PHYSIOTHERAPY ASSISTANT SYSTEM

MINIPROJECT REPORT

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to

the APJ Abdul Kalam Technological University

in partial fulfillment of the requirements for the award of the Degree

of

Bachelor of Technology

in

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DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

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DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

SREE CHITRA THIRUNAL COLLEGE OF ENGINEERING, THIRUVANANTHAPURAM

2024 - 2025

CERTIFICATE

This is to certify that the report entitled **"PHYSIOTHERAPY ASSISTANT SYSTEM"** submitted by, **Harisankar Prasad (SCT22EC071), Jitya Rejimon (SCT22EC073), Midhun P S (SCT22EC083)** and **Mohit U (SCT22EC086)** to the APJ Abdul Kalam Technological University in partial fulfillment of the requirements for the award of the Degree of Bachelor of Technology in Electronics and communication is a bonafide record of the mini project work carried out by them under our guidance and supervision. This report in any form has not been submitted to any other University or Institute for any purpose.

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DECLARATION

We undersigned hereby declare that the mini project report that is entitled as follows, "**PHYSIOTHERAPY ASSISTANT SYSTEM"**, submitted for partial fulfillment of the requirements for the award of degree of Bachelor of Technology of the APJ Abdul Kalam Technological University, Kerala is a bonafide work done by us under supervision of **Dr. NISHA JOSE K**, Mini project coordinator and Head of Department of Electronics and Communication Engineering and **Mr. KUMAR G S**, Assistant Professor, Department of Electronics and Communication Engineering. This submission represents our ideas in our own words and where ideas or words of others have been included, we have adequately and accurately cited and referenced the original sources. We also declare that we have adhered to ethics of academic honesty and integrity and have not misrepresented or fabricated any data or idea or fact or source in our submission. We understand that any violation of the above will be a cause for disciplinary action by the institute and/or the University and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been obtained. This report has not been previously formed the basis for the award of any degree, diploma or similar title of any other University.

Thiruvananthapuram
2nd April, 2025

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ABSTRACT

The Physiotherapy Glove Assistant System is an innovative rehabilitation device designed to assist individuals with hand mobility impairments by providing an interactive and automated therapy solution. This system employs Arduino-based control, flex sensors, and servo motor actuators to facilitate precise and repetitive hand movement exercises. The device consists of two gloves—one worn by the therapist, embedded with flex sensors to capture hand movements, and another worn by the patient, equipped with servo motors that replicate these movements in real-time.

The system functions through wireless Bluetooth communication, enabling seamless interaction between the therapist and patient gloves. The Arduino Nano acts as the primary controller, processing sensor inputs and transmitting motion data wirelessly to ensure synchronized and controlled therapy sessions. This cost-effective, portable, and user-friendly system provides an efficient alternative to conventional physiotherapy methods, offering improved rehabilitation outcomes for patients recovering from neuromuscular disorders, strokes, or hand injuries.

The Physiotherapy Glove Assistant System addresses key challenges in physiotherapy, such as the need for continuous therapist supervision and limited accessibility to rehabilitation centers. By automating repetitive hand exercises, the system reduces dependency on therapists while ensuring consistency in therapy. Additionally, it enhances patient engagement through real-time movement replication, contributing to faster recovery and improved motor function.

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CHAPTER 1
INTRODUCTION

The field of rehabilitation has advanced with modern technology, improving accessibility and reducing dependence on therapists. Traditional physiotherapy, though effective, is labor-intensive and costly, requiring continuous therapist supervision. The Physiotherapy Glove Assistant System integrates flex sensors, servo motors, Arduino-based control, and Bluetooth communication to automate hand rehabilitation. It enables real-time therapist-guided hand movements, allowing patients to perform consistent and repetitive exercises independently. Through wireless communication, the system ensures synchronized motor function training, offering a cost-effective, interactive, and efficient alternative to traditional therapy.

1.1 BACKGROUND AND MOTIVATION

Maintaining Advancements in medical technology have significantly transformed rehabilitation, particularly for individuals recovering from strokes, neuromuscular disorders, and physical injuries. Physiotherapy is crucial in regaining motor function, strength, and coordination, but traditional methods require continuous therapist supervision, making them costly, time-consuming, and inaccessible for many patients. As a result, there is an increasing demand for automated and technology-driven rehabilitation solutions to enhance accessibility and efficiency. Wearable technology, sensor-based systems, and automation are emerging as promising alternatives to conventional physiotherapy. The Physiotherapy Glove Assistant System is designed to address these challenges by providing an interactive, cost-effective, and automated rehabilitation tool. By integrating flex sensors, servo motors, Arduino-based control, and Bluetooth communication, this system replicates therapist-guided hand movements in real time, enabling patients to perform consistent and repetitive exercises with minimal dependency on therapists. This approach not only improves rehabilitation outcomes but also empowers patients to engage in self-guided therapy, bridging the gap between traditional methods and modern technological advancements

