometer, Pressure sensor etc. If 3-axis Magnetometer is connected to the auxiliary I2C bus, then MPU6050 can provide complete 9-axis Motion Fusion output.

FIGURE 4.4 MPU6050 MODULE

4.2.1.3 PIEZO ELECTRIC MODULE

A piezoelectric crystal is placed between two metal plates. At this point, the material is in perfect balance and does not conduct an electric current.

Mechanical pressure is then applied to the material by the metal plates, which forces the electriccharges within the crystal out of balance.

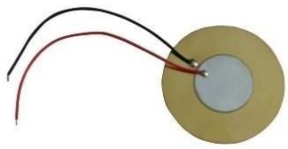

FIGURE 4.5 PIEZO ELECTRIC PLATE

4.2.1.4 VOLTAGE REGULATOR 7805

7805 is a three-terminal linear voltage regulator IC with a fixed output voltage of 5V which is useful in a wide range of applications. Currently, the 7805 Voltage Regulator IC is manufactured by Texas Instruments, ON Semiconductor, ST Microelectronics, PN Junction Diodes incorporated, Infineon Technologies, etc. This can implement constant voltage of 5 Volts with 1 Amps current rating. It comes on both SMD and DIP versions.

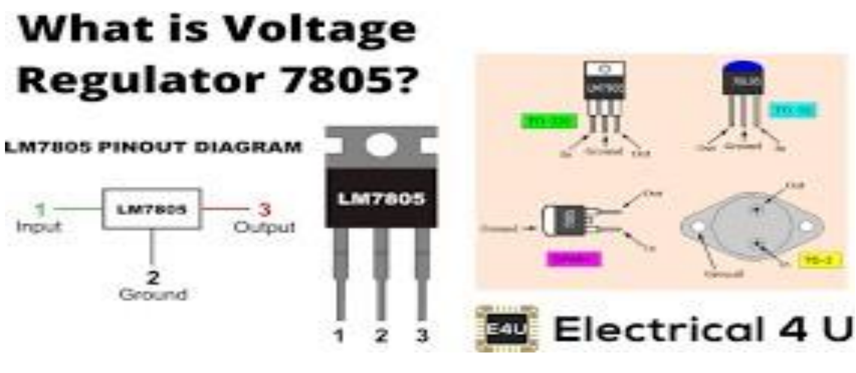

FIGURE 4.6 VOLTAGE REGULATOR 7805

4.2.1.5 HLK5M05 SMPS

- Ultra-thin, ultra-small
- Universal Input voltage range: 90 – 245 VAC
- Low Ripple, Low Noise
- High Output Short Circuit Protection and Over Current Protection
- Highly Reliable, Long Life Design, Continuous Working time of more than 1, 00,000 Hours
- Meets UL, CE requirements, product design to meet EMC and safety testing requirements
- Works without external circuit
- Input Voltage Range: 85 to 264 VAC
- Max Input Current: < 0.2A
- Input Inrush Current: < 10A
- No Load Rated Output Voltage: 5.0 VDC
- Short-Term Maximum Output Current: >1200 mA
- Long-term Maximum Output Current: >1000 mA
- Output Overcurrent Protection: 150 to 200

4.2.2.1 ARDUINO IDE

Arduino IDE (Integrated Development Environment) is the software for Arduino. It isa text editor like a notepad with different features. It is used for writing code, compiling the code to check if any errors are there and uploading the code to the Arduino. It is a cross- platform software that is available for every Operating System like Windows, Linux, macOS. It supports the C/C++ language. It is open-source software, where the user can use the software as they want it to. They can also make their modules/functions and add them to the software. It supports every available Arduino board including Arduino mega, Arduino Leonardo, Arduino

Ethernet and more. A Word file is called a Document similarly, an Arduino file is called a Sketch where the user writes code. The format of Arduino is saved as.When a user writes code and compiled it, the IDE will generate a Hex file for the code. (Hex files are Hexadecimal files which are understood by Arduino) and then sent to the board using a USB cable. Every Arduino board is integrated with a microcontroller; the microcontroller will receive the hex file and run as per the code written.

Arduino IDE consists of different sections:

