

INTELLIGENT CRUTCH TOOL FOR BODY POSTURE MANAGEMENT SYSTEM (ERGONOMICS)

Submitted in partial fulfilment of the requirements for the award of
Bachelor of Technology degree in Biomedical Engineering

by

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**DEPARTMENT OF BIOMEDICAL ENGINEERING
SCHOOL OF BIO AND CHEMICAL ENGINEERING**

SATHYABAMA

**INSTITUTE OF SCIENCE AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)**

**Accredited with Grade "A" by NAAC | 12B Status by UGC | Approved by AICTE
JEPPIAAR NAGAR, RAJIV GANDHI SALAI, CHENNAI - 600 119**

MARCH -2021



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DEPARTMENT OF BIOMEDICAL ENGINEERING

BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of **S.Mahesh Kumar(37240049)** who carried out the project entitled “**Intelligent Crutch Tool for Body Posture Management System (Ergonomics)**” under my supervision from **October 2020 to March 2021**

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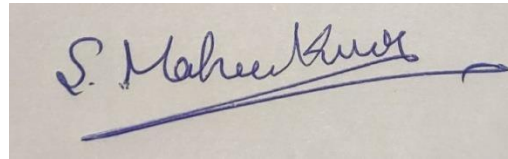
DECLARATION

I, **Mahesh Kumar.S (37240049)** hereby declare that the Project Report entitled **“Intelligent Crutch Tool for Body Posture Management System (Ergonomics)”** done by me under the guidance of **Dr. J. Prem Kumar**, Department of Biomedical Engineering is submitted in partial fulfillment of the requirements for the award of Bachelor of Technology degree in Biomedical Engineering.

DATE: APRIL 10, 2021

PLACE: CHENNAI

1.



SIGNATURE OF THE CANDIDATES

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We wish to express our thanks to all **Teaching and Non-teaching** staff members of the **Department of Biomedical Engineering** who were helpful in many ways for the completion of the project.

ABSTRACT

In the last decade, the clinical reasoning in physical therapy has been to develop systems for physiotherapists to make clinical decisions rapidly, effectively and efficiently, in response to the increasingly complex needs of health and rehabilitation units. Some studies show the importance of walking aids during rehabilitation from some diseases, and after surgery for arthroplasty in the elderly population, and elderly patients with balance disorders, muscle weakness. Walkers are important devices that aid the rehabilitation process. The use of a walker is recommended for gait changes and imbalance due to various factors, such as surgery of the lower limbs or neurodegenerative changes, especially in the early recovery period. In this project we design a solution for Patient using walkers, This device helps them to maintain the proper balance. The sensors embedded in the walker were chosen to extract the relevant information related to the walker's use during the physiotherapy sessions like applied forces on the walker. This device will automatically warn the walker's when they apply more pressure on a single side using haptic feedback. Along with this, we include the Electromyography sensor to detect the muscle movements of the patients. This walker has an automatic internal Lighting system based on the Surrounding Environment.

Keywords— Microcontroller, Liquid crystal Display, Force Applied-Foresensors, Haptic feedback.

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LIST OF ABBREVIATIONS

EMG	-	Electromyography
LDR	-	Light Dependent Resistor
FSR	-	Force Sensing Resistor
ICSR	-	Internal Convention of Scientific Research
AI	-	Artificial Intelligence
GUI	-	Graphical User Interface
LABVIEW	-	Laboratory Virtual Instrument Engineering Workbench

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CHAPTER 1:

INTRODUCTION

1.1. *ERGONOMICS:*

Humans have continuously thrived to complete their tasks effectively with less physical effort, energy, and time. This has helped us to achieve great feats but also confined us with very little movement throughout the day. Be it a person of any caliber, a student, an IT professional, or a business professional, all are spending long hours working on their computer and handheld devices unaware of their poor postures and reduced activity. Not only that, factors like obesity, excessive use of high heel, poor nutrition, and in general lack of awareness about a healthy lifestyle, lead to wrong body posture. All of these situations ultimately result in musculoskeletal disorders (MSDs) to psychological stress. For instance, in, it is reported that about 76% of computer operators in India alone showed a prevalence of some kind of musculoskeletal pain. The most affected regions were lower back, neck, upper back, and shoulder. A survey conducted at Harvard University of 304 engineering students showed that 65% of them experienced consistent pain in the upper body and neck throughout their graduation period. As mention in, by focusing on maintaining correct posture, stress evenly distributes on the muscles and ligaments. This leads to a decrease in wear and tear of joints and allows the muscles to work effectively. Other benefits of good posture are boosted self-confidence, proper functioning of vital organs, and overall a healthy body. The approaches that have been observed for posture detection are broadly divided into non-wearable and wearable technologies. Non-wearable vision-based approaches like computer vision and 3D motion capturing are one of the early approaches which involve image processing through software . The issue in these approaches is the big question on their practicality, higher cost, and their dependence on illumination and occlusion. Some other non-wearable approaches are smart phone-based application that tracks the wideness of the angle at which the user holds smartphone to detect the posture . Postorino is another non-wearable device that alerts the user when he or she leans too

much towards the computer screens by detecting the distance between the screen and the user.

1.2. HISTORY OF ERGONOMICS:

1.2.1 .Ancient societies

Some have stated that human ergonomics began with *Australopithecus Prometheus* (also known as “little foot”), a primate who created handheld tools out of different types of stone, clearly distinguishing between tools based on their ability to perform designated tasks. The foundations of the science of ergonomics appear to have been laid within the context of the culture of Ancient Greece. A good deal of evidence indicates that Greek civilization in the 5th century BC used ergonomic principles in the design of their tools, jobs, and workplaces. One outstanding example of this can be found in the description Hippocrates gave of how a surgeon's workplace should be designed and how the tools he uses should be arranged. The archaeological record also shows that the early Egyptian dynasties made tools and household equipment that illustrated ergonomic principles.

1.2.2. Industrial societies

Bernardino Ramazzini was one of the first people to systematically study the illness that resulted from work earning himself the nickname “father of occupational medicine”. In the late 1600s and early 1700s Ramazzini visited many worksites where he documented the movements of laborers and spoke to them about their ailments. He then published “De Morbis Artificum Diatriba” (Latin for Diseases of Workers) which detailed occupations, common illnesses, remedies. In the 19th century, Frederick Winslow Taylor accompanied the "scientific management" method, which proposed a way to find the optimum method of carrying out a given task. Taylor found that he could, for example, triple the amount of coal that workers were shoveling by substantially reducing the size and weight of coal shovels until the fastest shoveling rate was reached.

Crutches were used in ancient Egypt. In 1917, Emile Schlieck patented the first commercially produced crutch; the design consisted of a walking stick with an upper arm support. Later, A.R. Lofstrand Jr. developed the first crutches with a height adjustable feature. Over time, the design of crutches has not changed much, and the classic design continues to be the most common legacy of rehabilitation tool.

1.2.3..ISSUES RELATED TO CRUTCH USE

Issues Related to Crutch Use Mobility aids, such as crutches and walking canes, are widely used by a substantial share of the world population, for a variety of medical reasons. Crutches are prescribed as walking support in old age, for rehabilitation after injury or surgery to the lower body and strokes, after lower limb amputations, or for any kind of condition that affect the patient's motor capabilities, such as Motor Neurone Disease or spinal cord injuries. The number of mobility aids users also increases every year. In the USA alone, a total of around 6.1 million people of all ages use mobility devices regularly, and more than 575,000 patients are prescribed crutches each year (Kaye et al., 2000). Frequent use and misuse of walking aids can cause a variety of complications – including sprains, strains, inflammations, and bone fractures (Barnard et al., 2010). Despite mobility aids being involved in more than 30% of all medical-device related accidents (Hefflin et al., 2004), these occurrences tend to be underreported, but can nonetheless have very serious repercussions (Papadosifos, 2014). The frequency of such events can be explained by the fact that most patients have never been instructed on the proper use of their walking aids. (Bradley, Hernandez, Sinai, & York, 2011). The use of crutches brings also a variety of other physical issues, such as increased energy expenditure (Annesley et al., 2014)(Words, 2002), increased palmar loads – leading to risk of carpal tunnel injuries and wrist pain (Shortell et al., 2001) (Sala et al., 1998). For patients affected by more extreme conditions, such as above-knee amputations, increased energy expenditure was even higher, causing a number of unwanted effects during locomotion with crutches, such as increased blood pressure and increased cardiac output – as well as a high risk of losing

balance and falling (Erdman, Hettinger, & Saez, 1960). The Companion Crutch Michele Tonutti 16/06/15 9 It is therefore clear that, in order to avoid injuries and unnecessary fatigue, it is required to devise a way to monitor energy use and load bearing on the patient's limbs in a continuous way. Nevertheless, these problems have gathered little attention from the scientific community, in terms of both clinical practice and design modifications (Papadosifos, 2014).

CHAPTER 2

LITERATURE REVIEW

G. Prabhakar Reddy (2017) proposed Intelligent Cane Robot for walking Assistance of Elder and Handicapped People in which S3C2400 was developed using an ARM920T core, with new bus architecture AMBA method was used. The cane robot was developed in which it can move in any direction for elderly and handicapped people. It determines walking intension of the person and controls the motion according to that. By using sensors like IR sensors, ultrasonic sensors interfacing with microcontroller which supports elder and handicapped people which will help them to avoid lower limbs problems. The main drawback was using many sonar sensors which may confuse robot due to similar frequency of sensors and also cause wrong reading that leads to less accuracy.

Ankit Agarwal ,et.al.,(2019) implemented Ultrasonic Stick for blind using pulse echo technique. In this system the pulse echo technique was used to detect the obstacle and give some alert sound once the object is detected while traveling. It will calculate the difference between transmit time and receiving time by which we estimate distance between the user and obstacle which is Proceedings of the Third International Conference on Trends in Electronics and Informatics (The main drawback was it consumed lot of energy and power due to strong signal transmitting from one corner to another corner.

Alenjandro R. Garcia Ramirez et.al.,(2018) designed Voice Aided electric stick by using voice based system that helps blind people to aware about surroundings more effectively. The main contribution of this system was to detect obstacles that do not touch the grounds using haptic sensor. After obstacle is detected, the vibration takes place at the electronic stick and buzzer is activated and emergency message is sent through the GPS. The main drawback was it can detect only obstacles above the waistlines not of stones, steps.

Sharada Murali Shrivatsan R, (2020) designed Smart walking cane for blind people where obstacle detection system was made with GPS and GSM technology. This walking stick was designed to find out obstacles for user who is walking on the ground by using multiple sensors and also providing the awareness of environment. When the obstacle is detected feed back is given through vibrating motors and voice feedback for other obstacle to differentiate between obstacles respectively that can be heard from earphones. GPS and GSM module is used to send the message that is considered to be urgent are conveyed to the specific person that is mentioned in the code. This module can detect multiple obstacles present simultaneously according to program loaded in the module. The main drawback is It cannot distinguish between stationary and moving objects.

Kabalan Chaccour, et.al.,(2018) proposed Multi-sensor guided walker for visually impaired elderly people in which Assistant Living System is made where when the obstacle is detected, the message is conveyed through wireless communication using Zig-bee and GPS for outdoor. The heart and oxygen rate is also measured using appropriate sensors. The main limitation is wheels are not there for proper movement of cane in all direction.

Jovan.B.Ulri., (2019) made a WBAN prototype by utilizing wireless sensor platform off the-shelf general-compliant ZigBee radio interface and ultra low-power microcontroller. Standard platform interface for custom sensor boards are equipped with accelerometer for motion monitoring and bio amplifier for monitoring the electrocardiogram or electromyogram. Software modules for on-board processing, communications, and network synchronization has been developed using the Tiny OS operating system.