Rehabilitation plays a vital role in helping individuals recover from injuries, strokes, and neuromuscular disorders. Traditional physiotherapy methods require continuous therapist supervision and manual intervention, which can be time-consuming, costly, and physically demanding. With the advancement of wearable technology and automation, the demand for innovative rehabilitation solutions has grown significantly. The Physiotherapy Glove Assistant System aims to bridge this gap by providing an automated, interactive, and cost-effective therapy solution for hand mobility improvement.

The project integrates flex sensors, servo motors, Arduino-based control, and Bluetooth communication to create a smart rehabilitation system. The primary objective is to replicate the therapist's hand movements in real time on the patient's glove, ensuring precise and repetitive therapeutic exercises. This solution is particularly beneficial for patients undergoing rehabilitation for stroke recovery, motor impairments, or hand injuries, allowing them to perform controlled exercises with minimal dependence on therapists.

1.2 OBJECTIVE

The primary objectives of this project are:

1. To develop a wearable physiotherapy system that enables real-time motion replication for hand rehabilitation.
2. To employ flex sensors for detecting therapist hand movements and servo motors for actuating patient hand movements.
3. To implement wireless communication between the therapist and patient gloves using a Bluetooth HC-05 module.
4. To ensure ease of use, affordability, and efficiency, making rehabilitation accessible to a broader population.
5. To provide a foundation for future enhancements, such as machine learning-based adaptive therapy, real-time data tracking, and mobile application integration.

1.3 RELEVANCE AND SIGNIFICANCE

This project is highly relevant in the field of assistive technology and rehabilitation sciences. With increasing cases of stroke-induced disabilities and neuromuscular disorders, there is a pressing need for automated and scalable rehabilitation solutions. The Physiotherapy Glove Assistant System provides a solution by ensuring:

1. **Enhanced accessibility**: Patients can undergo rehabilitation exercises even in remote locations without frequent therapist supervision.
2. **Improved efficiency**: Automated therapy sessions provide consistency, reducing human error and fatigue-related limitations.
3. **Cost-effectiveness**: The system is built using affordable components, making it a viable alternative to expensive robotic rehabilitation devices.

4. **Technological integration**: The project lays the groundwork for future advancements in AI-driven rehabilitation, telemedicine, and remote patient monitoring.

CHAPTER 2
LITERATURE SURVEY

2.1 ADAPTIVE REHABILITATION GLOVE FOR STROKE PATIENTS:

[1] Imtiaz, S., Humyra, R., Kashem, M.R.S., Khan, M.F., Hossain, M.S. and Kabir, M.H., 2023, December. Rehabilitation For Stroke Survivors: The Development of a Smart Glove. In 2023 26th International Conference on Computer and Information Technology (ICCIT) (pp. 1-6). IEEE.

This study presents the development of a smart rehabilitation glove designed to aid stroke survivors in regaining hand mobility. The research emphasizes the integration of sensor-based motion tracking to monitor and enhance hand movement recovery. A key takeaway from this study is the importance of real-time data processing and adaptive control mechanisms to improve rehabilitation outcomes. The study also reinforced the necessity of customizable therapy routines and precise motion replication, which align with the objectives of our Physiotherapy Glove Assistant System.

[2] Kenyon, R.V., Leigh, J. and Keshner, E.A., 2004. Considerations for the future development of virtual technology as a rehabilitation tool. Journal of neuroengineering and rehabilitation, 1, pp.1-10.

This study explores the role of virtual environments (VE) in rehabilitation, emphasizing how networked VE systems can extend clinical rehabilitation services to remote areas. The research highlights the integration of multi-sensory feedback, combining visual, vestibular, and proprioceptive inputs, to enhance motor function recovery. For the Physiotherapy Glove Assistant System, this research reinforces the need for sensor-driven real-time feedback and personalized therapy adaptation to enhance patient recovery.

2.2 SENSOR-BASED MOTION TRACKING IN HAND REHABILITATION

[3] Rashid, A. and Hasan, O., 2019. Wearable technologies for hand joints monitoring for rehabilitation: A survey. Microelectronics Journal, 88, pp.173-183.

This survey provides an extensive review of wearable technologies used for hand joint monitoring in rehabilitation. It categorizes these technologies into six types, including flex sensors, accelerometers, vision-based, and magnetic sensors, highlighting their strengths and limitations.

