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DESIGN & FABRICATION OF 3D PRINTED BIONIC LEG WITH HUMAN MOTION CONTROL

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ABSTRACT: This prototype uses an Arduino microcontroller to design a myoelectric prosthetic that reads electrical signals from the residual limb and powers motors for motion. The goal is to create a prosthetic limb that can sense muscle movements and automate the motion, making the amputated person feel the bionic limb as their own. This prototype uses low-cost, high-power materials and POT muscle sensor to sense muscle movement. This project presents the design and implementation of a POT Sensor Board Leg Operation System for handicapped individuals. The system is built to assist people with mobility impairments by enabling leg movement control through a potentiometer (POT) sensor. The core components of the system include an Arduino Uno as the microcontroller, a CNC shield for motor control, an L298 motor driver for driving DC motors, and a 12V battery for power supply. The POT sensor is used to capture user inputs, translating rotational motion into electrical signals that are processed by the Arduino Uno. Based on the input, the L298 motor driver actuates the motor, enabling controlled movement of the leg support. The CNC shield helps in integrating the motor driver with the microcontroller, ensuring efficient signal transmission and motor control.

Keywords: 3d printing, Cost effective, Bionic leg, Polylactic acid (PLA), Motor drive, Potentiometer sensor (POT).

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1. INTRODUCTION

1.0 Bionic Leg

Bionic leg models, also known as robotic prosthetic legs, are advanced artificial limbs designed to simulate the function and appearance of a natural leg, incorporating technology like sensors, actuators, and microprocessors to enable natural movement and, in some cases, even sensory feedback. Here's a more detailed look at the background of bionic leg models:

1.0.1 The Need for Advanced Prosthetics

- **Addressing Amputation**

Amputations can have a significant impact on a person's quality of life, affecting mobility, independence, and psychological well-being. Limitations of Traditional Prosthetics: Traditional prosthetic legs often lack the natural feel, functionality, and control of a biological limb, leading to limitations in daily activities.

1.0.2 The Rise of Bionic Technology: Combining Robotics and Biology:

Bionic legs represent a fusion of robotics, engineering, and biological sciences, aiming to create prosthetics that are more natural and intuitive to use.

1.1 History

The oldest known prosthetics are two different artificial toes from ancient Egypt. One prosthetic toe, known as the “Greville Chester toe,” was made from cartonnage, which is a kind of papier- m a ^che´ made from glue, linen, and plaster. It is thought to be between 2,600 and 3,400 years old, though its exact age is unknown. Because it doesn’t bend, researchers believe it was cosmetic.

The other prosthetic, a wooden and leather toe known as the “Cairo toe,” is estimated to be between 2,700 and 3,000 years old. It is thought to be the earliest known practical artificial limb due to its flexibility and because it was refitted for the wearer multiple times. Approximately 300 years later—300 B.C.—in Italy, an ancient Roman nobleman used a prosthetic leg known as the “Capua leg.” The leg was made of bronze and hollowed-out wood and was held up with leather straps. Other known early prosthetics include artificial feet from Switzerland and Germany, crafted between the 5th and 8th centuries. These were made from wood, iron, or bronze and may have been strapped to the amputee’s remaining limb. Basic artificial limbs have been used since 600 BC. Wooden legs, metal arms, hooks for hands—while these primitive replacements gave the wearer back some semblance of movement or function, they were often uncomfortable, difficult to use, had poor functionality and were cosmetically unattractive

1.2 Current Scenario

Artificial limbs, or prostheses, are used to replace a missing body part which may have been lost due to trauma, disease or congenital defect. The type of prosthesis a person can use is dependent on the individual, including the cause of amputation or limb loss, and the location of the missing extremity. Today, researchers are striving to develop lighter, smaller, better-controlled, more lifelike and affordable options. What’s different about the new generation of prosthetic limbs is their union with bionic technology, and the way they combine fields of study as diverse as electronics, biotechnology, hydraulics, computing, medicine, nanotechnology and prosthetics. Technically, the field is known as biomechatronics, an applied interdisciplinary science that works to integrate mechanical elements and devices with biological organisms such as human muscles, bones, and the nervous systems.