1. Window Bar
2. Menu Bar
3. Shortcut Buttons
4. Text Edito

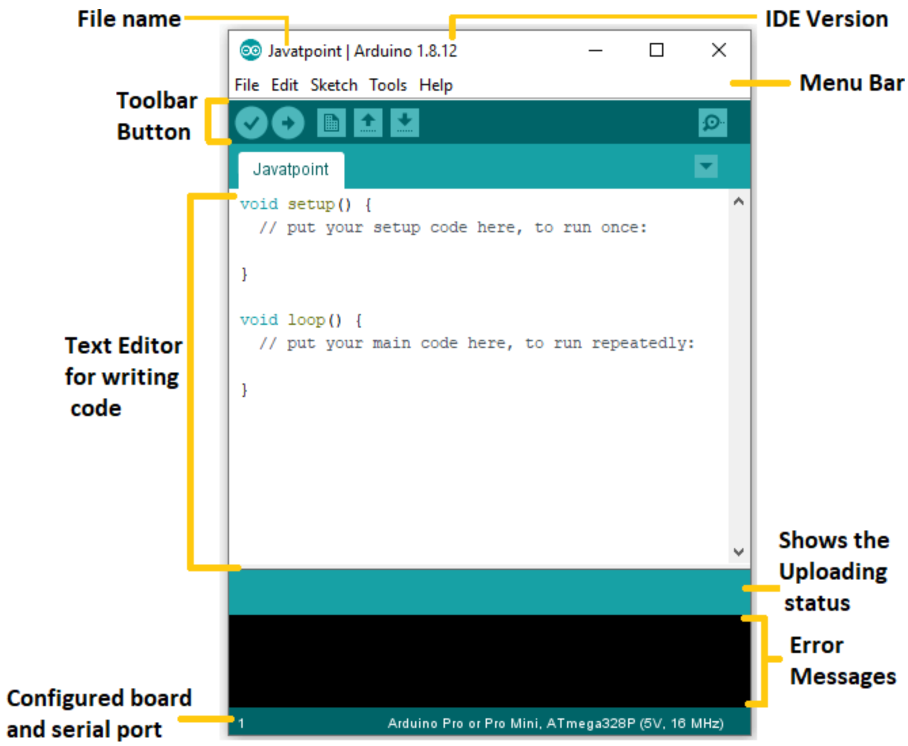

FIGURE 4.7 ARDUINO IDE

4.2.2.2 PROTEUS SIMULATION SOFTWARE

Proteus is used to simulate, design, and drawing of electronic circuits. It was invented by the Lab center electronic. By using proteus you can make two-dimensional circuits designs as well. With the use of this engineering software, you can construct and simulate different electrical and electronic circuits on your personal computers or laptops. There are numerous benefits to simulate circuits on proteus before make them practically. Designing of circuits on the proteus takes less time than the practical construction of the circuit. The possibility of error is less in software simulation such as loose connection that takes a lot of time to find out connection problems in a practical circuit. Circuit simulations provide the main feature that some components of circuits are not practical then you can construct your circuit on proteus.

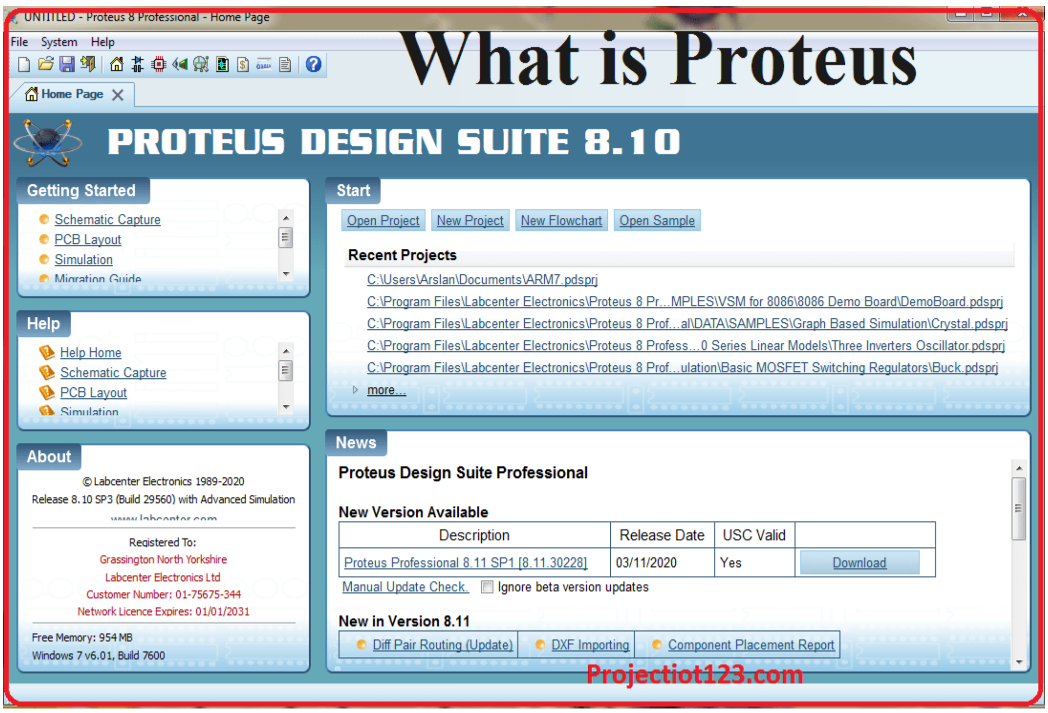

FIGURE 4.8 PROTEUS SIMULATION WINDOW

There is zero possibility of burning and damaging of any electronic component in Proteus. Electronic tools that are very expensive can easily get in proteus such as an oscilloscope. Using proteus you can find different parents of circuits such as current, a voltage value of any component and resistance at any instant which is very difficult in a practical circuit. There are 2 main parts of proteus first is used to design and draw different circuits and the second is for designing of PCB layout. First, is which used to design and simulate circucircuitsd second is A Rat used for designing of a printed circuit board. It also provides features related to the three-dimensional view of design in PCB

4.2.2.3 BLYNK WEB SERVER

The BLYNK application was designed for the primary purpose of the Internet of Things. **BLYNK** is a platform with IOS and Android apps to control Arduino, Raspberry Pi, and the likes over the Internet's digital dashboard where a graphic interface for a prototype can be built by simply dragging and dropping widgets. It can control hardware remotely, It can display sensor data, can storage and visualized data, and possessed a lot more functionality. There are three major components in the platform:

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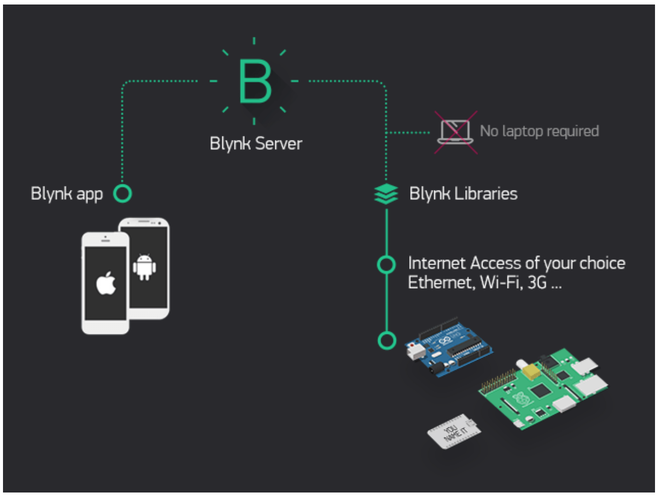