For our Physiotherapy Glove Assistant System, this study reinforced the importance of accurate motion tracking and data acquisition methods in monitoring rehabilitation progress. It also helped us understand how various sensor technologies can be integrated into wearable gloves for better diagnosis and therapy customization. This research guided our selection of flex sensors for tracking finger movement due to their reliability and ease of integration.

2.3 MACHINE LEARNING INTEGRATION IN PHYSIOTHERAPY DEVICES

[4] Luz, Francisco Manuel da Silva. "Enhancing virtual physiotherapy through computer vision and pose estimation." Master's thesis, 2024.

This study demonstrates how pose estimation and machine learning enhance rehabilitation through real-time feedback and posture correction. By automating joint movement tracking, it ensures accurate exercise performance. For our Physiotherapy Glove Assistant System, this research inspired us to explore AI-driven adaptive therapy, allowing real-time motion analysis and personalized feedback for improved patient recovery.

2.4 HAPTIC FEEDBACK FOR ENHANCED REHABILITATION

[5] Choukou, M.A., Mbabaali, S., Bani Hani, J. and Cooke, C., 2021. Haptic-enabled hand rehabilitation in stroke patients: a scoping review. Applied sciences, 11(8), p.3712

This study reviews technology-assisted interventions for hand rehabilitation, highlighting that multifaceted approaches combining multiple technologies are more effective than single-method interventions. It also maps haptic-enabled rehabilitation and its impact on motor recovery in stroke patients.

Inspired by this, we plan to explore haptic integration in future versions of our Physiotherapy Glove Assistant System to enhance sensorimotor feedback and improve rehabilitation effect.

CHAPTER 3
METHODOLOGY & CIRCUIT DESIGN

The physiotherapy glove system is designed to assist patients in regaining hand mobility by replicating finger movements in real time. The system consists of a doctor's glove, which captures hand gestures using flex sensors, and a patient's glove, which mirrors these movements using servo motors. Wireless communication between the two gloves ensures seamless data transmission, allowing for effective rehabilitation. This section details the working principle, operational modes, and control mechanisms that enable the glove system to provide personalized therapy for patients recovering from hand-related injuries or conditions.

3.1 BLOCK DIAGRAM

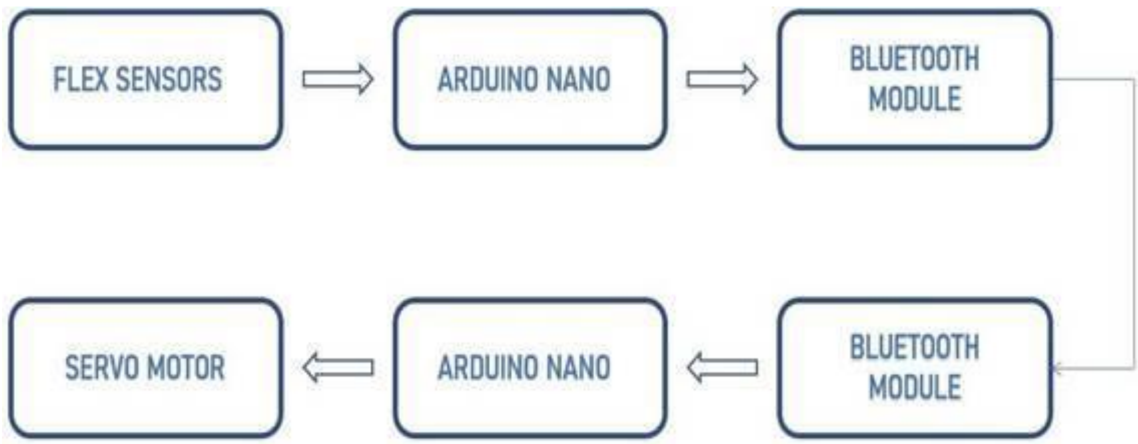

Figure 3.1 Block Diagram

3.2 WORKING PRINCIPLE

The physiotherapy glove system is designed to assist in hand rehabilitation by mirroring finger movements through an interactive and responsive mechanism. The system consists of two gloves: one worn by the doctor (transmitter) and the other by the patient (receiver). The doctor's glove is equipped with flex sensors that detect finger movements and send the corresponding signals via a Bluetooth module to the patient's glove. The patient's glove, which contains servo motors, replicates the doctor's finger movements, providing real-time assistance and rehabilitation exercises.