1.3 3d Printing

A 3d printing is an additive manufacturing technique where 3D objects and parts are made by the addition of multiple layers of material. It can also be called as rapid prototyping. It is a mechanized method where 3D objects are quickly made as per the required size machine connected to a computer containing blueprints of any object. The additive method may differ with the subtractive process, where the material is removed from a block by sculpting or drilling. The main reason to use 3d printer is for 90% of material utilization, increase product life, lighter and stronger. 3D printing is efficiently utilized in various fields such as aerospace, automobile, medical, construction and in manufacturing of many house hold products 3D printing called as desktop fabrication. It is a rapid prototyping process whereby a real object can be created from a 3D design. A 3D printer machine uses a CAD model for rapid prototyping process.

3D printing is called as desktop fabrication which is a process of prototyping where by a structure is synthesized from its 3d model. The 3d design is stored in as a STL format and after that forwarded to the 3D printer. The 3D printer prints the CAD design layer by layer forming a real object. 3D printing process is derived from inkjet desktop printers in which multiple deposit jets and the printing material, layer by layer derived from the CAD 3D data.3D printing is diversifying and accelerating our life, letting various qualities of products to be synthesized easier and faster.

1.4 Design Modelling:

In Tinkercad, you model by combining and manipulating basic shapes (primitives) on a 3D workplane, using a simplified constructive solid geometry (CSG) approach, where shapes can be either "solid" or "hole".

- Here's a breakdown of the modeling process:

1. **Start with a Project:** Begin by creating a new project in Tinkercad, which will give you a blank 3D workspace.
2. **Choose Shapes:** Select the shapes you want to use from the available primitives (e.g., boxes, cylinders, spheres) on the right-hand side of the screen.
3. **Place and Adjust:** Drag the chosen shapes onto the workplane, and use the handles to resize, rotate, and move them.
4. **Combine or Subtract:** You can combine shapes to create new, complex forms, or subtract one shape from another to create holes or cavities.
5. **Group and Ungroup:** Group shapes together

to treat them as a single object, or ungroup them to edit individual components.

6. **Refine and Iterate:** Continue adding, adjusting, and combining shapes until you achieve the desired design, and then refine by making small changes and iterations.

7. **Export and Print:** Once you are satisfied with your model, you can export it in a format like for 3D printing.

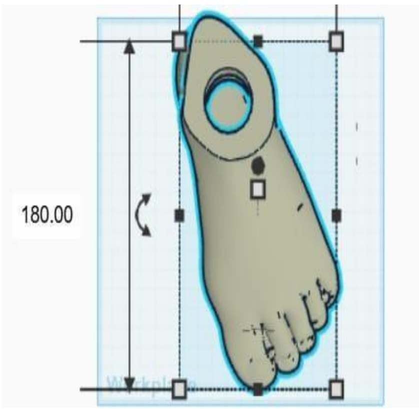

Fig1.1: Design of socket.

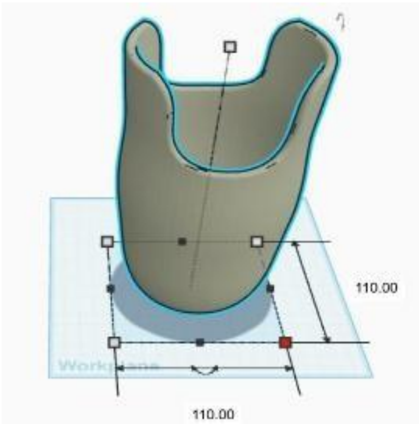

Fig1.2: Design of foot.

1.5 Finished Part:

The printer produced resolution is very much sufficient for many of the applications but the printing will be a slightly oversized version of this desired object which can be the standard resolution and then the process of removing material can give greater precision. Some printable polymers allow the surface finish to be smoother and improved using chemical vapour processes. There are some of the additive manufacturing techniques which are very capable of using multiple materials in this course of constructing parts. These techniques are very much able to print in multiple colours and colour combinations simultaneously. Some printing techniques require internal supports to be built for overhanging features during construction. These supports must be mechanically removed or dissolved after completion of the printing. The commercialized metal 3D printers which very much likely to involve in cutting the metal component of the metal substrate after deposition. The very new process for the GMAW 3D printing which will allow for substrate surface modifications to remove many aluminium components manually with hammer.