FIGURE 4.9 BLYNK WEB SERVER WORKING PLATFORM

CHAPTER 5

SYSTEM DESIGN AND WORKFLOW DIAGRAM

5.1 SYSTEM ARCHITECTURE:

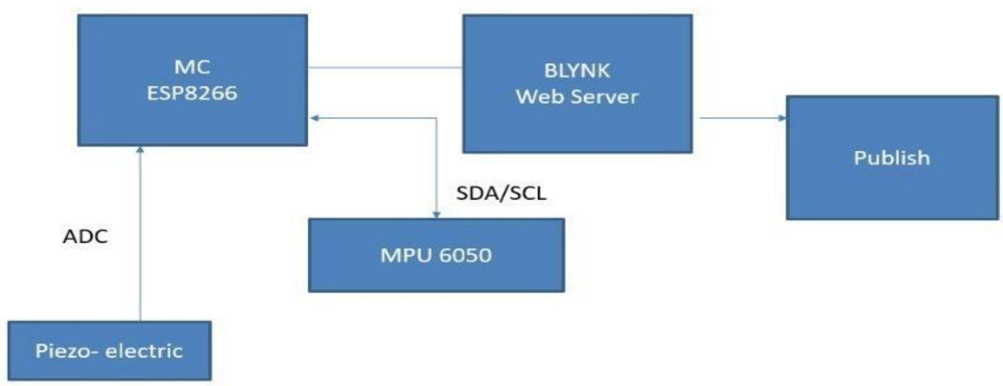

FIGURE 5.1: BLOCK DIAGRAM

PIEZOELECTRIC SENSOR: This component detects changes in foot pressure as the user moves. When pressure is applied to the piezoelectric sensor, it produces a voltage that is proportionate to the force applied. This voltage is then recorded and handled by a microcontroller using an analog-to-digital conversion (ADC).

MICROCONTROLLER: The microcontroller is the device's heart, handling data from the piezoelectric sensor, MPU 6050, and ESP8266 before transmitting it to the Blynk web server. The ESP8266 microcontroller, which is low-cost, low-power, and Wi-Fi-capable,is used in this gadget.

MPU 6050: The MPU 6050 is a 6-axis accelerometer and gyroscope instrument that detects the direction and movement of the foot. The MPU 6050 detects the acceleration and angular motion of the foot and transmits the data to the microprocessor for processing.

BLYNK WEB SERVER: A cloud-based tool that enables users to directly watch and manage their devices. The microcontroller in this gadget transmits data to the Blynk online server, which the user can then view via a smartphone app. The data can be viewed bythe user, and notifications can be sent if any abnormal changes in foot pressure or movement are identified.

The piezoelectric sensor detects the variations in foot pressure, the MPU 6050 measures the orientation and movement of the foot, the ESP8266 microcontroller processes the data and sends it to the Blynk web server, and the Blynk web server allows the user to remotely monitor and control the device.

5.2 WORKFLOW DIAGRAM:

- Connect to Blynk.
- If it is connected to Blynk it displays the WiFi mode.
- WiFi mode connects to the three components such as LED ON, MPU6050, and Piezoelectric.
- All these three components' connections are combined to display the device ON. If it doesn't connect to the Blynk it does not display WiFi.

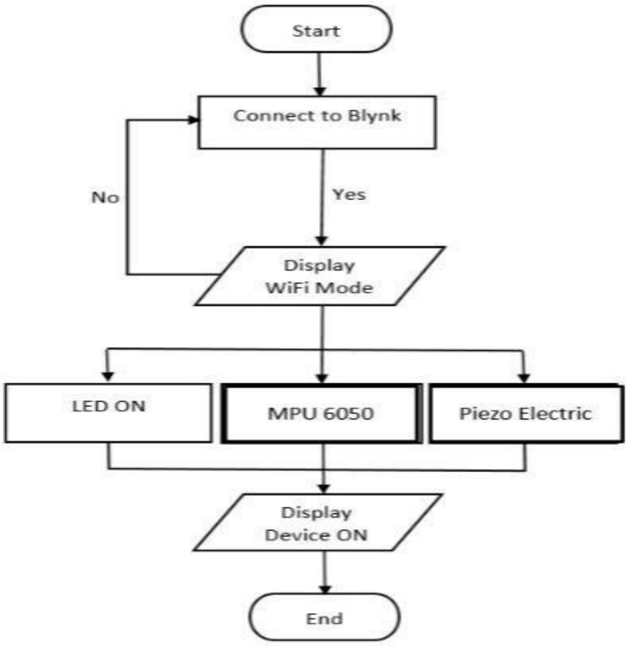

FIGURE 5.2 WORKFLOW DIAGRAM

5.3 UML DIAGRAM

UML is an acronym that stands for Unified Modeling Language.Simply put, UML is a modern approach to modeling and documenting software. In fact, it's one of the most popular business process modeling techniques. It is based on diagrammatic representations of software components. As the old proverb says "a pictureis worth a thousand words". By using visual representations, we are able to better understand possible flaws or errors in software or business processes. UML was created as a result of the chaos revolving around software development and documentation. In the 1990s, there were several different ways to represent and document software systems. The need arose for a more unified way to visually represent those systems and as a result, in 1994-1996, the UML was developed by three software engineers working at Rational Software. It was later adopted as the standard in 1997 andhas remained the standard ever, receiving only a few updates.

5.3.1 USE CASE DIAGRAM

Use case diagrams are considered for high-level requirement analysis of a system. So,when the requirements of a system are analyzed the functionalities are captured in use cases. So, it can say that use cases are nothing but the system functionalities written in an organized manner. Now the second things which are relevant to use cases are the actors(people).

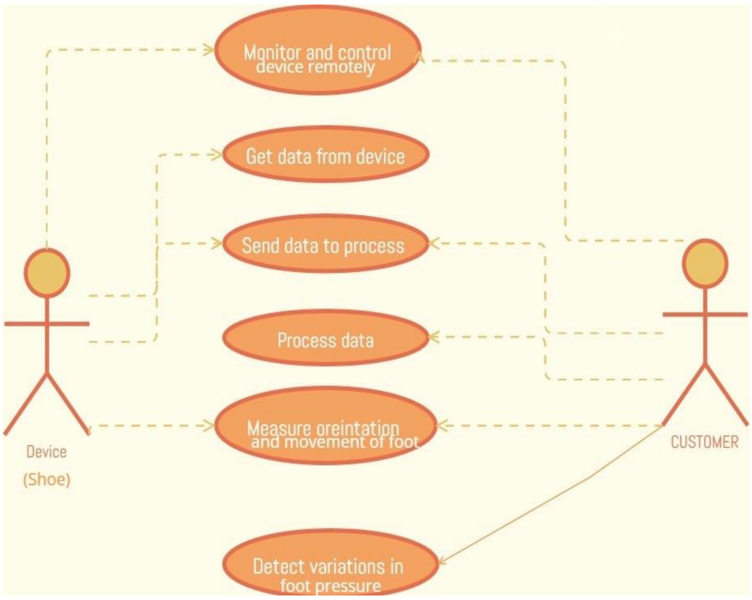

FIGURE 5.3 USE CASE DIAGRAM

5.3.2 CLASS DIAGRAM

Class diagram is basically a graphical representation of the static view of the system and represents different aspects of the application. So, a collection of class diagrams represents the whole system. The name of the class diagram should be meaningful to describe the aspect of the system. Each element and their relationships should be identified in advance responsibility of each class should be specified and because, unnecessary properties will make the diagram complicated. Use notes whenever required to describe some aspect of the diagram and at the end of the drawing it should be, understandable to the developer.