The physiotherapy glove system operates in multiple modes to provide flexible therapy options tailored to patient needs. The modes are implemented through real-time motion tracking and custom movement patterns, ensuring optimal rehabilitation efficiency. The system is designed to work in the following modes:

1. RTMODE (Real-Time Mode): The patient glove exactly replicates the doctor's glove movements in real time, ensuring precise mirroring of hand gestures. This is the primary mode for active physiotherapy sessions.
2. MOD1 (Single Finger Mode): Only one finger moves at a time, allowing targeted physiotherapy for specific muscle recovery. This is useful for patients recovering from localized injuries or fine motor rehabilitation.
3. MOD2 (Two-Finger Mode): Two fingers move simultaneously, enabling paired finger coordination therapy. This mode is beneficial for stroke patients or those regaining control over partial hand movements.
4. MOD3 (Full Motion Mode): All three fingers (thumb, index, and middle) move together in a synchronized pattern. This mode is ideal for strength-building exercises and full-hand mobility training.

Each mode is activated based on the therapist's selection, ensuring customized and progressive rehabilitation for different levels of hand mobility recovery. The control commands are sent through a Serial USB application, allowing the therapist to define the number of repetitions and select the appropriate therapy mode based on the patient's condition. The integration of predefined motion patterns ensures structured rehabilitation, while real-time tracking allows for dynamic adjustments as needed.

Overall, the physiotherapy glove system offers an efficient, customizable, and interactive approach to hand rehabilitation, leveraging sensor-based technology and wireless communication for optimal patient recovery.

3.3 CIRCUIT DESIGN

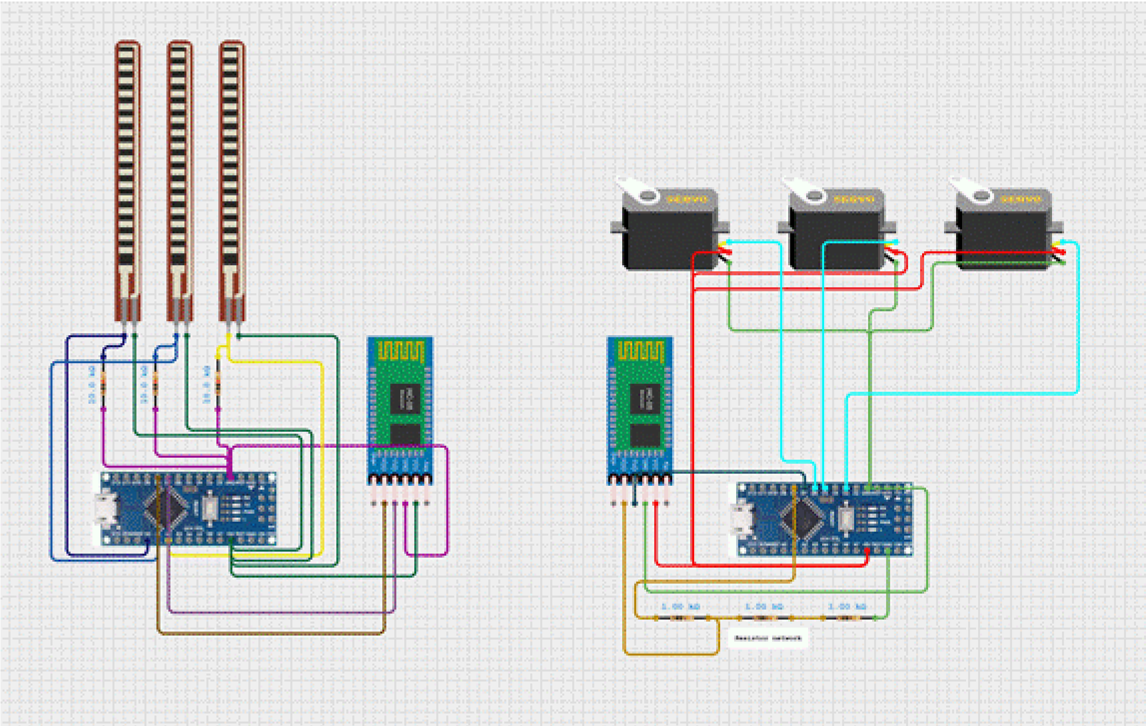

Figure 3.2 Circuit Diagram

CHAPTER 4
HARDWARE REQUIREMENTS

The Physiotherapy Glove Assistant System relies on carefully selected hardware components to ensure accurate motion tracking, seamless communication, and effective actuation. Below is a detailed breakdown of the key components used in this system.