Fig1.3: Finished part of socket

Fig1.4: Finished part of foot

2. Literature Survey

R. D. Howe and Y. Matsuoka,[1] "Robotics for surgery," Annual Review of Biomedical Engineering, vol. 1, pp. 211–240, 1999. In this paper the design of a novel modular hydraulic/pneumatic actuated tele-robotic system and a new infrastructure for MRI-guided intervention for closed-bore MRI-guided neurosurgery are presented.

R. H. Taylor and D. Stoianovici,[2] "Medical robotics in computer-integrated surgery," IEEE Transactions on Robotics and Automation, vol. 19, no. 5, pp. 765– 781, 2003 This paper provides a broad overview of medical robot systems used in surgery.

R. Lanfranco, A. E. Castellanos, J. P. Desai, and W. C. Meyers,[3] "Robotic surgery: a current perspective," Annals of Surgery, vol. 239, no. 1, pp. 14–21, 2004. Surgical robotics is a new technology that holds significant promise. Robotic surgery is often heralded as the new revolution, and it is one of the most talked about subjects in surgery today.

S. Badaan and D. Stoianovici,[4] "Robotic systems: past, present, and future," in Robotics in Genitourinary Surgery, pp. 655–665, Springer, New York, NY, USA, 2011. First used medically in 1985, robots now make an impact in laparoscopy, neurosurgery, orthopedic surgery, emergency response, and various other medical disciplines.

Johannes Bodner and John Fish [5] "The da Vinci robotic system for general surgical applications: a critical interim appraisal", Swiss Medical Weekly 2005; 135:674–678. Various general surgical procedures have proved feasible and safe when performed with the da Vinci™ robot.

Aruna D. Mane and Sirkazi Mohd. Arif,[6] "An Advanced Robot– Robin Heart (A Surgeon without hand Tremor)", International Journal of Engineering and Advanced Technology (IJEAT), ISSN: 2249 –8958, Volume- 2, Issue-5, June 2013. Recent advancements in embedded systems have opened up a vast area of research and development of haptic technology. Surgeries with minimum invasiveness and high precision are becoming vital requisite.

R. C. Luo, K.L. Su,[7] .A multi agent multi sensor based real-time sensory control system for intelligent security robot. IEEE International Conference on Robotics and Automation, vol. 2, 2003, pp.2394 .2399. In recent year, with the increase usage of wireless application, the demand for a system that could easily connect devise for transfer of data over a long distance without wires.

Bouzit, M.; Burdea, G.; Popescu, G.; Boian, R.,[9] "The Rutgers Master II-new design force-feedback glove", IEEE/ASME Transactions on Mechatronics, Volume 7, Issue 2, June 2002 Page(s):256-263. The Rutgers Master II-ND glove is a haptic interface designed for dextrous interactions with virtual environments.

3. Research Gap

3.1 Existing System:

Several assistive mobility devices and prosthetic leg movement systems have been developed to aid handicapped individuals. These systems primarily focus on motorized limb movement, sensor-based control, and IoT integration to enhance usability. The existing systems use different technologies, but they come with certain limitations that this project aims to improve upon.

1. Traditional manual prosthetic legs and braces require physical effort from the user or assistance from caregivers.
2. These methods are often uncomfortable, lack real-time adaptability, and do not provide an easy way to adjust movement speed or force.
3. Some motorized prosthetic limbs and mobility aids use pre-programmed movements controlled by buttons or preset configurations.
4. These devices are often expensive and not accessible to a large section of the population.

3.2 Problem Statement:

Mobility impairment is a significant challenge faced by handicapped individuals, affecting their independence and quality of life. Traditional prosthetic and assistive devices often rely on manual operation, mechanical systems, or expensive AI-driven solutions, which are either difficult to use, lack real-time adaptability, or are financially inaccessible.

- **Lack of real-time control:** Many assistive devices use pre-programmed movements, making them less adaptable to individual user needs.

- **High cost:** Advanced prosthetic limbs and smart assistive systems are expensive, limiting their accessibility.
- **Dependency on external assistance:** Many mobility aids require manual adjustment or caregiver intervention, reducing the independence of the user.
- **Limited IoT integration:** Most traditional systems do not allow for remote monitoring and control, making it difficult for caregivers to assist users effectively.

3.3 Proposed System:

To overcome the limitations of existing assistive mobility solutions, this project proposes a POT Sensor Board Leg Operation System. The system is designed to provide real-time, sensor-based motorized leg movement control, enhancing the mobility and independence of handicapped individuals.