Finally, before making the final version, the diagram should be drawn on plain paper and reworked as many times as possible to make it correct.

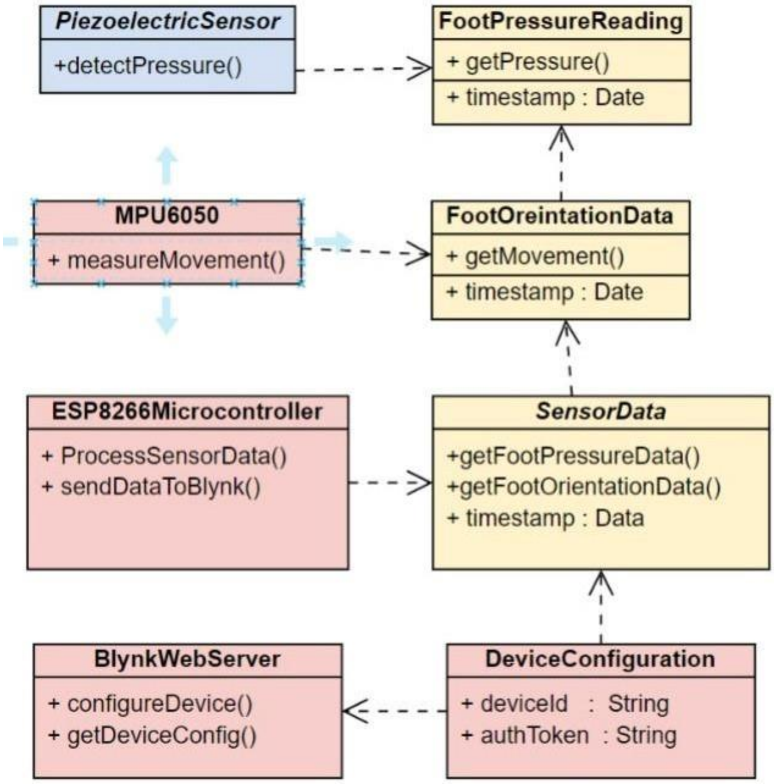

FIGURE 5.4 CLASS DIAGRAM

5.3.3 ACTIVITY DIAGRAM

An activity diagram is a particular operation of the system. Activity diagram are not only used for visualizing the dynamic nature of a system but they are also used to construct the executable system by forward and reverse engineering techniques. The only missing thing in activity diagram is the message part. It does not show any message flow from one activity to another. Activity diagram is some time considered as the flow chart. Although the diagrams look like a flow chart but it is not.It shows different flow like parallel, branched, concurrent.

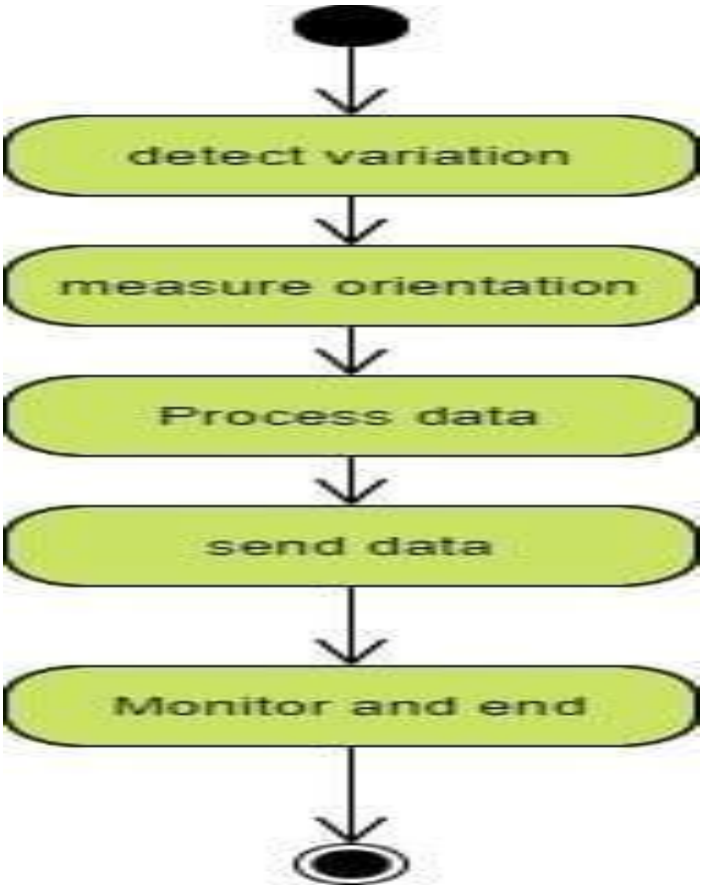

FIGURE 5.5 ACTIVITY DIAGRAM

5.3.4 SEQUENCE DIAGRAM

Sequence diagrams model the flow of logic within your system in a visual manner, enabling you both to document and validate your logic and are commonly used for both analysis and design purposes. Sequence diagrams are the most popular UML artifact for dynamic modeling which focuses on identifying the behavior within your system.