Weiya et al.(2018) integrated the WBAN and WSN applications in the nursing home's health care system, proposing Gradient Routing Protocol for WSN to meet the needs of WBAN data transfer in the boundary area, and tell the principle and implementation. Algorithm to find the displacement of people in the courtyard is also discussed in detail, and different algorithms are given for adopting a different situation. Jobs et al. described WBAN system for continuous ambulatory monitoring of human body physical activities.

YongQi Felix Chen, Danielle Napol et.al., (2018), "Smart Crutches Towards Instrumented Crutches for Rehabilitation and Exoskeletons-Assisted Walking" proposed to find the displacement of people in the courtyard is also discussed in detail, and different algorithms are given for adopting a different situation.

M.Tounai et.al.,(2019) "Development of Recorder of Crutch Walk", in Proc. of Japanese Society for Medical and Biological Engineering 2019, pp.449-454. Has done an instrumental recording in the crutch ware and devised a system for recording of data in the circuit.

IEmilio Sardini et.al., (2018) in his "Wireless Instrumented Crutches Measurements for Gait Monitoring ",in IEEE Transactions on Instrumentation and Measurements conveyed the existence of wireless transfer of data carried by EMG sensors

Naoaki Tsuda et.,al.,(2017) had done a simplification of measurement and visualization tool for crutch walk training", in IEEE/ASME International Conference on Advanced Intelligent Mechatronics (AIM) Page s: 910 – 915 .

Laurent Froissart et.,al.,(Sept 2019) "Load-Relief of Walking Aids on Osseo integrated Fixation: Instrument for Evidence-Based Practice", in IEEE Transactions on Neural Systems and Rehabilitation Engineering, Volume: 17 , Issue: 1, Page s: 9 – 14 [8] Y. Mori ; J. Okada ; K. Takayama" has done a research in the Development of a standing style transfer system "ABLE" for disabled lower limbs.

Brandon N. Fournier et.al.,(2017) "Modeling and Simulation of a Lower Extremity Powered Exoskeleton", in IEEE Transactions on Neural Systems and Rehabilitation Engineering Year: 2018 , Volume: 26 , Issue: 8 Page s: 1596 – 1603 analysed a system that simulate the functionality of lower

Omar Harib et.al., (2018) " Feedback Control of an Exoskeleton for Paraplegics: Toward Robustly Stable, Hands-Free Dynamic Walking ",employed the use of accelerometers to measure joint angles with good accuracy results.

A. Vasarhelyi, T. Baumert, Angelito Silverio (2017) has developed a smart cane which is an Instrumentation of a quad cane with audio-feedback monitoring system for partial weight-bearing support.

Naoaki Tsuda et.,al.,(2019) has impotently verified the Visualization system of crutch walking based on internal sensors", in IEEE/ASME International Conference on Advanced Intelligent Mechatronics .

Octavian Postolache (2017) "Physical rehabilitation assessment based on smart training equipment and mobile applications in E-Health and Bioengineering Conference (EHB)

A. Santic ; V. Bilas et.al.,(2018)" proposed a system for measuring forces in the legs and crutches from ambulatory patients", in Proceedings of the 19th Annual International Conference of the IEEE Engineering in Medicine and Biology Society. 'Magnificent Milestones and Emerging Opportunities in Medical Engineering'

Rajesh Kannan Megalingam (2019) "Medical Suit: Wearable Health Monitoring System for Elders and Bed-ridden Patients", in IEEE ISCO 2016, Karapagam College of Engineering, Coimbatore, has done a research in wearable monitoring system for designing a crutch tool for elderly patients.

Dunne et al. (2018) built up a system that relates the optical fiber sensor readings to the user's sitting posture]. Fiber optic sensors were also used to measure seated spinal posture in . However, this solution is limited to seated bending back postures. Second category of work turns to make use of non-intrusive pressure sensors. Dunne et al.

used textile piezo resistive pressure sensors to measure shoulder and neck movements through registering the pressure between skin and textile. However no test was performed to detect the sensors reaction to movements of varying magnitudes. Third category of works explores the use of accelerometers. ", in IEEE ISCO 2018.

Van Laerhoven (2019) et al. and Martin et al. measured postural activities using accelerometers by attaching the to the pants. He presented a multi-posture monitoring system using accelerometers embedded in a wearable vest. Moreover, a commercially available product, lumo lift , also helps monitor and coach upper body movements through the use of a gyroscope. The emphasis of this product however, is on the aesthetic integration of posture feedback to the wearable device rather than on reliable measurements. Some of the mentioned techniques above are not well suited to develop a wearable measuring system.

M. Lancini, et.,al.,(2020) has proposed a system in creating an instrumented crutches to measure the internal forces acting on upper limbs in powered exoskeleton users .He made use of the crutch tool exoskeletons in a curve state and analysed the moment of inertia acting on it.Simultaneously he calculated the accelerating speed of average elderly persons and proposed system for fall detection .

He also had a major research in “ Advances in Sensors and Interfaces (IWASI), 2018 6th IEEE International Workshop on, 2015, pp. 175–180

CHAPTER 3:

AIM AND SCOPE OF ERGONOMICS

DEFINITION

Ergonomics (or human factors) is the scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data and methods to design in order to optimize human well-being and overall system performance.

3.2. FEATURES AND PRINCIPLES:

3.2.1 Assess Risk:

Conducting an ergonomic assessment is a foundational element of the ergonomics process. Your ergonomic improvement efforts will never get off the ground without being able to effectively assess jobs in your workplace for musculoskeletal disorder (MSD) risk factors.

3.2.2 Plan Improvements:

The core goal of the ergonomics process is to make changes to your workplace that reduce risk. Making changes at scale requires a significant planning effort that includes prioritizing jobs to be improved, identifying effective improvement ideas, and cost-justifying the improvement projects.

3.2.3 Measure Progress:

Measurement is an important component of any successful continuous improvement process. High performing ergonomics programs are constantly measured using both leading and lagging indicators.

3.2.4 Scale Solutions:

By establishing a common set of tools to train your workforce, assess risk, plan improvements, measure progress, and design new work processes, you'll be able to scale ergonomics best practices throughout your organization.

3.3 .CLASSIFICATION OF GAITS:

The gate is known as the way we proceed. With crutches, our dual-legged style needs to be improved a bit.

Using crutches makes any strong user imaginable about their endurance.

Whether you are obliged to use crutches to follow a non-load bearing or partial load-bearing pattern - maintaining a gait is of utmost importance to get the maximum benefit from a crutch.

1) Crutch

When walking with a single crutches, you must hold the crutches on the opposite hand and foot and the base of the crutches should be at least 4 inches apart.

Walk on crutches like crutches is another leg. When using stairs with a crutch, rely on the handle of the ladder as much as possible.

2) 2 point gait

- A two-point gait will use two or four crutches at a time.
- In a two-point gait pattern, the patient will use a pair of his available options - a crutch and a leg.

- It can be a left foot and right crutches or right leg and left crutches. The use of each of these moves the patient forward at a time.

3) 3 point gait

- It is used in most cases, where one leg is fine and the other is restricted to use.
- Unhealthy feet and two crutches walk in the sink and the other leg follows.
- The crutch acts as a support for the lower leg and transfers the weight elsewhere.

4) 4 point gait

- A 4 point gait is used where partial load-bearing is possible. In this trick the steps seem random.
- Sequence I usually prefer a right crutch - left leg - left crutch - right leg.
- No point on the ground is in the same line.

5) Swing-to gait

- The patient presses both the crutches while tilting them forward and pulls both the legs towards the round.
- Partial load is allowed to be carried in this load.

6) Swing-through gait

- As in the previous one, both his legs have to be moved to cross the barrier at each stage.

- This move covers the most distance on any one step.
- It covers the convolution distance of walker from the feet.

3.4. WEARABLE SENSOR TECHNOLOGY



FIG 3.1.EARPHONE WEARTECH

FIG 3.2.VARIOUS PORTABLE WEARTECH

- Wearable sensing technology is most commonly adopted approach in the posture detection area. Body sensor Network (BSN) is used for estimation for Cranio -vertebral (CV) angle to detect forward posture(FHP) [9].
- Although BSNL is widely viewed and acknowledged its challenges such as cost, security and data management currently makes it very impractical scenario.
- In a three-axis accelerator is placed on the kilometer range .
- The back of the neck was used to classify 5 different seating position of 6 subjects with an average accuracy of 95.33%.

- However, a single sensor at a single position would require one large amounts of movement in other areas of body to achieve a quality result. IN], a tri-axial accelerometer.
- The subjects were placed on the back where the spine curves develop a phone app to detect postures.
- The purpose of this task is proposed using a posture monitoring system.
- Many accelerometers and gyroscope sensors are used in the proposed system.
- The gyroscope will amplify the data by keeping the signal track
- Angular velocity and inclination while accelerometer will give different linear motions like. different sitting, as well as standing positions are analyzed for several topics.
- Without this,Sensors have been installed at many places for yield

Better results when detecting bad posture.



**FIG 3.3.SHOE SENSORS AND
WIRELESS LAN COMMUNICATION.**



FIG 3.4.HAND GLOVES SENSOR

DESCRIPTION

1. Instrumented crutch incorporates a vibration response to notify user whenever weight is applied to crutches
- 2.If not exceeds the safe limit, it ensures safety so that the user can apply appropriately the amount of weight between the limbs, avoiding the risk of secondary injuries
- 3.Health care monitoring system Incorporate sensor technology to measure health care parameters such as force and speed during rehabilitation of speed .
- 4.Smart crutches are really Instrumented crutch system that uses motion capture system and force the plates for its calibration.
- 5.These devices can measure the weight that the patient applies to his lower extremities and provides a vibration response in response to the measured variant such as measurement of crutch parameters.
- 6.Force and speed require many external sensors such as Motion capturing system consisting of multiple cameras and a computer.
- 7.This is a huge effort of the authors to develop a crutch that can measure angles and angular design and implementation of intelligent crutches for medical applications.

8. In a crutch, the instrumental crutches with strain-gauge bridges, communication interfaces and three-axis accelerometers measure axial forces and shear forces, tilt angles, and time of impact on the ground in real time .

9. The movement of the patient can be easily analyzed and measured the tilt angle of crutches

10. For this purpose the gyroscope can be used.

11. Portable kinetic systems are used to Measure the true load applied directly during crutches the Information about assisted walking and measured parameter is derived from the raw loading of the data .

12. Telescopic crutches are capable of providing a standing posture on even or uneven ground .

13. Virtual prototyping is an expensive way to improve crutch design. Free hand dynamic walking experience can be gained by incorporating reaction Design . Due to misuse of crutches extended recovery period is sustained. So it is very important to monitor the use of crutches.

13. If the system is included with a graphical interface, The collected usage data can be easily converted into graphical plot and can be analyzed by the physician. Visual and simulation of data collected after comparing the vault.

14. The range would be good to allow a self-monitored user freedom . Interfering with mobile apps will be even better user friendly experience.

15. In this system, the communication interfaces such as Bluetooth modules can be Included .

16. Specially designed crutches include telemetry system with infrared sensor for measuring force, multiple receivers and an intelligent crutch unit.

17. The data is presented on a PC monitor.

3.6. SCOPE OF PRESENT INVESTIGATION:

In this project, we propose the sensors embedded in the walker were chosen to extract the relevant information related to the walker's use during the physiotherapy sessions like applied forces on the walker.

3.7. EXISTING AND PROPOSED SYSTEM:

3.7.1 Existing System

Some studies showed the importance of walking aids during rehabilitation from some diseases, and after surgery for arthroplasty in the elderly population, but there are no proper solutions for the walking aid system. The people didn't take that seriousness in this generally bought the walker and use it, due to the improper balances while using the walker their muscles are getting weaker.