The proposed POT Sensor Board Leg Operation System provides an affordable, intelligent, and efficient mobility solution for handicapped individuals. By integrating sensor technology, and motorized control, the system enhances independence, ease of use, and accessibility, making it a valuable assistive device for users with mobility impairments.

1. The POT sensor detects rotational movement input from the user and converts it into an electrical signal. The Arduino Uno processes this signal and generates appropriate control commands.
2. The CNC shield and L298 motor driver regulate the motor's speed and direction.
3. The motorized system moves the leg support accordingly, ensuring smooth and precise motion.

4. Design & Fabrication

4.1 Design Software:

4.1.1 TINKERCAD: TINKERCAD, founded by Kai Backman and Mikko Mononen, was launched in 2011 as a web-based 3D modeling tool, aiming to make 3D design accessible to everyone, and was acquired by Autodesk in 2013. It has since grown to include electronics and coding, introducing millions to the world of making and design and his cofounder Mikko Mononen, with a goal to make 3D modeling, especially the design of physical items, accessible to the general public, and allow users to publish their designs under a Creative Commons license.

1. Design Procedure:

In tinkercad, the design process involves selecting and placing basic shapes, adjusting them via rotation, scaling, and positioning, and then combining them to create complex 3D models.

- **Here's a more detailed breakdown:**

Start with Basic Shapes: Tinkercad provides a library of primitive shapes (like cubes, cylinders, spheres, etc.) that serve as the building blocks for your designs.

Place and Adjust: Drag shapes onto the workplane, then use the handles to resize, rotate, and move them into position.

Combine Shapes: Select multiple shapes and use the "Group" function to merge them into a single object, or use "Hole" to create cavities.

Refine and Iterate: Continue adding, adjusting, and combining shapes until you achieve the desired design.

Export and Print: Once you're satisfied with your design, you can export it in various formats (like STL) for 3D printing or other applications.

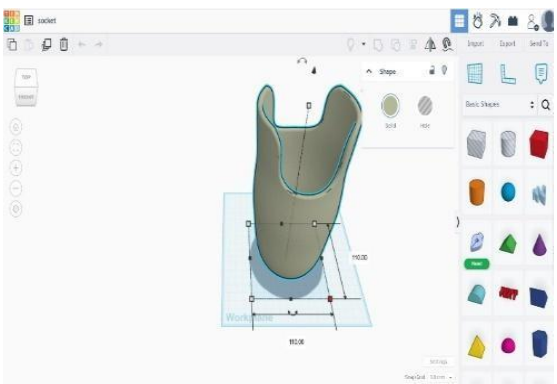

Fig4.1: Design output of socket in tinkecad design software.

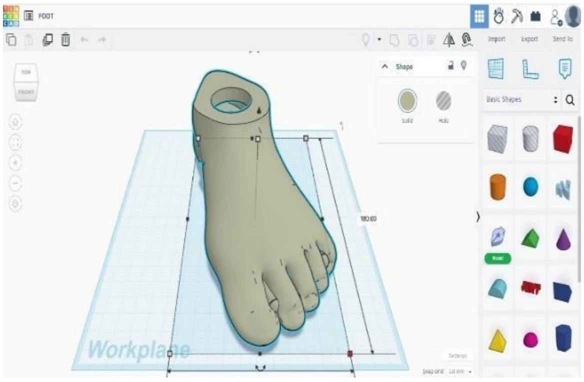

Fig4.2: Design output of foot in tinkecad design software.

4.2 Slicer Software:

4.2.1 CREALITY Slicer

CREALITY Slicer 4.8.2 is a slicing software developed by Creality based on Cura, designed for 3D printers, offering features like 3D model editing, importing, slicing, parameter profile editing, previewing, and saving.

- **Here's a more detailed breakdown:**

Functionality:

Slicing: Converts 3D models into a series of layers and instructions for 3D printers, enabling layer-by-layer printing.

Model Processing: Provides various model processing functions, including editing, importing, and previewing.

Parameter Profile Editing: Allows users to customize printing parameters for different materials and models.

Remote Control and Monitoring: Enables remote control and monitoring of 3D printers.

Printing from Computer: Facilitates printing directly from a computer.

4.2.2 Working Procedure:

Import Model: Open the CREALITY Slicer software and import the 3D model you want to print.