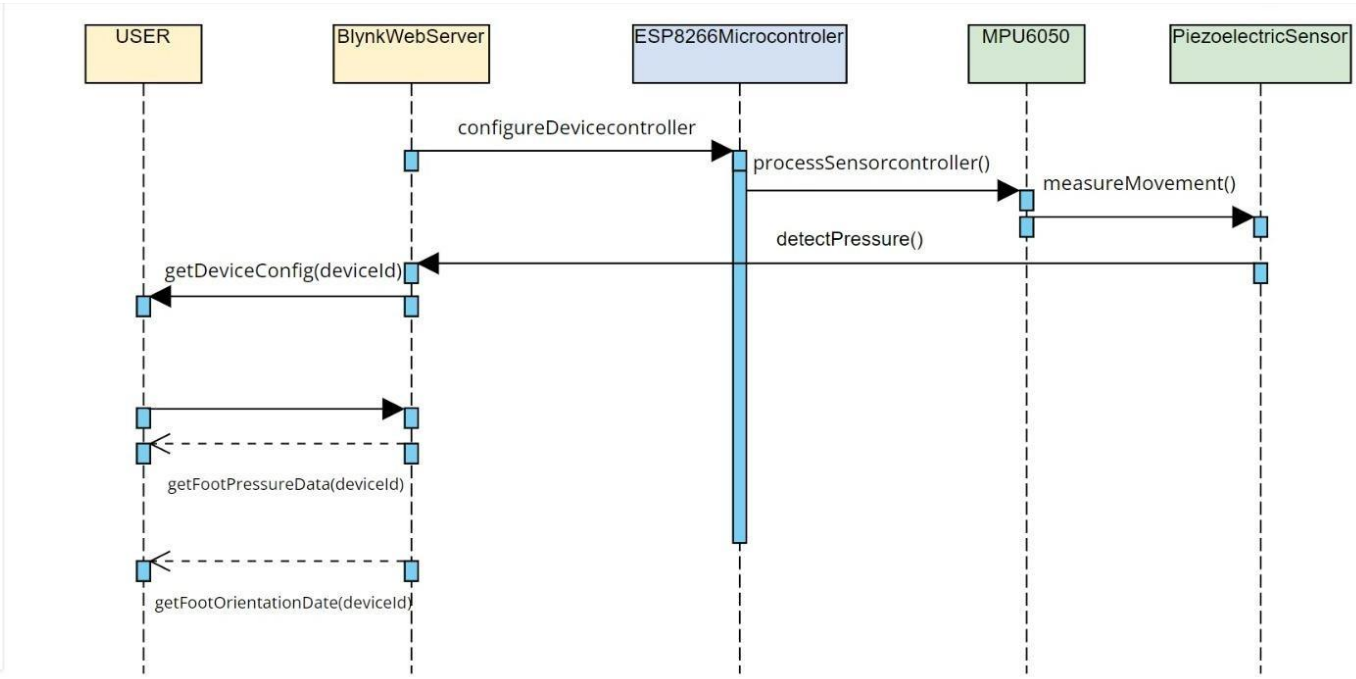

FIGURE 5.6 SEQUENCE DIAGRAM

CHAPTER 6

DISCUSSION

6.1 PROJECT DISCUSSION

We have designed a model that has a reliable feature that records instant variations on theangle of movement based on the position and degree of freedom of the sensor module. In addition to that we have created a free energy platform that could able to store charge in the system which can power up the battery since these patients suffering from genetic disorder needs to balance them with high pressure that can be converted back to a free form of energy based on this kind of kinetic plated called a piezoelectric dielectric plates. Data that we process will get uploaded to the server based on the router of any mode of internet connectivity.

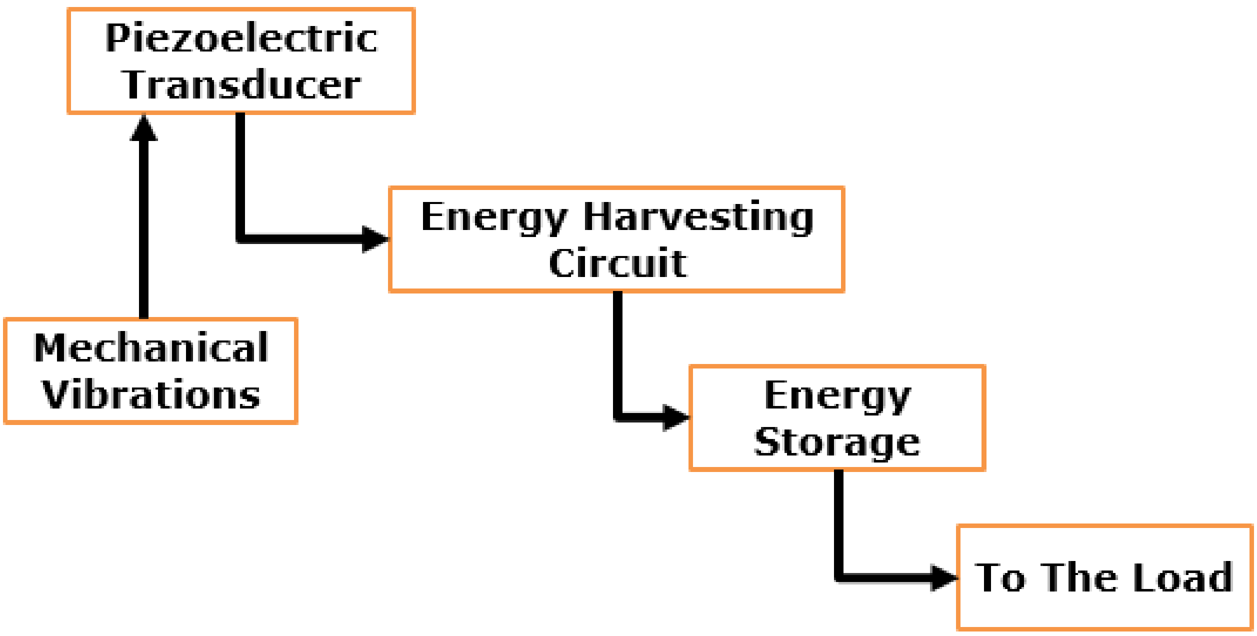

FIGURE 6.1 GENERAL BLOCK DIAGRAM OF POWER HARVESTING

6.2 WORKING MODEL WITHOUT DATASET

From the below Figure 6 .2 we could determine the device structure, indicating with arrows the motions for adjustment and corrections of the foot according to indications of medical doctor. The base of the device is composed by two rectangular plates which are grooved in such a way that are placed perpendicularly to the base to avoid the displacement of the foot outwards, and they are designed mainly to correct the adduction. These plates consequently are adjustable, according to the size of the foot and the particular anatomy of the patient.