3.7.2 Proposed System

In this project, we propose the sensors embedded in the walker were chosen to extract the relevant information related to the walker's use during the physiotherapy sessions like applied forces on the walker. This device will automatically warn the walker's when they apply more pressure on a single side using haptic feedback so that the patients can able to correct them. Along with this we include the Electromyography sensor to detect the muscle movements of the patients.

3.8. ADVANTAGES

- This crutch tool has been designed to create proper and proportionate balance in both arms using muscular force sensors.
- Accuracy level is up to 85 to 90 per cent. More Expectancy battery life

3.9. LIMITATIONS

Rollators: Studies have shown a decrease in quadriceps use during the standing phase due to decreased knee movement. There is also an increase in hip flexion throughout the standing phase due to increased trunk flexion. "Decreased knee flexion during rollout may explain the joint dehydration associated with the joint seen in this condition."

Quad Stick / Reed: are heavier than a regular stick / cane. Need a gait pattern.

Deterioration: This can be seen up to 30% of the time people were using their 2-wheel-mounted crutch / walker frames improperly by not putting the right amount of weight on the frame when stepping.

Battery Consumption: Over usage of battery cells in current crutch system leads to depletion of energy and excessive release of heat.

CHAPTER 4

METHODOLOGY

4.1. BLOCK DIAGRAM

Block Diagram—

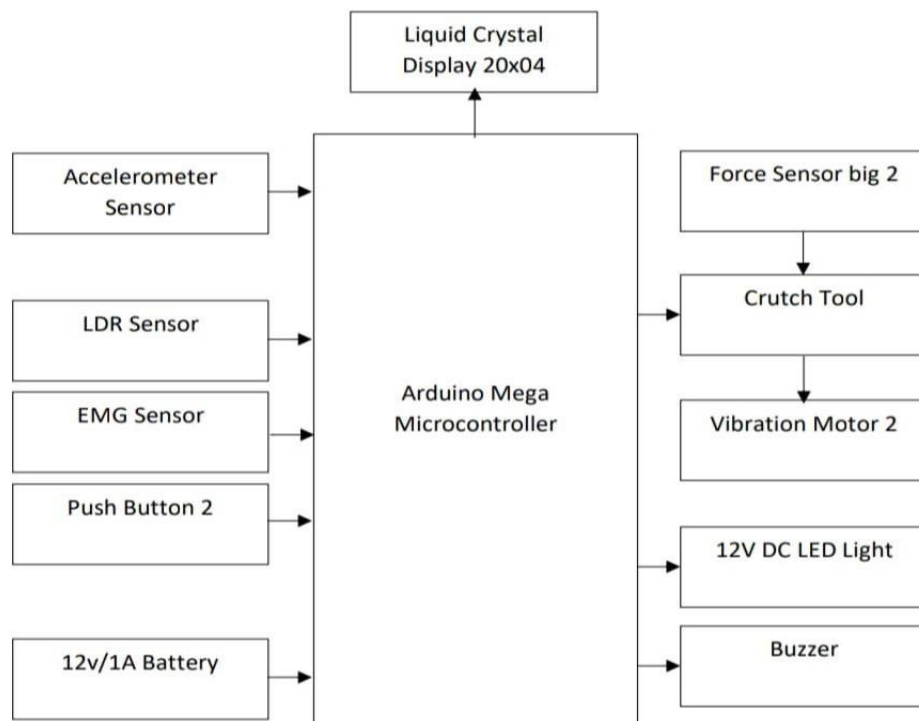


Fig.4.1. BLOCK DIAGRAM OF CRUTCH TOOL

4.1.1. BLOCK DIAGRAM EXPLANATION

1.FORCE SENSOR/FORENSORS:

Force sensors weigh freight on manufacturing and transportation equipment. They also monitor loads on machines subject to stringent safety standards — such as mine lifts, construction cranes, industrial tanks, grain silos, and locomotives — to ensure equipment isn't overloaded.

2. LDR (LIGHT DEPENDENT RESISTOR) SENSOR:

LDR sensor module is used to detect the intensity of light. It is associated with both analog output pin and digital output pin labelled as AO and DO respectively on the board. When there is light, the resistance of LDR will become low according to the intensity of light. The greater the intensity of light, the lower the resistance of LDR.

3.ACCELEROMETER SENSOR:

the accelerometer sensor can be used to measure the acceleration exerted upon the sensor. Usually, the acceleration is given in two or three axis-vector components that make up the sum/net acceleration. It is an N-Channel MOSFET.

This is done in such a way that the crutch is made completely user friendly. The control unit is designed to produce an audio response. The offset is greater than when the user is stressed by the user. The offset is different for each person and here for each person it is the continuous force means that can be applied by a person (Injury to the feet) that measures the force applied by FSR User on crutches. Accelerometer measures the

acceleration of crutches. Both parameters are everywhere at Instant time so that the user can correct the crutches by themselves

4. *IBRATION MOTOR:*

Vibration sensor is the device that measures the amount and frequency of vibration in a given system, machine, or piece of equipment. Those measurements can be used to detect imbalances or other issues in the asset and predict future breakdowns.

The sensor output is an AC signal proportional to the vibration of the structure at the mounting point of the sensor. This AC signal is superimposed on a DC bias voltage (also referred to as Bias Output Voltage or Rest Voltage). The DC component of the signal is blocked by a capacitor.

5.*ALERT BUZZER:*

The Piezo Alert is the advanced electronic audible signal device that emits a compelling sound with minimum current draw. This solid-state device operates from as little as 3VDC to as much as 28VDC and is rated at 20mA. Sound output is proportional to input voltages and ranges from a minimum of 68dB to over 100dB at 28VDC at 1 ft. The piezo electronic contact points give it high reliability and an exceptional long life. The piezo alert signal operates in free air only. It is not compatible with under water applications. The recommended operating range is from -13°F to 158°F (-25°C to 70°C).

6.CRUTCH TOOL:

Crutches allow you to completely remove weight from the extremity. Crutches require good stability and upper body strength, so they are often less useful to elderly patients. However, crutches can provide both excellent support and freedom for those with ample strength. It is a four-point gait type walker. (Those who can tolerate partial weight bearing on both legs usually use the four-point gait. The sequence is right crutch, left leg, left crutch, right leg. This is the slowest of all gaits but also the safest in that three of the four points are in contact with the ground at any given time.)

7.LED LIGHT with 12V ,1 A BATTERY:

Connect the positive terminal of the **12-volt** power supply to one side of the resistor.

Connect the other side of the resistor to the anode of the **LED**.

Check the **LED** data sheet to identify the anode and cathode. The cathode is commonly the shorter lead and located nearest any flat side of the **LED**.

The 1 Ampere battery provides the ambient power supply for the sensors.

Arduino Uno

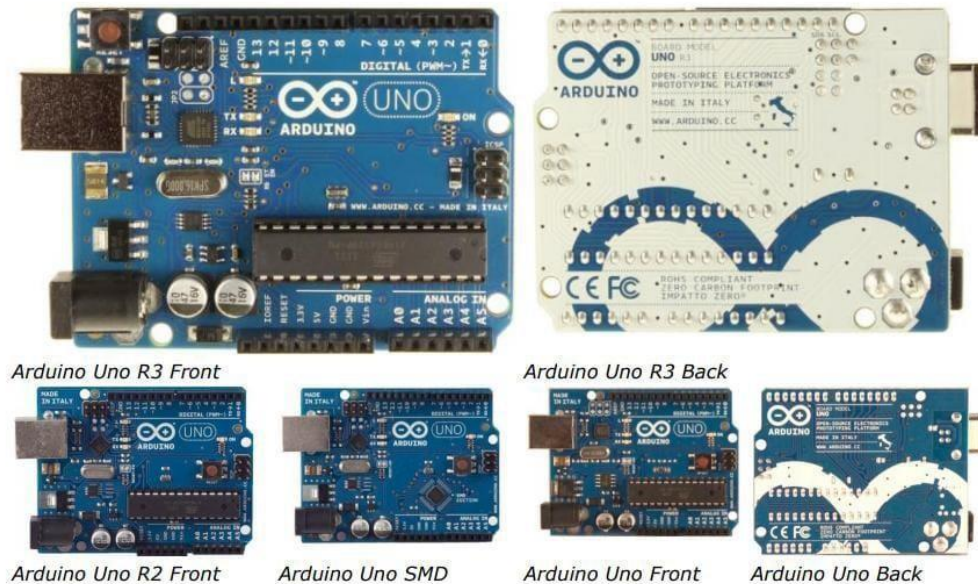


Fig 4.1: ARDUINO UNO ATMEGA 328

4.2. HARDWARE USED:

4.2.1. COMPONENTS:

Aluminum alloy straight walker,

Atmega328 Microcontroller 1

02.Liquid Crystal Display 20x04

03Liquid Crystal Display Base 1

04.Accelerometer Sensor

05. Force Sensor BIG 2

06.Vibration Motor

07. Push Button 2

08. LDR Sensor 1

09.12V LED

10. Buzzer 1

11.12v/1A battery

12. Walker 1

4.2.1 COMPONENTS OF THE CRUTCH TOOL

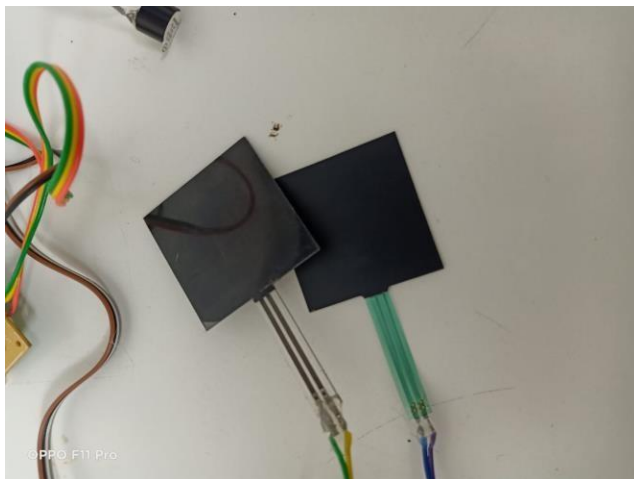
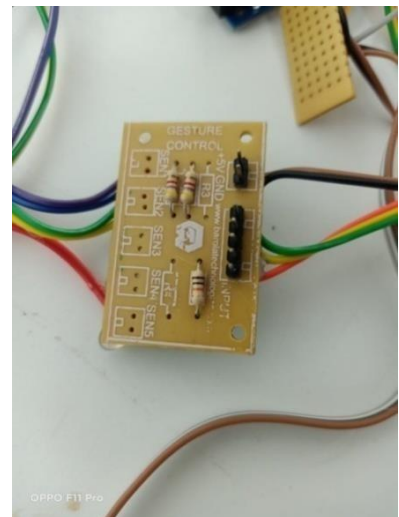