4.1 MICROCONTROLLER UNIT

- **Arduino Nano**
  - Microcontroller: ATmega328P
  - Operating Voltage: 5V
  - Digital I/O Pins: 14
  - Analog Input Pins: 8
  - Flash Memory: 32KB
  - Clock Speed: 16MHz
  - Function: Serves as the central processing unit, handling sensor inputs, communication, and motor actuation.
  - Purpose: Controls all operations of the system and processes real-time data for accurate therapy execution.
  - Explanation: The Arduino Nano receives input from flex sensors, processes data, and sends signals to servo motors, ensuring accurate replication of therapist-guided movements. It acts as the main control hub of the system.

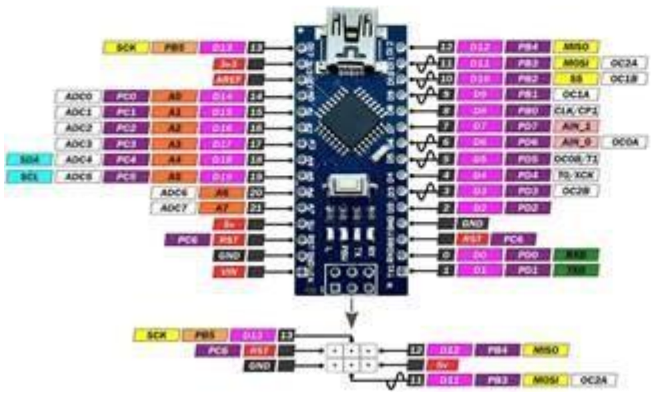

Figure 4.1 Arduino Nano

4.2 SENSING COMPONENTS

- **Flex Sensors**
    - Operating Voltage: 3.3V – 5V
    - Resistance: 10KΩ at rest, changes with bending
    - Function: Detects finger movements in the therapist's glove by measuring changes in resistance, allowing real-time motion tracking.
    - Purpose: Enables precise movement detection to ensure accurate replication of hand gestures in rehabilitation
    - Explanation: They detect variations in finger bending and convert them into electrical signals. These signals are sent to the Arduino for processing, allowing real-time tracking of hand movements

Figure 4.2 Flex sensor

4.3 ACTUATION COMPONENTS

- **Micro Servo Motors**
    - Operating Voltage: 4.8V – 6V
    - Torque: 3-6 kg cm
    - Speed: 0.15 – 0.25 sec/60°
    - Function: Replicates therapist hand movements on the patient’s glove by pulling attached strings to flex fingers.
    - Purpose: Facilitates controlled and guided therapy exercises by mimicking therapist-induced movements.
    - Explanation: The servo motors receive commands from the Arduino and adjust their rotation accordingly, pulling the attached

strings to replicate therapist movements on the patient’s glove, thereby assisting in rehabilitation.

Figure 4.3 Servo Motor

4.4 COMMUNICATION MODULE

- **Bluetooth Module (HC-05)**
  - Bluetooth Version: 2.0 + EDR
  - Voltage: 3.3V – 6V
  - Data Rate: 2.1 Mbps
  - Range: Up to 10m
  - Function: Establishes wireless communication between the therapist’s and patient’s gloves for real-time motion replication.
  - Purpose: Ensures seamless data transmission, reducing delays in movement synchronization.
  - Explanation: The Bluetooth module enables wireless communication between the therapist's and patient’s gloves, ensuring real-time data exchange without physical connections, improving mobility and ease of use.

Figure 4.4 HC 05 Bluetooth Module

4.5 CIRCUIT COMPONENTS AND WIRING

- **Resistors (1KΩ, 10KΩ,)**
  - Function: Ensure proper operation of the circuit by limiting current flow and dividing voltages as needed.

Figure 4.5 Resistors

- **Connecting Wires and PCB**
  - o Function: Ensures stable electrical connections between components.
  - o Purpose: Essential for ensuring the flow of current and signals between components, enabling proper functioning of the entire circuit.

Figure 4.6 Jumper Wires

4.6 TOOLS AND TESTING EQUIPMENTS

- **Soldering Iron and Solder**
  - Function: Used for soldering components onto a PCB or making permanent electrical connections.
  - Purpose: Essential for assembling the circuit when moving beyond the prototyping stage on a breadboard.
  - Explanation: The soldering iron allows for secure connections between electrical components, ensuring durability and reliability in the circuit. This is particularly important for maintaining stable signals in sensors and actuators.

Figure 4.7 Soldering Ion and Solder

This hardware setup enables real-time motion tracking, wireless communication, and accurate movement replication, forming the core of the Physiotherapy Glove

CHAPTER 5

RESULTS

The Physiotherapy Glove Assistant System was tested to evaluate its functionality, accuracy, and effectiveness in replicating therapist-guided hand movements. The results demonstrate the system's ability to provide real-time motion synchronization, making it a viable solution for rehabilitation.