Printer Profile: Select your CREALITY 3D printer model from the available profiles.

Adjust Settings: Customize the printing settings, including layer height, printing speed, infill density, supports, and other parameters.

Preview & Slice: Preview the 3D model and then slice it to generate the G-code for your printer.

Print: Transfer the G-code to your CREALITY 3D printer and start printing.

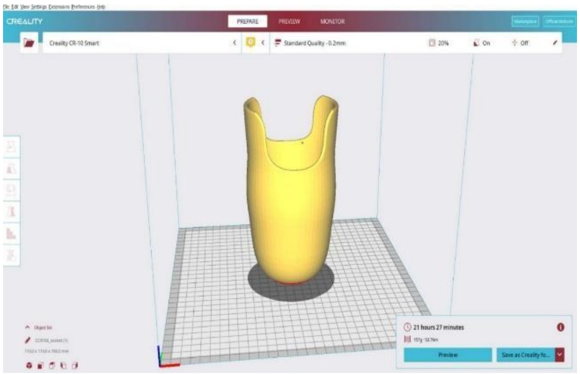

Fig4.3: uploaded socket design in slicer software.

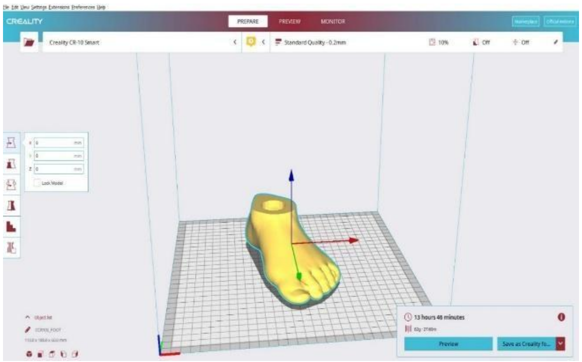

Fig4.4: uploaded foot design in slicer software.

4.3 Slicing To Generate G-Code:

The "layer by layer" method involves breaking down a 3D model into thin, horizontal slices (layers), which the printer then builds sequentially, layer upon layer, to create the final object.

- **Here's a more detailed explanation**:

Slicing: The slicer software takes a 3D model (usually in STL format) and divides it into a series of 2D slices or layers based on a specified layer height.

1. Layer Height:

The thickness of each layer determines the resolution and detail of the print, with smaller layer heights resulting in finer details but longer print times.

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2. **Path Generation:**

For each layer, the slicer calculates the optimal path for the printer's nozzle to follow, ensuring efficient and accurate printing.

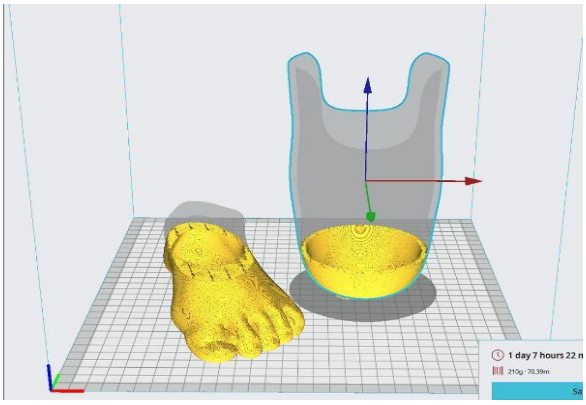

Fig4.5: Layer by layer slices of uploaded foot & socket design STL file.

3. **Support Structures:**

If the model has overhangs or complex geometries, the slicer software can automatically generate support structures to ensure stability during printing.

4. **G-code Generation:**

Once the slicing and path generation are complete, the slicer software converts these instructions into G-code, a set of instructions that the 3D printer uses to execute the print.