Fig 4.2.1.(A)FORCE SENSOR



**Fig 4.2.1.(B)N-MOSFET
RESISTOR**

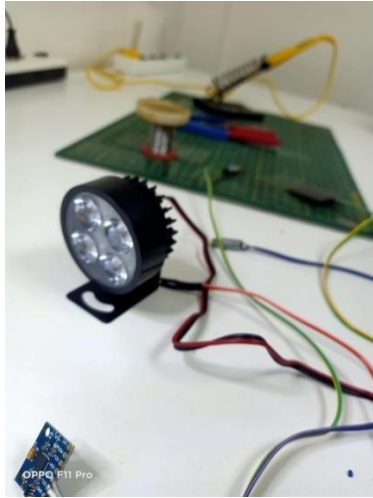


Fig 4.2.1(c) LED LIGHT



FIG 4.2.1(D)LIQUID CRYSTAL DISPLAY

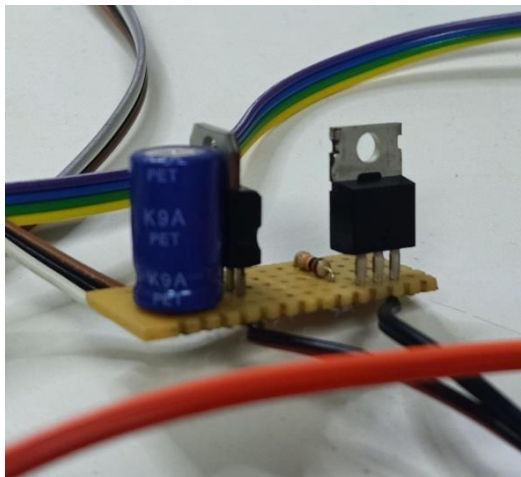


FIG 4.2.1. (E) MOTOR DRIVER



**FIG.4.2.1(F) ACCELEROMETER
SENSOR**

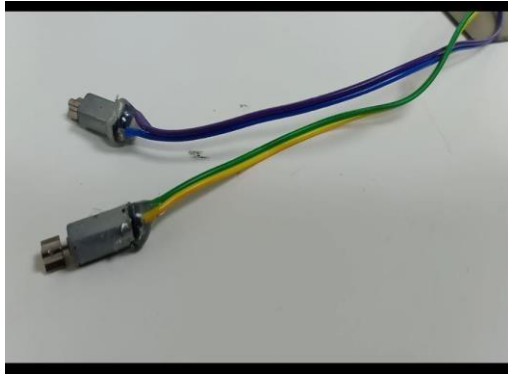


FIG.4.2.1.(G) VIBRATION MOTOR



FIG.4.2.1. (H) BATTERY WITH 12V SUPPLY

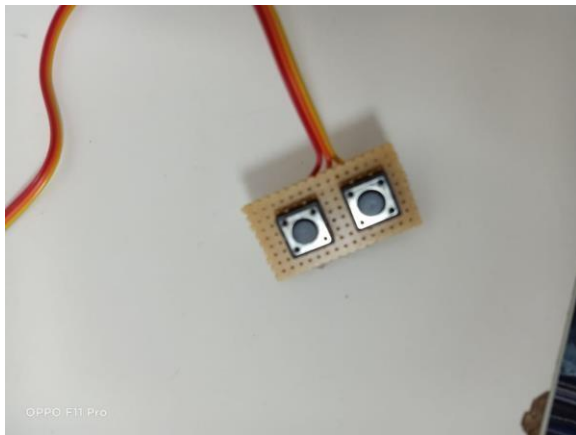
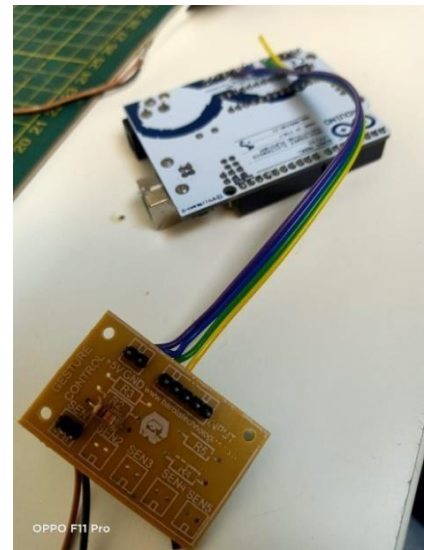


FIG4.2.1.(I)SWITCHES



**FIG.4.2.1(K) MOTHER BOARD WITH
ARDUINO**

4.2.2. SOFTWARE USED:

Arduino IDE

The Arduino Integrated Development Environment (IDE) is a cross-platform application (for Windows, mac OS, Linux) that is written in functions from C and C++.^[3] It is used to write and upload programs to Arduino compatible boards, but also, with the help of third-party cores, other vendor development boards. The source code for the IDE is released under the GNU General Public License, version 2. The Arduino IDE supports the languages C and C++ using special rules of code structuring. The Arduino IDE supplies a software library from the Wiring project, which provides many common input and output procedures. User-written code only requires two basic functions, for starting the sketch and the main program loop, that are compiled and linked with a program stub *main ()* into an executable cyclic executive program with the GNU tool chain, also included with the IDE distribution. The Arduino IDE employs the program to convert the executable code into a text file in hexadecimal encoding that is loaded into the Arduino board by a loader program in the board's firmware. By default, it is used as the uploading tool to flash the user code onto official Arduino boards.

Arduino doesn't run either C or C++. It runs machine code compiled from either C, C++ or any other language that has a compiler for the Arduino instruction set.

4.3. ANALYSIS TECHNIQUE

The content of usage of crutch using arduino technology (Alattas.R, K. Elleithy.,et.,al.,October 2018).When using crutches during stance, the crutches will put a position constraint on the shoulder, thus reducing the number of degrees of freedom. Additional hip-joint stiffness was applied to stabilize the hip joint and, therefore, to stabilize stance. The required hip-joint stiffness for changing crutch placement and hip-joint offset angle was studied under static and dynamic conditions. Modeling results indicate that, by using additional hip-joint stiffness, stable crutch supported paraplegic standing can be achieved, both under static as well as dynamic situations. The static equilibrium postures and the stability under perturbations were calculated to be dependent on crutch placement and stiffness applied. However, postures in which the hip joint was in extension (C postures) appeared to be the most stable postures. Applying at least 60 N m/rad hip-joint stiffness gave stable equilibrium postures in all cases. Choosing appropriate hip-joint offset angles, the static equilibrium postures changed to more erect postures, without causing instability or excessive arm forces to occur the applied pressure on the walker gets displayed on the LCD display for analyzing the essential force applied. Applying more than 800 N gives a warning alarm using buzzer indicating overload.

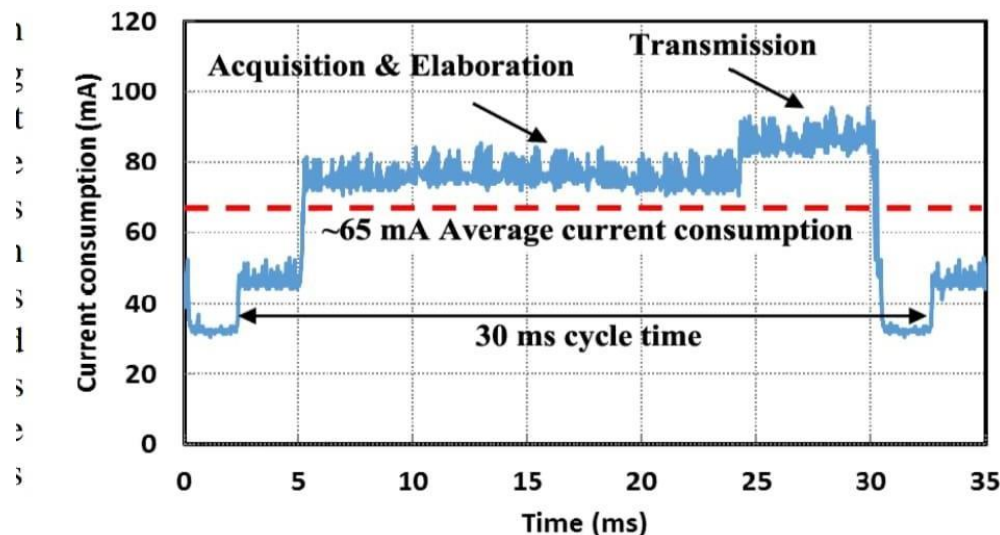


Fig. 9. Current consumption during one cycle.

Fig 4.3.CURRENT CONSUMPTION DURING ONE CYCLE

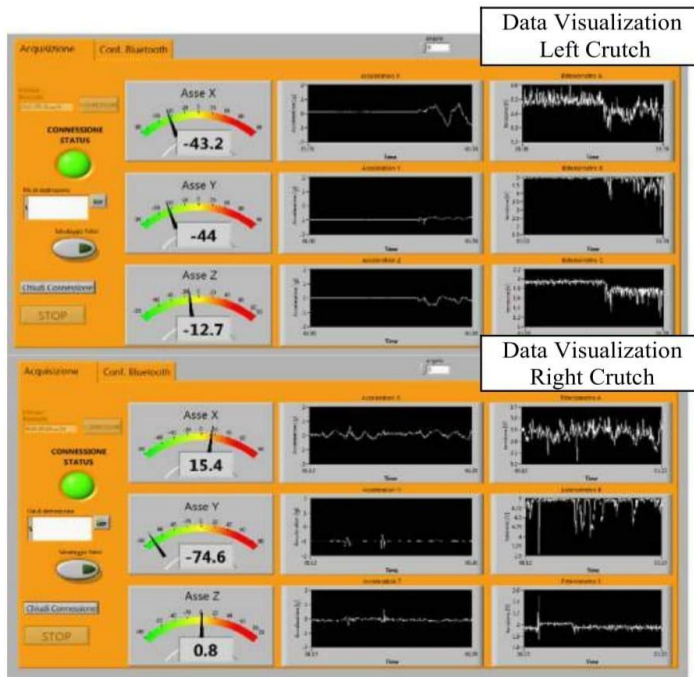


Fig. 5. Image of the realized LabVIEW GUI.

Fig.4.4.LABVIEW GUI

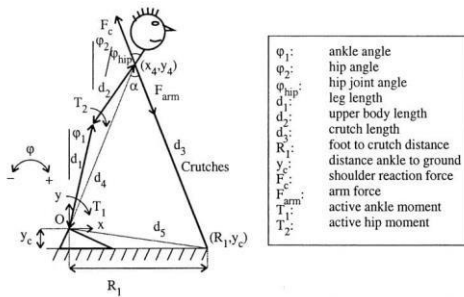


Fig. 1. Double inverted pendulum model of crutch-assisted paraplegic standing. The knee is assumed to be locked. In the lower link, the shanks and thighs of both legs are lumped together. The length of the lower link is d_1 . The upper link consists of the upper body, arms, and head lumped together and has length d_2 . The crutches have length d_3 , are assumed massless, and only force the shoulder position to be constrained. The tip of the crutches is at a horizontal distance R_1 of the ankle joint. The distances d_4 , d_5 , and angle α are only used in calculations and have no functional meaning. F_c represents the constraint force, and F_{arm} represents the arm force. These two forces are equal in magnitude and opposite in direction.