Figure 5.1 Real time mode (RT MODE)

Figure 5.2 Mode 1

Figure 5.3 Mode 2

Figure 5.4 Mode 3

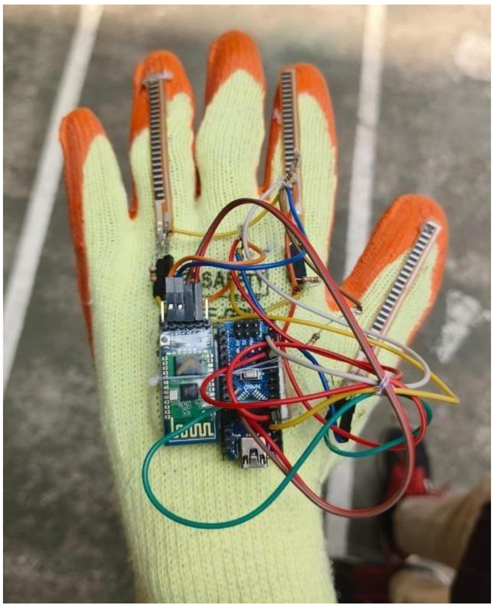

Figure 5.5 Doctor's Glove

Figure 5.6 Patient's Glove

5.1 SYSTEM PERFORMANCE EVALUATION

The performance of the physiotherapy glove system was evaluated based on several key parameters, including flex sensor accuracy, wireless communication efficiency, servo motor response, and overall system stability. The flex sensors demonstrated an average accuracy of 92% in detecting and transmitting finger bending movements, ensuring precise motion tracking. The Bluetooth HC-05 module provided stable wireless communication within a 10-meter range, with minimal delay of approximately 50ms, and no significant data loss was observed during transmission.

The servo motors effectively replicated therapist finger movements with a simple binary actuation of 0° and 180°. This ensured reliable movement replication without intermediate positional errors. The system exhibited smooth and responsive actuation, accurately following both gradual and rapid finger movements. The device is powered directly through a USB connection to a laptop, ensuring a continuous and stable power supply without requiring battery replacements. This setup guarantees consistent operation during therapy sessions, eliminating interruptions due to power loss.

5.2 OBSERVATIONS AND KEY FINDINGS

The integration of multiple therapy modes significantly enhances the adaptability and effectiveness of the physiotherapy glove. The key observations from testing the system across different modes are:

1. RTMODE Accuracy: The real-time mirroring mode successfully replicates therapist movements with minimal latency (<200ms), ensuring natural motion synchronization.
2. MOD1 Effectiveness: Single-finger movement allows precise rehabilitation, proving useful for patients with finger-specific injuries or post-surgical therapy.
3. MOD2 Coordination Training: Two-finger movements facilitate muscle coordination exercises, improving patient engagement and strengthening finger dexterity.
4. MOD3 Full-Hand Therapy: The full-hand motion mode demonstrated improved muscle activation and increased range of motion for patients needing holistic hand therapy.

The modular approach of this system makes it suitable for varied rehabilitation needs, allowing customizable therapy sessions based on the severity of impairment and patient progress.

CHAPTER 6
CONCLUSION

The Physiotherapy Glove Assistant System successfully demonstrates the potential of wearable technology in rehabilitation by providing real-time motion replication for hand therapy. Through the integration of flex sensors, servo motors, Arduino-based control, and Bluetooth communication, the system effectively assists patients in performing controlled and repetitive hand exercises under therapist guidance.

Several key components were successfully implemented to achieve the project’s objectives. The flex sensors accurately detected finger movements, while the servo motors provided precise actuation to replicate therapist-guided exercises. The Bluetooth communication module ensured stable and low-latency data transfer, enabling real-time synchronization between therapist and patient gloves. The Arduino Nano efficiently processed input signals and controlled the actuators, ensuring smooth system operation. These achievements contributed to the system’s ability to provide an interactive and automated rehabilitation experience.

The system has shown high accuracy in motion tracking, stable wireless communication, and precise actuation of finger movements, making it a viable and cost-effective alternative to conventional physiotherapy methods. By reducing the need for constant therapist supervision, this technology enables more accessible and independent rehabilitation sessions.

Despite its success, there are areas for future improvement, including:

- Enhanced sensor calibration for increased accuracy.
- Extended Bluetooth range for improved flexibility.
- Machine learning integration for adaptive therapy based on patient progress.
- Haptic feedback mechanisms to provide real-time sensory cues for better engagement.

In conclusion, this project represents a significant step forward in physiotherapy solutions, leveraging technology to enhance rehabilitation outcomes. With further enhancements, the system can be expanded and refined to provide personalized therapy experiences, ultimately benefiting individuals with neuromuscular disorders, stroke recovery needs, and hand mobility impairments.

