Robotic Arm for Physiotherapy

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***Abstract*- Robotic systems are increasingly being adopted in healthcare to improve the quality and effectiveness of rehabilitation therapies. Physiotherapy for patients affected by paralysis or stroke often requires repetitive, precise, and supervised movements, which can be physically demanding for therapists and time-consuming for patients. This paper presents the design and methodology of a robotic arm for physiotherapy that assists patients in performing controlled upper-limb rehabilitation exercises. The proposed system integrates a microcontroller-based control unit, servo-driven joints, safety mechanisms, and a basic blood pressure monitoring system to ensure patient safety during therapy. The system aims to provide reliable, cost-effective, and adaptable rehabilitation support while reducing the workload of physiotherapists and improving patient recovery outcomes.**

***Index Terms*- Physiotherapy robot, Robotic arm, Rehabilitation system, Servo motor control**

I. INTRODUCTION

The integration of robotics in healthcare has significantly transformed patient care and rehabilitation practices. Robotic systems are now widely used in surgical assistance, rehabilitation therapy, and patient support applications due to their precision, repeatability, and reliability. In rehabilitation, especially for patients affected by paralysis or stroke, continuous and guided physiotherapy is essential for regaining motor functions. However, conventional therapy often depends heavily on the availability and physical effort of physiotherapists.

Rehabilitation robots offer targeted therapy by assisting patients in performing repetitive and controlled movements. These systems help maintain consistency in exercises, monitor patient performance, and ensure safety during therapy sessions. The proposed robotic arm for physiotherapy focuses on assisting upper-limb movements, providing controlled motion, and monitoring patient conditions to enhance recovery and improve quality of life.

II. OBJECTIVES OF THE WORK

The main objective of this project is to provide ease and effective rehabilitation support to patients affected by paralysis through a robotic physiotherapy system. The specific objectives include: - To design a robotic arm capable of performing controlled physiotherapy movements. - To reduce the physical workload of physiotherapists. - To ensure patient safety using emergency stop mechanisms and monitoring systems. To develop a cost-effective and user-friendly rehabilitation device.

III. LITERATURE REVIEW

Several studies have explored the application of robotic systems in rehabilitation. Recent research shows that robotic assistance can significantly increase muscle activation and improve rehabilitation outcomes. Virtual reality-based rehabilitation systems have also been shown to enhance patient engagement and recovery by improving mobility, strength, and coordination.

Previous works have proposed upper-limb robotic systems that synchronize human arm movements, manage biomechanical constraints, and operate without additional sensors. Brain–computer interface (BCI) based robotic arms have demonstrated high accuracy in performing three-dimensional tasks. Exoskeletonbased physiotherapy devices using EMG signals have enabled personalized assistance. Other studies emphasize task-oriented training and adaptive robotic control to improve arm-hand skills after stroke. These studies collectively highlight the effectiveness and growing importance of robotic rehabilitation systems.

IV. METHODOLOGY

A. Mechanical Design

The mechanical structure of the robotic arm is designed to be lightweight, compact, and adjustable for different patients. The system provides to-and-fro motion using servo-driven joints to ensure precise and smooth movement. A stable base is included to maintain patient comfort and safety during operation.

B. Electrical Design

The electrical system is controlled using an ATmega2560 microcontroller, which acts as the central control unit. The system operates on a 230 V AC supply that is stepped down to 12 V DC using a regulated power supply. Servo motors are controlled through PWM signals, and optocouplers are used for electrical isolation and noise reduction. An emergency stop mechanism and a basic blood pressure monitoring system are incorporated for patient safety.

V. HARDWARE IMPLEMENTATION

A. Microcontroller (ATmega2560)

The ATmega2560 microcontroller serves as the brain of the system. It processes sensor data, controls motor movements, and manages communication between different modules. Its large memory and multiple I/O pins allow integration of various sensors and actuators.

B. Optocoupler (PC817)

The PC817 optocoupler is used to isolate control signals between the microcontroller and motor drivers. It protects the system from voltage spikes, reduces electrical noise, and ensures safe operation.

C. Servo Motor and BPMS

Servo motors provide precise and controlled movements required for physiotherapy exercises. The Blood Pressure Measurement System (BPMS) monitors patient blood pressure in real time during rehabilitation to ensure safety and prevent overexertion.

D. Emergency Stop

An emergency stop switch allows the patient or therapist to immediately stop the device in case of discomfort or abnormal operation, ensuring user safety.

VI. CIRCUIT ANALYSIS

The system uses a regulated power supply with a bridge rectifier and capacitor filter to obtain ripple-free DC voltage. A Zener voltage regulator ensures a stable 12 V supply. The microcontroller controls servo motors, monitors sensors, and manages safety features to provide safe and controlled physiotherapy sessions.

VII. EXPECTED RESULTS

A. Expected Results in S7

- Understanding of robotic arm components and structure.
- Study of microcontroller programming and sensor integration.
- Enhanced knowledge of rehabilitation robotics.

B. Expected Results in S8

- Design and development of a functional robotic arm prototype.
- Performance evaluation of the rehabilitation system.
- Implementation of additional features for improved efficiency.

VIII. CONCLUSION

The proposed robotic arm for physiotherapy aims to provide a safe, efficient, and cost-effective solution for upper-limb rehabilitation. By integrating controlled motion, monitoring systems, and safety mechanisms, the system can assist patients in recovery while reducing the workload of physiotherapists. This project demonstrates the potential of robotics in improving rehabilitation outcomes and enhancing patient care.

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