FIG 4.5. BODY POSTURE ANALYSIS

Arduino UNO

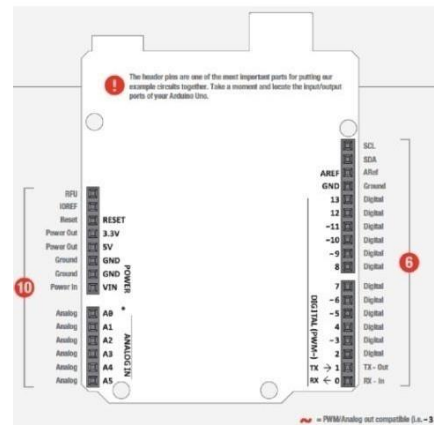


FIG 4.6. ARCHITECTURE
DIAGRAM OF ARUIDNO ATMEGA 328

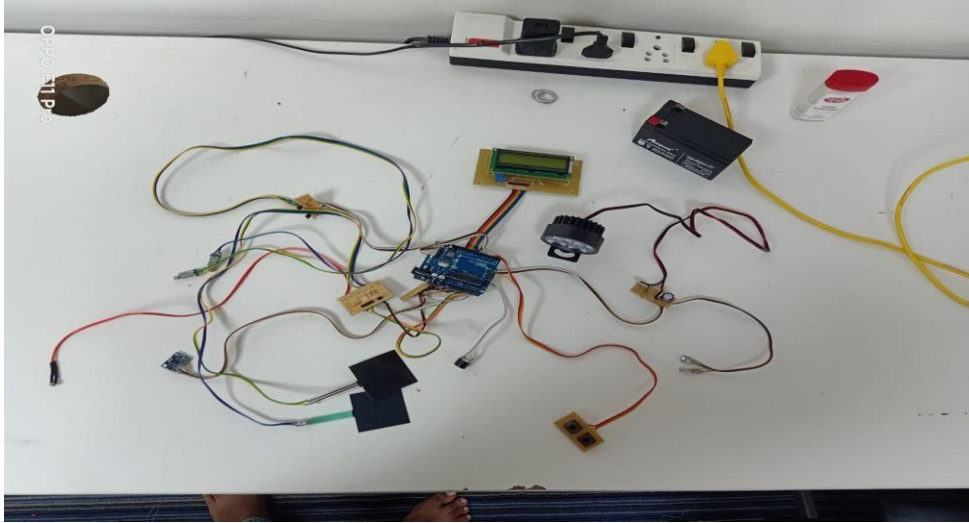
STAGE 1: COMPLETION OF INTERNAL HARDWARE COMPONENTS:

- The components are taken in a sequential manner starting with force sensors, then the wires are connected to the Arduino ATMEGA 328 Microcontroller.
- Wires are welded, glued and connected to respective terminals.
- FORESENSORS>>VOLTAGE DIVIDEND>>ARDUINO ATMEGA 328>>12V 1A BATTERY.
- Connection of accelerometer and LDR SENSORS to the main circuit board.

STAGE 2: PROGRAMMING AND CALIBRATION OF SENSORS:

- After the hardware layout is completed, the Arduino At -mega 328 is coded with a set of numerical operations for light emission, buzzer alert activity, fall detection, body balancing measurements etc....
- The analog input ranges from 0 to 1023. After the coding part, they are transferred to the Arduino board.
- The ARDUINO UNO performs a set of operations and executes commands to the motor driver after receiving particular function received from the user.

4.1 HARDWARE COMPONENTS TO BE EMBEDDED ON CRUTCH TOOL



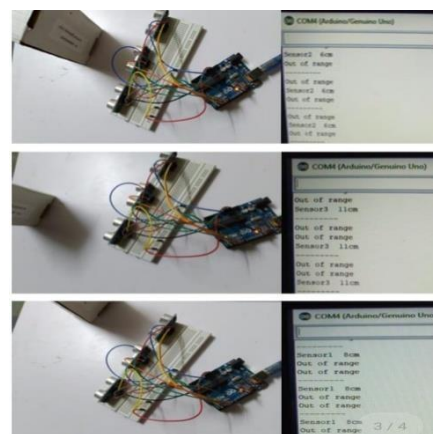
Wiring an FSR to Arduino UNO

- It is quite easy to connect FSR to an Arduino.
- You need to connect a 10k Ω pull-down resistor in series with the FSR to create a voltage divider circuit. Then the point between the pull-down resistor and the FSR is connected to the A0 ADC input of an Arduino.
- The Overall circuits are connected to the hardware components after welding and adhered.
- The load cells are mounted on the walker legs, one on each leg and the LIDAR is suspended on a selfie-stick pointing to the injured foot. The five sensors (four load cells and the LIDAR) are sampled at 50 S/s and the resulting data stream is transmitted over the air to a host (computer or tablet) where it is processed. The Bluetooth link emulates a serial port on both sides allowing transmission speeds up to 1 Mbps.

STAGE 3: Fixation of Sensors with the CRUTCH TOOL(WALKER):



4.7. CRUTCH TOOL



4.8. MANUAL CALIBRATION

AND CHECKUP OF GAIT SENSORS USING ARDUINO IDE

- Initially the force sensors are placed on the bent rim of the walker, the wearable sensors are symmetrically arranged side by side with the walker.
- The LED light source is fixed to the center of the horizontal pane walker, along with LDR sensor attached to it.
- The ARDUINO controller fed with commands are synchronously activated by switching the 12v dc supply with connection of terminals.

- When given pressure at the rim, the force sensors detect the movement and the value of units are shown in the LCD display as: **F1=728 N; F2=785 N**;
- If pressure applied is more than 800 N, the alert buzzer emits loud noise indicating heavy pressure. When lights are off, the LDR sensors get activated and light automatically glows for detecting obstacles.
- The accelerometer gets activated when the patient loses balance and fall.
- The 12V,1A BATTERY has battery life of 724 hp and can lasts for 1 month.
- The Vibration motor gets vibrated on sensing the force and thus calibration process is provoked.
- This is sensed by Arduino and the necessary commands are generated.
- The values are displayed on the Liquid crystal board.
- Recommended highly for persons with Sports Injury, Aged persons and persons suffering from Cerebral Palsy.

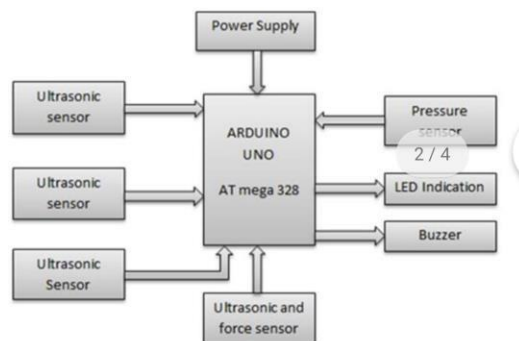


FIG. 4.9.FLOWCHART OF MUTISENSOR PROJECT

III. SYSTEM ARCHITECTURE

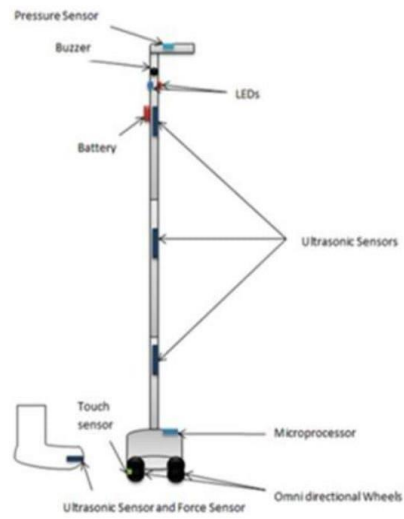


Fig. 1 Architecture Diagram of proposed system

FIG. 4.10. ARCHITECTURE OF THE CRUTCH TOOL

CHAPTER 5: RESULTS AND DISCUSSION

5.1. PERFORMANCE EVALUATION AND INFERENCE

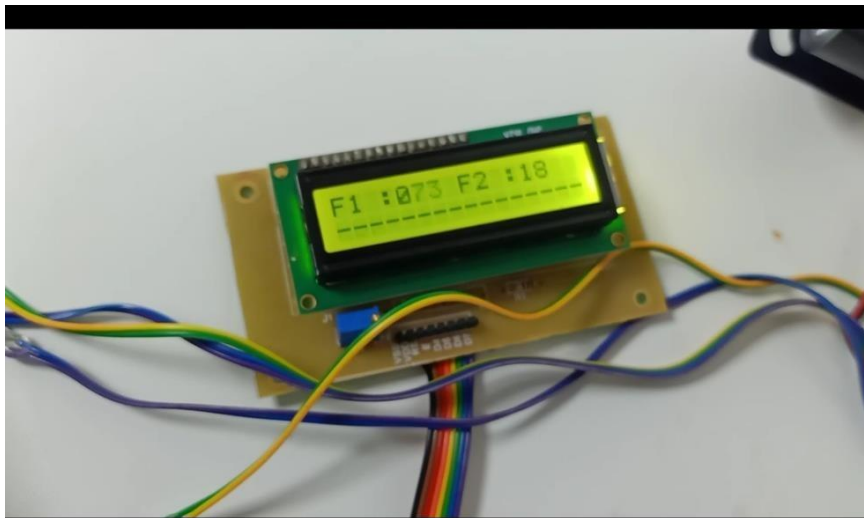


FIG.5.1. DISPLAY VALUE OF PATIENT PRESSURE APPLIED ON THE WALKER

1. When there is no pressure, the sensor looks like an infinite resistor (open circuit). The harder you press on the head of the sensor, the lower the resistance between two terminals will be, but as you remove the pressure it will return to its original value.

2. The graph below displays approximately the resistance of the sensor at different force measurements for the FSR 402 sensor. Note that the data is plotted on logarithmic scales.

3. The sensors mounted on the walker manipulates the pressure applied on the force sensors and the value gets received by the receiver end of the mother board
4. The Arduino At-mega exhibits the set of computations and crosschecks the inbuilt value;
5. When given pressure at the rim, the force sensors detect the movement and the value of units are shown in the LCD display as: **F1=728 N; F2=785 N;**
6. If pressure applied is more than 800 N, the alert buzzer emits loud noise indicating heavy pressure. When lights are off, the LDR sensors get activated and light automatically glows for detecting obstacles.
7. If it exceeds more than 800 N, then the buzzer gets activated
8. The LED Light glows only when the surrounding of the system gets in darker conditions
9. The accelerometer sensor gets activated when there is a fall detection by the patient or any obstacle in front of the walker.
10. The crutch tool maintains the proper balancing of the body.