The device can adjust to leg growth by means of the lateral bars, which can move freely upwards or downwards, according to physicians' instructions and patient needs. These same bars have a joint at the bottom that allow to turn or rotate them, aiming at extending or bending the foot, to correct the equinus malformation. The final prototype is constructed aluminum alloy for easy machining and handling (weight of 150 gr), commercial availability, lightweight and maintenance, such that the final biomechanical device is shown in Figure 6.2. This mechanic device is easily adjustable to adapt to the natural growth of patients

FIGURE 6.2 EXISTING PROTOTYPE MODEL WITH CONSTANT ADJUSTMENTS

6.2.1 MERITS

The existing model is designed with Light Weight Aluminum frame

Easy to access and reliable design that can adjust itself

Most widely used model for clubfoot patient

6.2.2 DEMERITS

No proper counterbalance in the system

Data collection ability is not possible

Our proposed model even has data collection ability but work on router or mobilehotspot.

FIGURE 6.3 REAL-TIME WORKING MODEL OF OUR PROPOSED SYSTEM

CHAPTER 7

TESTING

7.1 UNIT TESTING

Unit testing is an important aspect of software development that involves testing individual components or units of a system to ensure that they are functioning as intended. In the context of designing insole shoes for orthotic patients with clubfoot or ankle displacement, unit testing would involve testing the individual components of the shoe design to ensure that they meet the required specifications and are suitable for use by the target patient population. Some examples of unit tests that could be performed on the insole shoe design include:

- Material testing: Testing the materials used in the shoe design to ensure that they are durable, lightweight, and suitable for use by orthotic patients with clubfoot or ankle displacement.

- Comfort testing: Testing the shoe design to ensure that it is comfortable to wear and does not cause any discomfort or irritation to the patient's foot.

- Arch support testing: Testing the shoe design to ensure that it provides adequate arch support for patients with clubfoot or ankle displacement.

7.2 BLACK BOX TESTING

Black box testing is a type of software testing that involves testing the functionality of a system without knowing its internal structure or workings. In the context of designing insole shoes for orthotic patients with clubfoot or ankle displacement, black box testing would involve testing the shoe design from the perspective of the user, without knowing the details of the shoe's internal components or mechanisms.

Some examples of black box tests that could be performed on the insole shoe design include:

- Fit and comfort testing: Testing the fit and comfort of the shoe design by having a sample group of orthotic patients with clubfoot or ankle displacement wear the shoes and provide feedback on their comfort and fit.
- Arch support testing: Testing the effectiveness of the arch support provided by the shoe design by having orthotic patients with clubfoot or ankle displacement wear the shoes and provide feedback on the level of support provided.
- By performing these black box tests, you can evaluate the overall effectiveness of the insole shoe design for orthotic patients with clubfoot or ankle displacement from the perspective of the user. This can help to identify any issues or areas for improvement in the shoe design, and ensure that the final product is safe, effective, and suitable for use by the target patient population.

7.3 WHITE BOX TESTING

White box testing is a type of software testing that involves testing the internal structure and workings of a system to ensure that they meet the required specifications. In the context of designing insole shoes for orthotic patients with clubfoot or ankle displacement, white box testing would involve testing the internal components and mechanisms of the shoe design to ensure that they work together as intended and meet the required standards.

Some examples of white box tests that could be performed on the insole shoe design include:

- Material testing: Testing the materials used in the shoe design to ensure that they are durable, lightweight, and suitable for use by orthotic patients with clubfoot or ankle displacement.

- Insole and sole construction testing: Testing the construction of the insole and sole of the shoe to ensure that they provide the required level of support and correction for the patient's foot, and that they are securely attached to each other.

- Upper construction testing: Testing the construction of the upper part of the shoe to ensure that it provides the required level of support and protection for the patient's foot, and that it is securely attached to the sole and closure system.

7.4 INTEGRATION TESTING

Integration testing is a type of software testing that involves testing the interactions between different components or modules of a system to ensure that they work together seamlessly. In the context of designing insole shoes for orthotic patients with clubfoot or ankle displacement, integration testing would involve testing the integration of the various components of the shoe design to ensure that they function together as intended and meet the required specifications.

Some examples of integration tests that could be performed on the insole shoe design include:

- Insole and sole integration testing: Testing the integration between the insole and the sole of the shoe to ensure that they fit together properly and provide the required level of support and comfort to the patient's foot.

- Upper and sole integration testing: Testing the integration between the upper and the sole of the shoe to ensure that they fit together properly and provide the required level of support and protection to the patient's foot.

7.5 REGRESSION TESTING

Regression testing is a type of software testing that is performed to ensure that changes or updates to a system do not adversely affect its existing functionality. In the context of designing insole shoes for orthotic patients with clubfoot or ankle displacement, regression testing would involve testing the shoe design after making any changes or updates to the design or materials, to ensure that the new version still meets the required specifications and standards. Some examples of regression tests that could be performed on the insole shoe design include:

- Fit and comfort testing: Re-testing the fit and comfort of the shoe design after making any changes to the design or materials, to ensure that the new version still provides the required level of comfort and support for orthotic patients with clubfoot or ankle displacement.

- Arch support testing: Re-testing the effectiveness of the arch support provided by the shoe design after making any changes to the design or materials, to ensure that the new version still provides the required level of support for patients with clubfoot or ankle displacement.

- Shock absorption testing: Re-testing the effectiveness of the shoe's shock absorption after making any changes to the design or materials, to ensure that the new version still provides the required level of protection against impact.

CHAPTER 8

RESULT AND ANALYSIS

Overall, the project shows how versatile Arduino can be. The concept behind the project holds, in that using Arduino provides a cheap and effective way to create. The current design which we created for the clubfoot right now is basic and can be upgraded with a little imagination and hard work. The background research that we did with Arduino proved that the concept and idea were possible. Several people have used the Muscle Sensor Kit in order to use their muscles to control a device. For example, a younggentleman could code the Muscle Sensor into reading the contraction of his bicep muscle to move the character.