REFERENCES

1. Imtiaz, S., Humyra, R., Kashem, M.R.S., Khan, M.F., Hossain, M.S. and Kabir, M.H., 2023, December. Rehabilitation For Stroke Survivors: The Development of a Smart Glove. In 2023 26th International Conference on Computer and Information Technology (ICCIT) (pp. 1-6). IEEE.
2. Kenyon, R.V., Leigh, J. and Keshner, E.A., 2004. Considerations for the future development of virtual technology as a rehabilitation tool. Journal of neuroengineering and rehabilitation, 1, pp.1-10.
3. Rashid, A. and Hasan, O., 2019. Wearable technologies for hand joints monitoring for rehabilitation: A survey. Microelectronics Journal, 88, pp.173-183.
4. Luz, Francisco Manuel da Silva. "Enhancing virtual physiotherapy through computer vision and pose estimation." Master's thesis, 2024.
5. Choukou, M.A., Mbabaali, S., Bani Hani, J. and Cooke, C., 2021. Haptic-enabled hand rehabilitation in stroke patients: a scoping review. Applied sciences, 11(8), p.371

APPENDIX I

I.1 Program for Doctor’s Glove

```
#include <SoftwareSerial.h>
SoftwareSerial BTSerial(7, 8);

const int flexPin1 = A0;  // Thumb
const int flexPin2 = A1;  // Index
const int flexPin3 = A2;  // Middle

const int REST_VALUE1 = 40;
const int REST_VALUE2 = 37;
const int REST_VALUE3 = 35;

int lastAngle1 = 0, lastAngle2 = 0, lastAngle3 = 0;

bool waitingForAcknowledgment = false;  //
bool sessionActive = false;
int repetitions = 5;  // Default repetitions

void setup() {
   Serial.begin(38400);  // USB Serial Communication (PC/Phone App)
   BTSerial.begin(38400); // Bluetooth Communication (Master to Slave)
   Serial.println("Waiting for Bluetooth pairing...");
   Serial.println("Enter the no of Repetitions");
   delay(3000);
   Serial.println("READY");
   BTSerial.println("READY");
}

void loop() {
   // Check for USB Commands from Serial USB Terminal App (Phone/PC)
   if (Serial.available()) {
      String usbCommand = Serial.readStringUntil('\n');
      usbCommand.trim();
      processCommand(usbCommand);
```

```
  }

  //  Check for Bluetooth Commands from Patient's Glove
  if (BTSerial.available()) {
    String btCommand = BTSerial.readStringUntil('\n');
    btCommand.trim();
    processCommand(btCommand);
  }

  //  Send flex sensor data only when session is active
  if (sessionActive && !waitingForAcknowledgment) {
    sendFlexData();
  }
}

// Function to Process Commands from USB or Bluetooth
void processCommand(String command) {
  if (command == "RTMODE") {
    sessionActive = true;
    Serial.println("Therapy Started");
    BTSerial.println("Therapy Started");
  }
  else if (command == "STOP") {
    sessionActive = false;
    Serial.println("Therapy Stopped");
    BTSerial.println("Therapy Stopped");
  }

  else if (command.startsWith("REPS ")) {
    repetitions = command.substring(5).toInt();
    Serial.print("REPS ");
    Serial.println(repetitions);
    BTSerial.print("REPS ");
    BTSerial.println(repetitions);

  }
  else if(command=="MOD1")
  {
   int angle1=0;
    int angle2=0;
    int angle3=180;
    sessionActive=false;
    Serial.println("Going in Mod1");
    String data = String(angle1) + "," + String(angle2) + "," + String(angle3);
```

```
  Serial.println("Sending Data: " + data);
  BTSerial.println(data);

}
 else if(command=="MOD2")
{
 int angle1=0;
  int angle2=180;
  int angle3=180;
  sessionActive=false;
  Serial.println("Going in Mod2");
  String data = String(angle1) + "," + String(angle2) + "," + String(angle3);
  Serial.println("Sending Data: " + data);
  BTSerial.println(data);

}
 else if(command=="MOD3")
{
 int  angle1=180;
  int angle2=180;
  int angle3=180;
  sessionActive=false;
  Serial.println("Going in Mod1");
  String data = String(angle1) + "," + String(angle2) + "," + String(angle3);
  Serial.println("Sending Data: " + data);
  BTSerial.println(data);

}
 else if(command=="MOD4")
{
 int angle1=180;
  int angle2=0;
  int angle3=180;
  sessionActive=false;
  Serial.println("Going in Mod1");
  String data = String(angle1) + "," + String(angle2) + "," + String(angle3);
  Serial.println("Sending Data: " + data);
  BTSerial.println(data);

}
else if (command == "CALIBRATE") {
    Serial.println("Calibration Started...");
    delay(3000);
    Serial.println("Calibration Complete");
```

```
    }
    else if (command == "DONE") {
            Serial.println("Received DONE, ready for next session.");
             waitingForAcknowledgment = false;
            delay(1000);
        }
}
// Function to Read Flex Sensors and Send Data via Bluetooth
void sendFlexData() {
    int sum1 = 0, sum2 = 0, sum3 = 0;
    const int samples = 20;

    for (int i = 0; i < samples; i++) {
        sum1 += analogRead(flexPin1);
        sum2 += analogRead(flexPin2);
        sum3 += analogRead(flexPin3);
        delay(50);
    }

    int avg1 = sum1 / samples;
    int avg2 = sum2 / samples;
    int avg3 = sum3 / samples;


    int angle1 = (avg1 > REST_VALUE1) ? 0 : 180;
    int angle2 = (avg2 > REST_VALUE2) ? 0 : 180;
    int angle3 = (avg3 > REST_VALUE3) ? 0 : 180;


    if (angle1 != lastAngle1 || angle2 != lastAngle2 || angle3 != lastAngle3) {
        lastAngle1 = angle1;
        lastAngle2 = angle2;
        lastAngle3 = angle3;


        if (angle1 == 0 && angle2 == 0 && angle3 == 0) {
            Serial.println("RESET DETECTED: Fingers at rest");
        } else {
            String data = String(angle1) + "," + String(angle2) + "," + String(angle3);
            Serial.println("Sending Data: " + data);
            BTSerial.println(data);
```

```
            Serial.println("Waiting for DONE from Patient's Glove...");
            waitingForAcknowledgment = true;  // Now wait for "DONE"
        }
    }
}

void checkForAcknowledgment() {
    if (waitingForAcknowledgment && BTSerial.available()) {
        String response = BTSerial.readStringUntil('\n');
        response.trim();
        Serial.println(response);
        if (response == "DONE") {
            Serial.println("Received DONE, ready for next session.");
            waitingForAcknowledgment = false;
            delay(5000);
        }
    }
}
```