4.3.1 Start G-Code:

G28 ; Home

G92 E0 ; Reset Extruder

G1 Z2.0 F3000 ; Move Z Axis up

G1 X10.1 Y20 Z0.28 F5000.0 ; Move to start position

G1 X10.1 Y200.0 Z0.28 F1500.0 E15 ; Draw the first line

G1 X10.4 Y200.0 Z0.28 F5000.0 ; Move to side a little

G1 X10.4 Y20 Z0.28 F1500.0 E30 ; Draw the second line

G92 E0 ; Reset Extruder

G1 Z2.0 F3000 ; Move Z Axis up

4.3.2 End G-Code:

G91 ; Relative positionning G1 E-2 F2700 ;Retract a

bit

G1 E-2 Z0.2 F2400 ; Retract and raise Z G1 X5 Y5

F3000 ; Wipe out

G1 Z10 ; Raise Z more

G90 ; Absolute positionning G1 X0 Y0 ; Present print

M106 S0 ;Turn-off fan

M104 S0 ;Turn-off hotend M140 S0 ;Turn-off bed

M84 X Y E ; Disable all steppers but Z

4.4 CREALITY Cr-10 Smart Machine:

Fig: 4.6

The CREALITY CR-10 Smart is a 3D printer known for its large build volume (300x300x400mm), features like built-in Wi-Fi, intelligent auto-leveling, and a 4.3-inch touchscreen, and its modular design.

4.4.1 Specifications:

Key Features: Large Build Volume: The CR-10 Smart boasts a substantial build volume of 300x300x400mm, making it suitable for larger prints.

Smart Features: Wi-Fi Connectivity: Built-in Wi- Fi allows for remote control and monitoring via the CREALITY Cloud app.

Intelligent Auto-Leveling : The printer features an automatic bed leveling system for easy setup and consistent first layers.

4.3-inch Touchscreen: A user-friendly touchscreen interface simplifies operation and navigation.

Dual Z-Axis: The dual Z-axis design with dual diagonal drawbars enhances stability and print quality.

Silent Operation: The printer incorporates a 32-bit silent mainboard, low-noise power supply, and efficient cooling fans for a quiet printing experience.

Modular Design: The printer's modular design allows for easy assembly and maintenance.

Filament Runout Detection: The CR-10 Smart has filament runout detection.

Upgraded Extruder Feeder: The printer has an upgraded extruder feeder.

Printing LEDs: The printer has printing LEDs.

Carborundum Glass Platform: The printer has a carborundum glass platform.

Supported Materials: PLA, ABS, HIPS, TPU, PETG, PA, and Carbon Fiber Composites.

4.5 Fabrication:

The development of assistive technologies for handicapped individuals has been a significant area of research, with a focus on sensor-based mobility solutions, IoT integration, and motorized limb support systems. This literature survey reviews previous works and technologies related to POT sensor-based leg operation systems using IoT, Arduino, motor drivers, and battery-powered systems.

Sensor-Based Mobility Assistance:

Several studies have explored sensor-based control mechanisms to assist physically challenged individuals. Potentiometer (POT) sensors have been widely used in prosthetic and rehabilitation systems for motion control due to their ability to convert mechanical movement into an electrical signal (Anandan et al., 2020). Research by Singh et al. (2019) demonstrated the effectiveness of POT sensors in motorized prosthetic limbs, showing their capability to provide smooth and controlled movement.

Arduino-Based Control Systems:

Arduino microcontrollers have been extensively used in assistive technology due to their low cost, ease of programming, and compatibility with multiple sensors and motor drivers. Kumar et al. (2021) developed an Arduino-controlled limb movement system, where a POT sensor provided input signals for motorized movement, proving the feasibility of such a setup. Another study by Sharma et al. (2022) successfully implemented an Arduino and IoT-based remote-controlled prosthetic limb, demonstrating how IoT integration enhances accessibility.

Motor Control Using L298 Motor Driver & CNC Shield:

The L298 motor driver is a common choice for controlling DC motors due to its high efficiency and dual H-Bridge configuration. Research by Patel & Gupta (2020) explored motorized rehabilitation devices using L298 and Arduino, achieving precise movement control. The CNC shield has been used in various projects for precise motor coordination, as shown in the work by Rao et al. (2019), where it was utilized in an automated mobility-assist system.

Battery-Powered Mobility Solutions:

The use of 12V batteries in motorized medical devices has been explored in several research papers, emphasizing portability, energy efficiency, and reliability. Studies by Verma et al. (2022) found that 12V lithium-ion battery-based mobility aids provided long-lasting and sustainable power for assistive devices.

It is evident that POT sensors, Arduino, motor drivers, CNC shields, and IoT integration play a crucial role in developing efficient, cost-effective, and user-friendly mobility assistance systems. The POT Sensor Board Leg Operation System builds upon these advancements by integrating IoT-based monitoring, precise motor control, and an easy-to-use interface for handicapped individuals, contributing to the ongoing innovation in assistive technologies.