FIGURE 8.1 BLYNK WEB SERVER LIVE DATA

Advanced Technologies, the developers of the Muscle Sensor, picked up the contractions of the muscles and displayed lights and played sound with each contraction, making it seem like you were Iron Man himself.15 The metals that were used were relatively cheap, roughly $25 and $10 for 4 feet each of the 1-inch and ½-inch diameter aluminum rods, respectively. From the metal purchased, about 4 arms could have been made if I so chose to. The Arduino itself, along with the motors, shield, and sensors, total roughly $200. As long as a computer is available, and battery power for the Arduino and the Muscle Sensor, a myoelectric arm can be built and created for under $300. This is an amazing reduction in cost compared to the $5,000 to $50,000 for a prosthetic that lasts five years, at most. The Arduino based club foot orthotic shoe may not be as sturdy or versatile as these more advanced prosthetics, but if you are on a budget, or health insurance does not cover enough of an advanced prosthetic design can be developed in future.

8.1 FUTURE SCOPE

There are several modifications to improve the design that we have created forthe club foot genetic disorder patient, first, a more secure elbow joint could be created. There are various metal pieces can be found in hardware stores, or even designed, to create a more functional elbow. Recall that my ankle elbow only consisted of cutting a special design out of a thin sheet of aluminum and attachingit to the sides of the aluminum rods. Second, a further understanding of the Muscle Sensor should be had to create the prosthetic's myoelectric aspect.

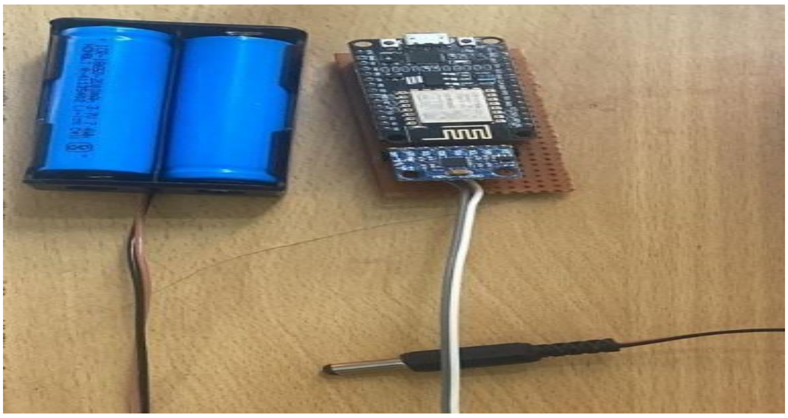

FIGURE 8.2 FINAL MODEL OF HARDWARE SETUP BEFORE FIXING

The idea is out there, and it is possible to do so, however, we were not able to get this to work. For this to work, a threshold should be set on contraction so when that threshold is reached, the myoelectric leg will move. Along with an understanding of the Muscle Sensor, there are different ways that one could readthe input signals. For example, you could translate strength of contraction into how far the arm moves, or is able to hold its position with resistance pressing against it. Another example is designing pattern recognition software for Arduino, to make the arm more state of the art and functioning better. Finally, besides reducing the cost of the arm, even though it is low cost as is, more research can be done on increasing the amount of functionality in the arm. For instance, creating a hand or a hook that works in synchronous with the arm. Since Arduino is so versatile, many projects can be deduced from this one idea. This research project is very open ended, and with the right imagination, can be taken anywhere.

FIGURE 8.3 FINAL MODEL OF HARDWARE SETUP AFTER FIXING

CHAPTER 9

CONCLUSION AND FUTURE WORK

The project's success in showcasing the versatility of Arduino can be attributed to its open-source nature, which allows users to modify and adapt the platform to suit their specific needs. This flexibility makes Arduino an excellent tool for creating a wide range of applications, from simple DIY projects to complex industrial automation systems. The idea of using Arduino to develop a cost-effective solution is particularly compelling, given the high costs associated with traditional engineering solutions. With Arduino, users can achieve the same functionality at a fraction of the cost, making it an attractive option for individuals, startups, and even established companies. While the current design for the clubfoot may be basic, it has great potential for improvement. With some imagination and hard work, the design could be enhanced to provide even more functionality and customization options. For example, additional sensors or actuators could be integrated into the design, allowing for more precise control and monitoring of the device. Based on the modifications you have suggested, here are some potential areas of future scope for improving the design of the clubfoot prosthetic:

- Improved elbow joint: As you mentioned, creating a more secure elbow joint could greatly improve the functionality of the prosthetic. This could involve exploring different materials or designs for the joint, as well as testing the prosthetic's durability and range of motion.

- Myoelectric aspect: Incorporating a myoelectric aspect into the prosthetic could allow the patient to control it using muscle signals. This would require a deeper understanding of the Muscle Sensor technology and how it can be integrated into the prosthetic. Additionally, the software and programming necessary to interpret and respond to the muscle signals would need to be developed.

- Customization options: Since clubfoot can vary in severity and location, it may be beneficial to explore customization options for the prosthetic. This could include designing different sizes or shapes of the prosthetic to fit individual patients' needs, or incorporating adjustable components to allow for changes in the patient's condition over time.

- Cost-effectiveness: Depending on the materials and technology used in the prosthetic, it may be expensive to produce and maintain. Future research could focus on finding more cost-effective solutions that still provide the necessary level of functionality and comfort for the patient.

- User feedback: Finally, it's important to gather feedback from patients who use the prosthetic to ensure that it is meeting their needs and improving their quality of life. This feedback can help inform future modifications and improvements to the design.

Overall, the project serves as an excellent example of the versatility and potential of Arduino as a platform for creating innovative and cost-effective solutions. It demonstrates that with a little creativity and dedication, users can create a wide range of applications that would otherwise be out of reach using traditional engineering solutions.