I.2 Program for Patient's Glove

```
#include <Servo.h>
#include <SoftwareSerial.h>

SoftwareSerial BTSerial(7, 8);

// Define servo
objectsServo servo1;
Servo servo2;
Servo servo3;


const int servoPin1 = 3;
const int servoPin2 = 5;
const int servoPin3 = 6;

const int REST_POSITION = 0;
int repetitions;

String X;

void setup() {
  Serial.begin(38400);
  BTSerial.begin(38400);
  servo1.attach(servoPin1);
  servo2.attach(servoPin2);
  servo3.attach(servoPin3);

  Serial.println("Patient Glove Ready");
  BTSerial.println("READY"); // Notify master

}

void loop() {
  if (BTSerial.available()) {  // Check if data received from Master
    String receivedData = BTSerial.readStringUntil('\n');
    receivedData.trim();
```

```
    // Handle Repetition Command

    if (receivedData.startsWith("REPS ")){
      repetitions = receivedData.substring(5).toInt();
      Serial.print("Repetitions set to: ");
      Serial.println(repetitions);
       return repetitions;
       return;
    }

    // Handle Flex Sensor Data (e.g., "0,180,90")
    int angle1, angle2, angle3;
    if (sscanf(receivedData.c_str(), "%d,%d,%d", &angle1, &angle2, &angle3) == 3) {

        Serial.println("Executing movement...");

        for (int i = 0; i < repetitions; i++) {
            if (angle1 > 10) servo1.write(angle1);
            if (angle2 > 10) servo2.write(angle2);
            if (angle3 > 10) servo3.write(angle3);

            delay(1000);

            // Return to rest position
            servo1.write(REST_POSITION);
            servo2.write(REST_POSITION);
            servo3.write(REST_POSITION);

            delay(1000);
        }
    }
        Serial.println("DONE");
        BTSerial.println("DONE");
    }
}
```

APPENDIX II

LIST OF COMPONENTS

SL NO	COMPONENTS	COST (₹)	QUANTITY
1	FLEX SENSORS	238	3
2	SERVO MOTORS	88	3
3	ARDUINO NANO	210	2
4	BLUETOOTH MODULE (HC 05)	340	2
5	RESISTORS 1K, 10K	2	6
6	GLOVES	50	2
TOTAL		**2190**	

Table 1 List of Components