4.5.1 Hardware Details:

1. L298 MOTOR DRIVER
2. POT SENSOR
3. ARDUINO UNO
4. CNC SHIELD
5. 12V LIPO BATTERY
6. JUMPER WIRES

4.5.2 Software Details:

1. ARDUINO IDE
2. EMBEDDED 'C'

4.6 Arduino Ide:

The Arduino IDE (Integrated Development Environment) is a cross-platform software application designed for writing, compiling, and uploading code to Arduino microcontroller boards. It serves as the primary tool for developers, hobbyists, and students to create interactive electronics projects. With its intuitive interface and straightforward workflow, the Arduino IDE has become popular worldwide for prototyping and developing both simple and complex systems. The Arduino IDE stands out for its simplicity, flexibility, and extensive support network. It is ideal for beginners learning programming and electronics, as well as professionals developing advanced systems, making it a versatile tool in the world of embedded systems and IoT.

1. ARDUINO IDE Coding:

- #define IN_1 10
- #define IN_2 D8
- #define IN_3 D7
- #define IN_4 D3 54
- #define IN_C D5
- #include
- #include
- #include
- String command;
- const char* ssid = "BIONIC_LIMB";
- ESP8266WebServer server(80);
- void setup() {
- pinMode(IN_1, OUTPUT);
- pinMode(IN_2, OUTPUT);
- pinMode(IN_3, OUTPUT);
- pinMode(IN_4, OUTPUT);
- pinMode(IN_C, OUTPUT);
- digitalWrite(IN_C, LOW);
- stopLimb();
- void goAhead() {
- Serial.println("FORWARD");
- digitalWrite(IN_1, LOW);
- digitalWrite(IN_2, HIGH);
- digitalWrite(IN_3, LOW);
- digitalWrite(IN_4, HIGH);
- }
- void goBack() {
- Serial.println("BACKWARD");
- digitalWrite(IN_1, HIGH);
- digitalWrite(IN_2, LOW);
- digitalWrite(IN_3, HIGH);
- digitalWrite(IN_4, LOW);
- }

- void stopLimb() {
- Serial.println("STOP");
- digitalWrite(IN_1, LOW);
- digitalWrite(IN_2, LOW);
- digitalWrite(IN_3, LOW);
- digitalWrite(IN_4, LOW);
- }

4.7 Functions Of The Using Components:

Power Supply & Switch Functionality:

- The system is powered by a 3-cell LiPo battery (12V), which provides the necessary voltage to drive the motor and Arduino.
- A switch is connected to control the power supply, allowing the user to turn the system ON or OFF.
- The L298 motor driver, CNC shield, and Arduino Uno receive power from this battery.

Role of the POT Sensor:

- The POT sensor (potentiometer) acts as a user input device. It converts the user's manual rotation into an Analog voltage signal.
- The Analog signal is fed into the Arduino Uno through one of its Analog input pins (A0-A5).
- This signal determines the desired movement and speed of the motorized leg support.
- Turning the potentiometer changes the resistance, modifying the voltage level, which the Arduino processes to adjust motor speed and direction.

Arduino Uno Processing & CNC Shield Integration:

- The Arduino Uno is the central controller. It:
- Reads the POT sensor input.
- Processes the Analog voltage and converts it into digital motor control signals.
- Sends these signals to the L298 motor driver via the CNC shield.
- The CNC shield acts as an interface between the Arduino Uno and motor driver, enabling precise motor control.

Motor Control using L298 Motor Driver:

- The L298 motor driver receives control signals from the Arduino via the CNC shield.
- It regulates motor movement based on the potentiometer input.
- The motor moves forward, backward, or stops depending on the user's input through the POT sensor.
- The speed of the motor is also controlled by PWM signals from the Arduino.