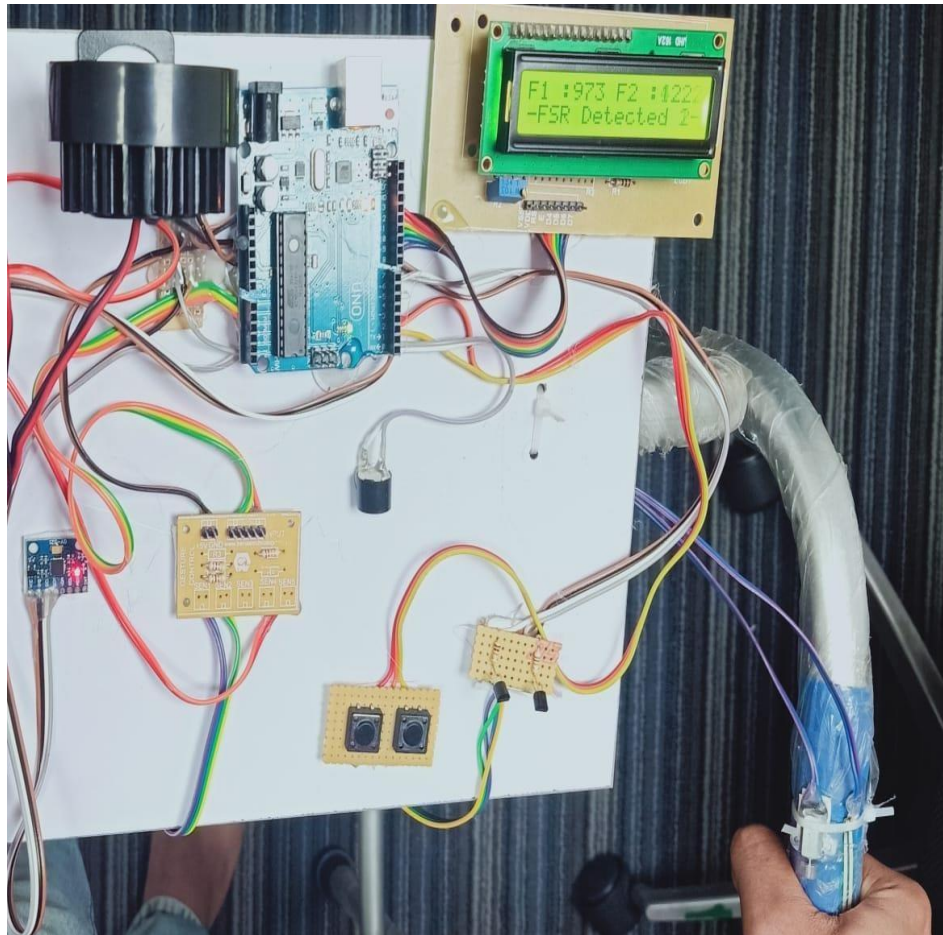


FIG 5.1.(A) PICTURE DEPICTING VALUE OF SENSOR F1=973 N; F2=1220 N EXPRESSING VARIATION OF PRESSURE APLIED BY BOTH HANDS



FIG 5.1.(B) LIGHT EMISSION DURING DARK CONDITIONS

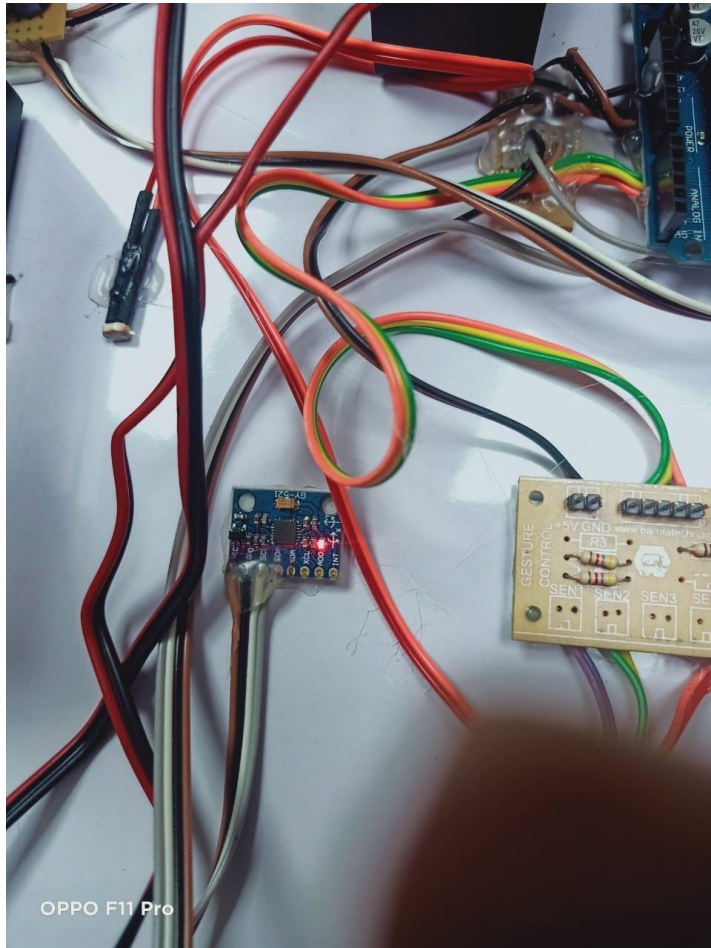


FIG 5.1. (d)FALL DETECTION WITH ALERT BUZZING SOUND INDICATING FALL

Technical calibration of proposed system

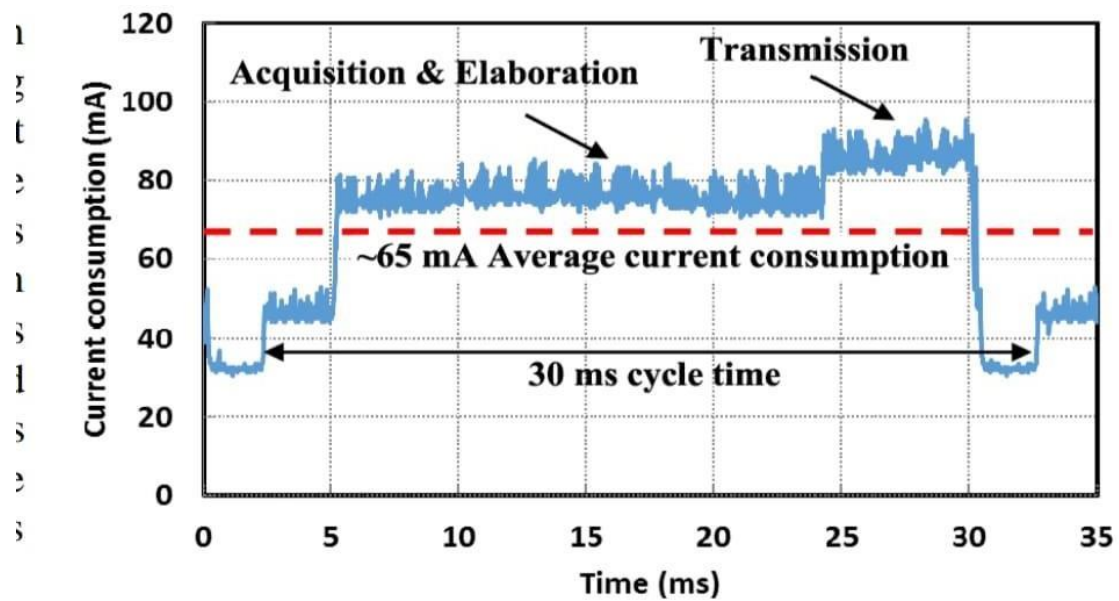


Fig. 9. Current consumption during one cycle.

Fig. 5.2.CURRENT CONSUMPTION DURING ONE CYCLE

TABLE I
SUMMARY DETAILS FOR THE CONDUCTED ANALYSIS
ON THE TWO INSTRUMENTED CRUTCHES

	Hysteresis (N)	Non- linearity (N)	Drift (N) @ 1h	Sensitivity (V/N)	Resolution (N)
Axial bridge – Right Crutch	3.23	5.60	-0.05	0.005	0.96
Shear_x bridge – Right Crutch	1.11	0.42	0.10	0.012	0.4
Shear_y bridge – Right Crutch	1.07	2.46	-0.04	0.013	0.37
Axial bridge – Left Crutch	3.36	5.00	0	0.005	0.96
Shear_x bridge – Left Crutch	0.35	4.22	-0.13	0.009	0.53
Shear_y bridge – Left Crutch	0.26	2.20	-0.06	0.01	0.48

Fig.5.3. TABLE SHOWING SUMMARISED DETAILS OF CRUTCH ANALYSIS

TABLE II
AGGREGATE RESULTS ON THE TEN SUBJECTS. VALUES EXPRESSED
AS MEAN (%BW) AND STANDARD DEVIATION ($\pm$ SD)

	NWB		10%PWB	
	%BW	$\pm$ SD	%BW	$\pm$ SD
Subject1	100	6	15	7
Subject2	110	20	26	20
Subject3	99	21	15	11
Subject4	101	11	10	14
Subject5	102	7	16	12
Subject6	106	26	24	13
Subject7	100	22	9	7
Subject8	103	11	35	24
Subject9	101	17	29	21
Subject10	100	17	16	9
MEAN	102	16	19	14