APPENDIX 1

SOURCE CODE

```
#include <Adafruit_MPU6050.h>

#include <Adafruit_Sensor.h>

#include <Wire.h>

#define BLYNK_TEMPLATE_ID "TMPL9XwJ_28j"

#define BLYNK_TEMPLATE_NAME "ClubFoot"

#define BLYNK_AUTH_TOKEN "rs4bSOf01q5pTsNNCkcY-nco75ODF5pK"

#define BLYNK_PRINT Serial

#include <ESP8266WiFi.h>

#include <BlynkSimpleEsp8266.h>

#define ADC A0

BlynkTimer timer;

char auth[] = BLYNK_AUTH_TOKEN;

char ssid[] = "MSJ Broadband";

char pass[] = "MSI19911993";

Adafruit_MPU6050 mpu;
```

```
void setup(void)


{
 Serial.begin(115200);
 while (!Serial)
 delay(10);
 Serial.println("Adafruit MPU6050 test!");
 if (!mpu.begin())
 {
   Serial.println("Failed to find MPU6050 chip");
   while (1)
   {
     delay(10);
   }
  }
 Serial.println("MPU6050 Found!");
 mpu.setAccelerometerRange(MPU6050_RANGE_8_G);
 Serial.print("Accelerometer range set to: ");
 switch (mpu.getAccelerometerRange()) {
```

```
case MPU6050_RANGE_2_G:
Serial.println("+-2G");

break;
case MPU6050_RANGE_4_G:
Serial.println("+-4G");
break;
case MPU6050_RANGE_8_G:
Serial.println("+-8G");
break;
case MPU6050_RANGE_16_G:
Serial.println("+-16G");
break;
}
mpu.setGyroRange(MPU6050_RANGE_500_DEG);
Serial.print("Gyro range set to: ");
switch (mpu.getGyroRange()) {
case MPU6050_RANGE_250_DEG:
Serial.println("+- 250 deg/s");
```

```
 break;
 case MPU6050_RANGE_500_DEG:
 Serial.println("+- 500 deg/s");

break;
 case MPU6050_RANGE_1000_DEG:
 Serial.println("+- 1000 deg/s");
 break;
 case MPU6050_RANGE_2000_DEG:
 Serial.println("+- 2000 deg/s");
 break;
 }
mpu.setFilterBandwidth(MPU6050_BAND_21_HZ);
Serial.print("Filter bandwidth set to: ");
 switch (mpu.getFilterBandwidth()) {
 case MPU6050_BAND_260_HZ:
 Serial.println("260 Hz");
 break;
 case MPU6050_BAND_184_HZ:
```

```
Serial.println("184 Hz");
break;
case MPU6050_BAND_94_HZ:
Serial.println("94 Hz");

break;
case MPU6050_BAND_44_HZ:
Serial.println("44 Hz");
break;
case MPU6050_BAND_21_HZ:
Serial.println("21 Hz");
break;
case MPU6050_BAND_10_HZ:
Serial.println("10 Hz");
break;
case MPU6050_BAND_5_HZ:
Serial.println("5 Hz");
break;
}
```

```
 Blynk.begin(auth, ssid, pass);

 timer.setInterval(100L, sendsensor);

Serial.println("");

 delay(100);

}


void sendsensor()

{

int charge = analogRead(ADC);

float voltage= charge * (5.0 / 1023.0);

sensors_event_t a, g, temp;

mpu.getEvent(&a, &g, &temp);

int accelerationx = a.acceleration.x;

int accelerationy = a.acceleration.y;

int accelerationz = a.acceleration.z;

int rotationx = g.gyro.x;

int rotationy = g.gyro.y;

int rotationz = g.gyro.z;

int temperature = temp.temperature;
```

```
Serial.print("Acceleration X: ");

Serial.print(a.acceleration.x);

Serial.print(", Y: ");

Serial.print(a.acceleration.y);

Serial.print(", Z: ");

Serial.print(a.acceleration.z);


Serial.println(" m/s^2");

Serial.print("Rotation X: ");

Serial.print(g.gyro.x);

Serial.print(", Y: ");

Serial.print(g.gyro.y);

Serial.print(", Z: ");

Serial.print(g.gyro.z);

Serial.println(" rad/s");

Serial.print("Temperature: ");

Serial.print(temp.temperature);

Serial.println(" degC");

Serial.print("Charging Voltage: ");
```

```
Serial.print(voltage);
Serial.println(" [Volts]");
 Blynk.virtualWrite(V0, accelerationx);
 Blynk.virtualWrite(V1, rotationx);
 Blynk.virtualWrite(V2, accelerationy);
 Blynk.virtualWrite(V3, rotationy);
 Blynk.virtualWrite(V4, accelerationz);

Blynk.virtualWrite(V5, rotationz);
 Blynk.virtualWrite(V6, temperature);
 Blynk.virtualWrite(V7, voltage);
 Serial.println("");
 delay(500);
}
void loop()
{
  Blynk.run();
  timer.run();
}
```

APPENDIX 2

CONFERENCE SUBMISSION

2023 IEEE International Conference on Computer, Electronics & Electrical Engineering and their applications (IC2E3) : Submission (466) has been created. External Inbox ×

Microsoft CMT <email@msr-cmt.org>
to me

Mon, Mar 20, 9:17 PM

Hello,

The following submission has been created.

Track Name: +Creat New Submission

Paper ID: 466

Paper Title: INNOVATIVE DESIGN OF INSOLE SHOES FOR ORTHOTIC PATIENTS WITH CLUB FOOT OR ANKLE DISPLACEMENT

Abstract:
Internet of Things (IoT) is an upcoming promising technology that is used for automation in both industries and commercial applications. Orthotic patients are the one who suffers a lot in regular life due to the impact of club foot disorder. The major problem is dealt with the physical imbalance which we are trying to fix in our project by counterbalancing. The existing system used for this purpose common semi-automized system that supports only a few patients properly. The objective of this research is to create counterbalance support with the magnitude changes and export data logs to our server base for real-time improved fabrication of shoes based on their physical practice. In the proposed work we create a cloud system that tracks their body movements based on a six-axis accelerometer and three-axis gyroscopic modules. This data log will be saved on the cloud web server for our future study to develop the required counterbalance formula for the individuals.

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Authors:
- sit19it010@sairamtap.edu.in (Primary)
- sit19it025@sairamtap.edu.in
- sit19it074@sairamtap.edu.in

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