4.8 Block Diagram:

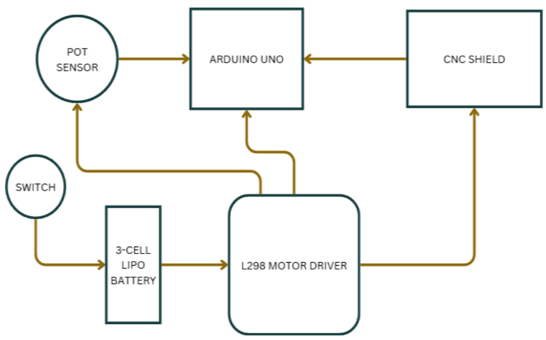

Fig: 4.7

4.9 Circuit Diagram:

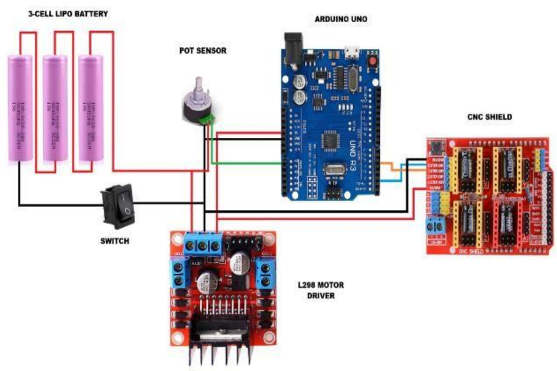

Fig: 4.8

5. RESULTS

5.1 The POT Sensor Board Leg Operation System was successfully implemented and tested using
the Arduino Uno, CNC Shield, L298 Motor Driver, POT sensor, and 12V battery. The results obtained demonstrate the system's effectiveness in controlling the movement of a motorized leg support based on real-time user input.

- **Real-Time Control:** The POT sensor effectively translates user input into motor movement, allowing smooth and precise leg motion.
- **Accurate Motor Response:** The L298 motor driver, controlled by the Arduino Uno, ensures accurate speed and directional control.
- **Stable Power Supply:** The 12V LiPo battery provides sufficient and stable power for motorized movement.
- **Ease of Use:** The **POT sensor provides an intuitive way to control movement**, requiring minimal effort.
- **Comfort & Smooth Operation:** The motorized movement is **smooth and responsive**, enhancing user comfort.
- **Increased Independence:** The system allows **users to control their own movement**, reducing dependency on caregivers.

5.2 Advantages:

- **Reduces Dependency on Caregivers:** Users can control their own movements, improving their confidence and independence.
- **Improves Quality of Life:** Provides a convenient and smart alternative to traditional mobility aids.
- **Adjustable Speed & Sensitivity:** The POT sensor can be calibrated to different user preferences.
- **Expandable Features:** Additional components, such as AI-based motion prediction or enhanced safety sensors, can be integrated.
- **Low Power Consumption:** The Arduino-based system ensures efficient power usage, increasing battery life.
- **Intuitive Control:** The POT sensor allows easy movement control with minimal effort, making it suitable for users with limited mobility.
- **Instant Response:** The POT sensor provides real-time control, allowing users to adjust movement instantly.

6. CONCLUSION

The POT Sensor Board Leg Operation System for handicapped individuals using IoT technology has been successfully designed and implemented. This system provides an affordable, efficient, and user-friendly solution for mobility assistance. By integrating key components such as the Arduino Uno, L298 Motor Driver, CNC Shield, POT Sensor, and a 12V battery, the system ensures smooth, real-time control of leg movement with minimal effort from the user. The POT sensor-based control mechanism allows for precise and intuitive movement, making it highly accessible for handicapped individuals. The IoT integration further enhances functionality by enabling remote monitoring and control, ensuring better assistance from caregivers when needed. This system offers significant advantages over traditional mobility aids, including cost- effectiveness, portability, energy efficiency, and ease of customization. The use of a battery- powered motorized system ensures usability in various settings, improving user independence and quality of life. The POT Sensor Board Leg Operation System is a practical and innovative solution for individuals with mobility impairments. It bridges the gap between affordability and advanced assistive technology, providing a reliable and intelligent mobility aid that enhances independence, comfort, and quality of life.

Fig6.1: **Final hardware output**

6.1 Future Scope Of The Project:

The POT Sensor Board Leg Operation System for handicapped individuals using IoT technology has a broad scope in the field of assistive technology and mobility enhancement. The project focuses on developing an intelligent, user- friendly, and cost-effective solution that allows individuals with mobility impairments to control leg movement with ease.

1. Assistive Technology for Handicapped Individuals.
2. Integration of IoT for Remote Monitoring and Control.
3. Ensures smooth and precise motor operation through an L298 motor driver and CNC shield.
4. Utilizes an Arduino Uno for efficient processing and motor control.
5. Possible expansion to voice-controlled or brainwave-based mobility assistance

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