Fig. 5.4. AGGREGATE SAMPLE RESULTS OF TEN PATIENTS

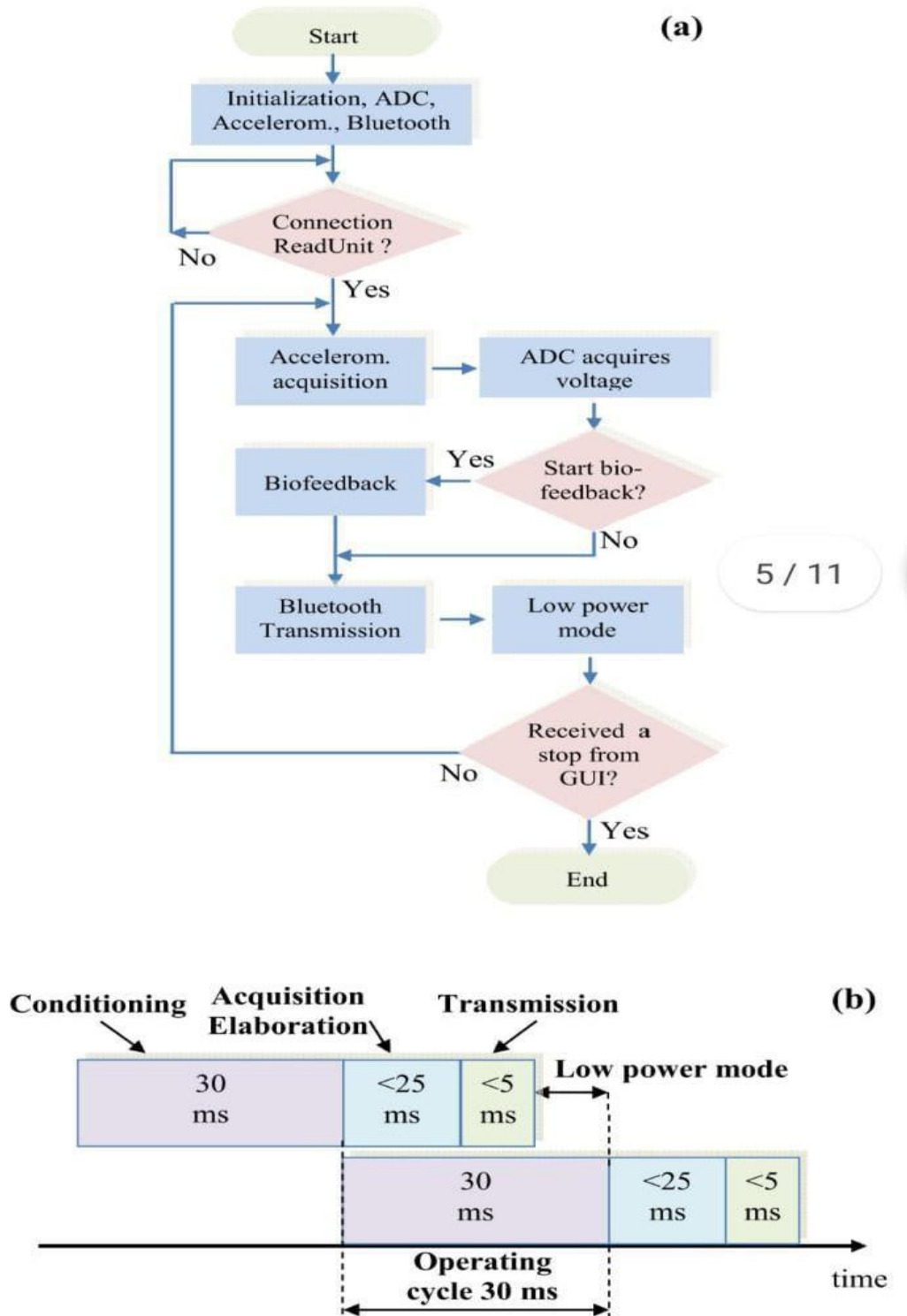


Fig.5.5. SCHEMATIC FLOWCHART ASSOCIATED WITH ACQUISTION AND TRANSMISSION ACTIVITIES

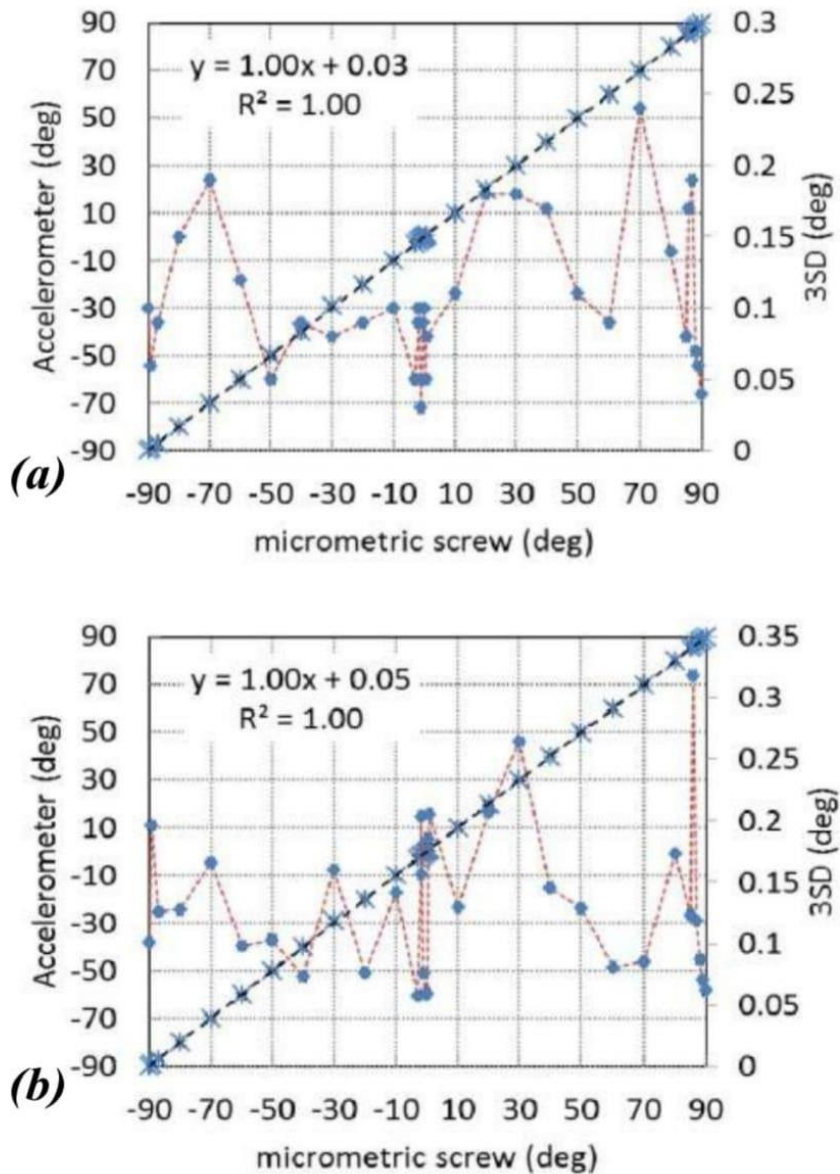


Fig. 6. Antro-posterior angle tests, mean (green dots), and standard deviation—3SD (blue squares) for the (a) left crutch and (b) right crutch.

Fig.5.6. ANTERO POSTERIOR ANGLE TESTS OF LEFT AND RIGHT CRUTCH

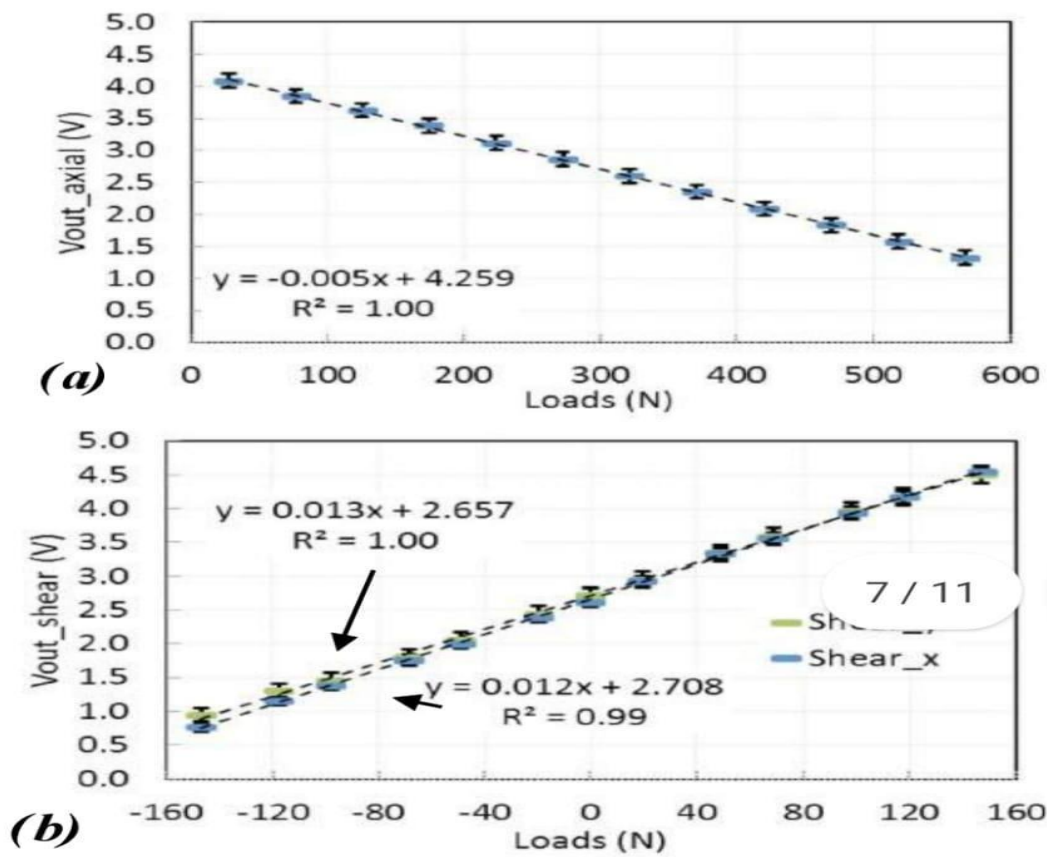


Fig. 8. (a) Axial force tests, conditioning circuit output voltages versus mechanically applied loads (mean and 3SD)—right crutch. (b) Shear force tests, conditioning circuit output voltages versus mechanically applied loads (mean and 3SD)—right crutch.

Fig: 5.7.GRAPH DEPICTING AXIAL FORCE TESTS WITH CONDITIONNG CIRUIT OUTPUTS

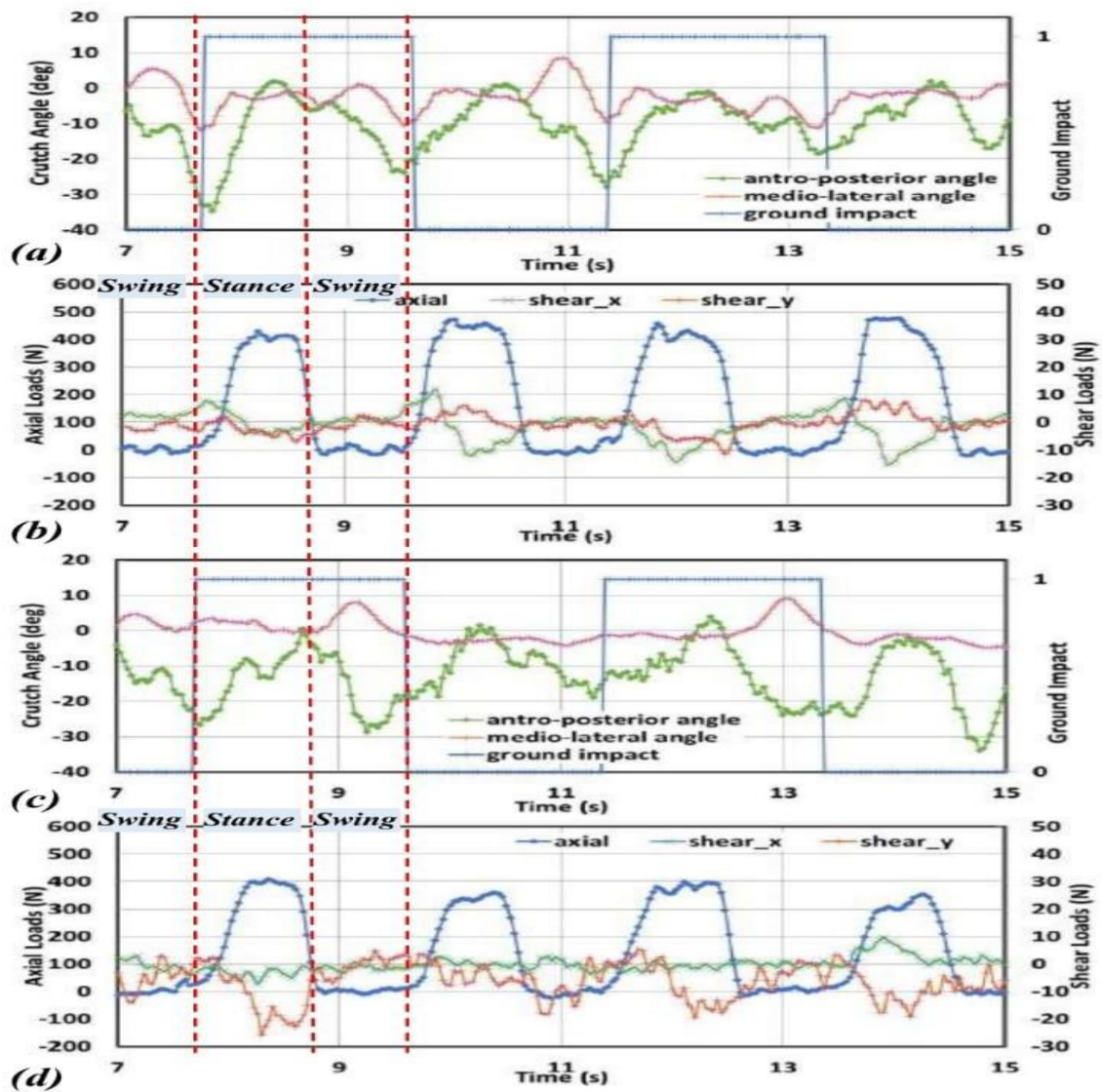


FIG.5.8. WIRELESS CONSUMPTION ANALYSIS DEPICTING CRUTCH ANGLE AND AXIAL LOADS OF THE PATIENT AND THE TOOL

Alattas.R, K. Elleithy et.al.,(2018) developed the Intelligent crutches are developed for normal people. But the design can be extended to blind people by incorporating an ultrasound sensor or IR sensor to measure the distance between the patient and the obstacle. In this case one more audio notification should be provided to the user about the obstacles in his way to avoid possible accidents. One more possibility is to send the usage data to doctors so that the patient can improve his rehabilitation exercise under his doctor's guidance. In this approach a memory module and a communication module should be incorporated with the crutch, so that after the usage of the crutch for the day the user can send his usage statistics to his doctor and the doctor can guide him throughout his rehabilitation period. In this research we are considering the forearm crutch. The same design is possible for every type of crutches such as canes, auxiliary crutch, and gutter crutch. The audio feedback can be replaced with display feedback. In this proposed system, it is designed in such a way that the user exhibit less effort to find the path or obstacle in front of them or became easy o navigate outside comfortably and prevent from dangerous fall. Automatic fall detector is designed for this purpose.

Our approach is similar to the postural monitoring system developed by Wang et al. Where two sensors attached to a garment are used in reference to each other to measure the spinal angle. However, our approach is more automated as their system relied on a therapist calibrating the system on each user to a range of various postures. Moreover, because the measurements in the postural monitoring system is dynamic, accelerometers cannot give the same accuracy as in the static case. Thus, in addition to the inertial acceleration, the gravitation must also be considered. Accelerometers and gyroscopes are commonly incorporated for dynamic positional changes. To measure inclination in spinal curvature, angular rates of rotations are integrated to obtain the positions in the sagittal plane. However, the position values are still due to some inaccuracies as they are affected by drift problems due to the integration method used . On the other hand, the AHRS modules have an accuracy of better than 1 degree, and have high accuracy in dynamic estimations, as they use a combination of

accelerometer, gyroscope and magnetometer for stabilization in measurements making them a better option for data collection. The next section in this report will discuss the AHRS and will provide more technical information on the accuracy and data collection method. Previous work can be classified into three categories in term of the adopted method of obtaining measurements: First category of work is based on fiber optic sensors. These sensors use the intensity of light passing through as a measurement tool which is proportional to the bend in the sensor. The system aims to simplify and speed up muscle strain sensor EMG monitoring that exist in patients, athletes, and sportsmen who using it. So, this research can help doctor or health workers in monitoring patients, athletes and old aged people

CHAPTER 6: SUMMARY AND CONCLUSION

6.1. SUMMARY

In this project, we could create a crutch tool with sensor technology that is efficiently developed to monitor the proper technical functioning and critical analysis of pressure by force sensors with various alternate sensors for fall detection, alert signaling, light detection etc. Initially, we saw connection of various sensors with the use of wires. Then they are all molded, glued and well interconnected with the Arduino microcontroller. We saw how the Arduino at mega 328 works, its functional specifications, characteristics of crutch tool and their fixation importance. Also, we infer linear characteristics of the graph of the pressure-time variant graph. The LDR sensor consisting N-type MOSFET and motor driver cordially operates at 1A,12V battery supply. The advantages of the design include low power consumption, the possibility of self-monitoring, economical, eco-friendly, saves patient from emergency situations, reduces pain etc. the design can be extended to blind people by incorporating an ultrasound sensor or IR sensor to measure the distance between the patient and the obstacle. In this case one more audio notification should be provided to the user about the obstacles in his way to avoid possible accidents. One more possibility is to send the usage data to doctors so that the patient can improve his rehabilitation exercise under his doctor's guidance. In this approach a memory module and a communication module should be incorporated with the crutch, so that after the usage of the crutch for the day the user can send his usage statistics to his doctor and the doctor can guide him throughout his rehabilitation period. In this research we are considering the forearm crutch. The same design is possible for every type of crutches such as canes, auxiliary crutch, and gutter crutch. The audio feedback can be replaced with display feedback.

6.2. CONCLUSION

In this research, a forearm crutch with required sensors is developed and this unique technology is developed to monitor the proper usage of crutch with the accurate value and care. The user will be notified about the incorrect usage of the crutch via, the audio system(buzzer) provided with the crutch. The crutch is user friendly and economical. As the intelligent crutch tool is developed using the necessary external sensors, it thereby eliminates the complexity of using internal and external sensors. The force sensors play an important role and accelerometer sensors to measure the angle inclination and acceleration of the falling tool. The design is used for balancing the patient's walk on the basis of weight exerted on the crutch and speed of movement of the patient using the crutch. The collected data are compared with the reference values while the user gets notifications simultaneously. As a conclusion of my proposed project research, we have confirmed that this developed system of crutch tool can measure, analyze and calibrate the motion of the patient walker based on the sensors embedded on and within the crutch. It eliminates the complexity of using internal and external sensors. It makes use of a force sensor and an accelerometer to measure the respective parameters. The design is for balancing the walk on the basis of weight exerted on the crutch and speed of movement of the patient using the crutch. The collected data are compared with the reference values and the user is notified whenever the patient exceeds the preset limit. The main advantages of the design include low power consumption, the possibility of self monitoring, economical, reduces strain of the patient, light weight. As a conclusion of this paper, we have confirmed that the developed system can measure and adulate the motion of a crutch based on only external sensors embedded with the crutch..

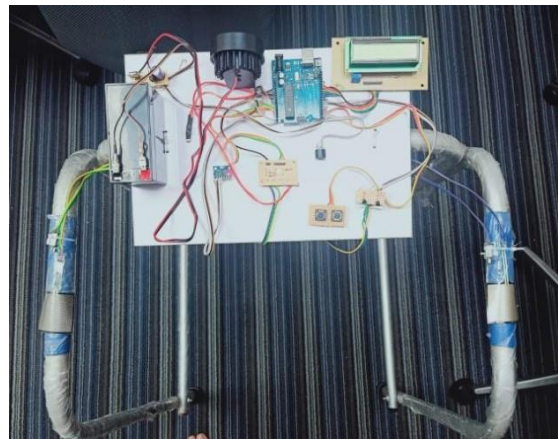
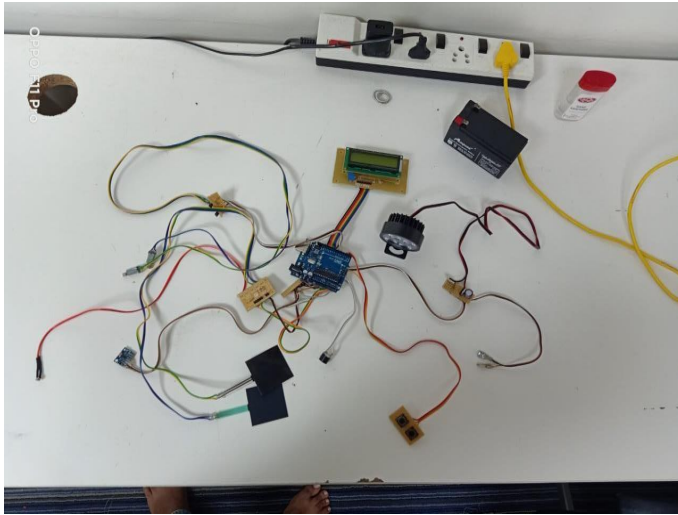


FIG 6.1. OVERALL CRUTCH TOOL COMPONENTS

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.

APPENDICES:

The IDE programming used for the project are as follows:

```
#include<LiquidCrystal.h>
#include <Wire.h>
LiquidCrystal lcd(13, 12, 11, 10, 9, 8);
#define splash splash1
#define fsr1 A0
#define fsr2 A1
#define ldr A2

#define ky1 2
#define ky2 3
#define buz 4
#define led 5
#define vb1 6
#define vb2 7

const int ACC = 0x68; // I2C address of the MPU-6050
unsigned int AcX, AcY, AcZ;
int fStatus, f_Status;
int roll_, rol;
int fsr1_r, fsr2_r, ldr_r, k1_r, k2_r;
int vb1_t, vb2_t;

int light_auto, light_Status;
```

```

int fsi = 0;
void setup() {
  // put your setup code here, to run once:
  Serial.begin(9600);
  pinMode(ky1, INPUT_PULLUP);
  pinMode(ky2, INPUT_PULLUP);
  pinMode(led, OUTPUT);
  pinMode(vb1, OUTPUT);
  pinMode(vb2, OUTPUT);
  pinMode(buz, OUTPUT);
  Wire.begin();
  Wire.beginTransmission(0x68);
  Wire.write(0x6B); // PWR_MGMT_1 register
  Wire.write(0);    // set to zero (wakes up the MPU-6050)
  Wire.endTransmission(true);
  LcDSet();

}

void LcDSet() {

  lcd.begin(16, 2);
  splash(0, "IntelligenT");
  splash(1, "Crutch-Tool");

  delay(2000);
  lcd.clear();

}

```

```

void loop() {
    // put your main code here, to run repeatedly://<500>800
    rol = getAcc();
    k1_r = digitalRead(ky1);
    k2_r = digitalRead(ky2);
    ldr_r = analogRead(ldr);
    fsr1_r = analogRead(fsr1);
    fsr2_r = analogRead(fsr2);

    Serial.print(" Ldr = ");
    Serial.print(ldr_r);
    Serial.print(" Fsr1 = ");
    Serial.print(fsr1_r);
    Serial.print(" Fsr2 = ");
    Serial.print(fsr2_r);
    Serial.println();
    lcd.setCursor(0, 0);
    lcd.print("F1 :   ");
    lcd.setCursor(4, 0);
    lcd.print(fsr1_r);

    lcd.setCursor(8, 0);
    lcd.print("F2 :   ");

    lcd.setCursor(12, 0);
    lcd.print(fsr2_r);

```

```
lcd.setCursor(0, 1);  
lcd.print("LDR:   ");  
lcd.setCursor(4, 1);  
lcd.print(ldr_r);
```

```
lcd.setCursor(8, 1);  
lcd.print("ACC:   ");  
lcd.setCursor(14, 1);  
lcd.print(rol);
```

```
if (fsr1_r > 800) {  
    digitalWrite(vb1, HIGH);  
    vb1_t = 250;  
    splash(1, "FSR Detected 1");  
}  
else {  
    digitalWrite(vb1, LOW);  
    vb1_t = 0;
```

```
splash(1, "");  
}  
if (fsr2_r >= 829) {
```

```
    lcd.setCursor(8, 0);  
    lcd.print("F2 :   ");  
    lcd.setCursor(12, 0);  
    lcd.print(fsr2_r + 800);  
digitalWrite(vb2, HIGH);  
    splash(1, "FSR Detected 2");
```

```
    vb2_t = 250;  
}  
else {  
    digitalWrite(vb2, LOW);  
    fsi = 0;  
    vb2_t = 0;  
}
```

```
if (k1_r == 0 and light_auto == 0) {  
    splash(1, "LED Mode OFF");  
    delay(100);  
    light_auto = 1;  
  
}  
else if (k1_r == 0 and light_auto == 1) {  
    splash(1, "LED Mode ON");  
    delay(100);  
    light_auto = 0;  
}
```

```

if (light_auto == 0) {
  if (ldr_r < 500) {
    digitalWrite(led, HIGH);
  }
  else {
    digitalWrite(led, LOW);

  }
}
else {

```

```

if (k2_r == 0 and light_Status == 0) {
  digitalWrite(led, HIGH);
  splash(1, "LED ON");
  delay(100);
  light_Status = 1;
}
else if (k2_r == 0 and light_auto == 1) {
  splash(1, "LED OFF");
  digitalWrite(led, LOW);
  delay(100);
  light_Status = 0;
}
}

```

```

if (rol == 1) {

```

```

    digitalWrite(buz, HIGH);
    splash(1, "Fall Detected");
}
else {
    digitalWrite(buz, LOW);
}

```

```

    delay(100);
}

```

```

int getAcc() {
    Wire.beginTransmission(ACC);
    Wire.write(0x3B); // starting with register 0x3B (ACCEL_XOUT_H)
    Wire.endTransmission(false);
    Wire.requestFrom(ACC, 14, true); // request a total of 14 registers
    AcX = Wire.read() << 8 | Wire.read(); // 0x3B (ACCEL_XOUT_H) & 0x3C
    (ACCEL_XOUT_L)

    AcY = Wire.read() << 8 | Wire.read(); // 0x3D (ACCEL_YOUT_H) & 0x3E
    (ACCEL_YOUT_L)
    AcZ = Wire.read() << 8 | Wire.read(); // 0x3F (ACCEL_ZOUT_H) & 0x40
    (ACCEL_ZOUT_L)
    if (AcX > 49000 && AcX < 57000)
    {

```

```

    fStatus = 1;
    Serial.println("-----FALL--DETECTED -----");
    //  delay(20);

}

else if (AcX > 7000 && AcX < 15000)
{
    fStatus = 1;
    //  Serial.println("-----FALL--DETECTED-----");
    //  delay(20);

}

else if (AcY > 7000 && AcY < 15000 )
{

    fStatus = 1;
    //  Serial.println("-----FALL--DETECTED-----");
    //  delay(20);

```

```
}
```

```
else if (AcY > 49000 && AcY < 57000 )
{
    fStatus = 1;
    // Serial.println("-----FALL--DETECTED-----");
    // delay(20);
}
else {
    fStatus = 0;
    // Serial.println("_____SAFE_____");
    // delay(20);
}
// Serial.print("X = "); Serial.print(AcX);
// Serial.print(" | Y = "); Serial.println(AcY);
return fStatus;
// delay(333);
}
```

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