DEVELOPMENT OF A WEARABLE PROGRESS TRACKING DEVICE IN FINGER REHABILITATION FOR STROKE PATIENTS WITH ANDROID APP

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Keywords:

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Introduction:

When a person suffers a stroke, one of the most common problems they face is losing the ability to move their fingers properly. Simple tasks like holding a glass, writing, or picking up objects become very difficult. To recover from this, patients need regular rehabilitation exercises but the problem is that most existing tools used to measure finger movement are manual, require a trained therapist to operate, and cannot track progress over time in a simple way.

This project was built to solve that problem. We developed a small wearable device that attaches to the finger and measures how much the finger is lifting (dorsal extension) in real time. The device uses an MPU6050 sensor and an ESP32 microcontroller to capture the angle and send it wirelessly to an Android app on the patient's phone and stored in cloud.

Figure 1: Wearable Device

Objectives:

1. **Accurate and Real-Time Monitoring:**
    - Develop a system to measure finger joint angles in real-time using IMU sensors, providing precise tracking of finger movements.
    - Overcome limitations of conventional tools like goniometers or vision-based systems which are less convenient or less accurate.
2. **Rehabilitation Support for Patients**:
    - Assist stroke survivors and arthritis patients in monitoring their finger mobility and progress during rehabilitation.
    - Enable physiotherapists and caregivers to track improvement objectively, even remotely.
3. **Integration with Mobile Application:**
    - Create a user-friendly mobile app that visualizes finger motion, records therapy sessions, and provides progress reports.
    - Allow patients to perform home-based exercises with guided feedback, promoting independence.
4. **Early Detection and Preventive Intervention:**
    - Identify abnormal finger joint patterns or stiffness early, helping to prevent further functional loss or deformities.
    - Facilitate timely intervention by healthcare professionals.
5. **Portable and Wearable System Design:**
    - Design a compact, low-cost, and wearable solution for continuous daily monitoring without affecting natural hand movements.
    - Ensure scalability for wider adoption in clinics, hospitals, and home care settings.

Methodology:

(1) Hardware Setup:

The MPU6050 sensor is placed on the finger at the MCP joint. It measures the angle at which the finger is lifted. The ESP32 microcontroller reads this data, removes noise using a filter, and sends the angle to the phone via Bluetooth.

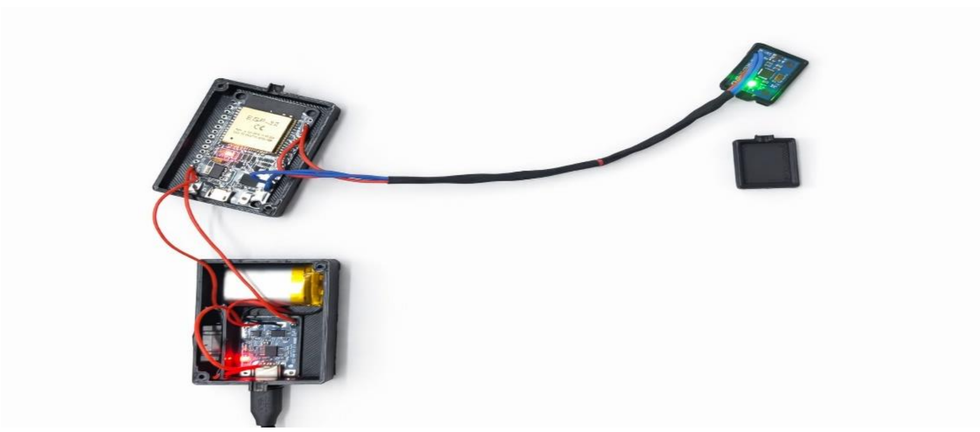

Figure 2: Hardware Setup

(2) Bluetooth Communication:

The ESP32 sends angle data wirelessly to the Android app using Bluetooth Low Energy (BLE). The app connects to the device, receives the angle values continuously, and displays them on screen.

(3) Android App:

The app was built using Flutter. When the patient opens the app, they sign in using their email or Google account. The first time they use the app, they fill in their details name, age, gender, and which finger is being measured. Before each measurement, the app asks which finger to measure and shows the saved finger as the default.

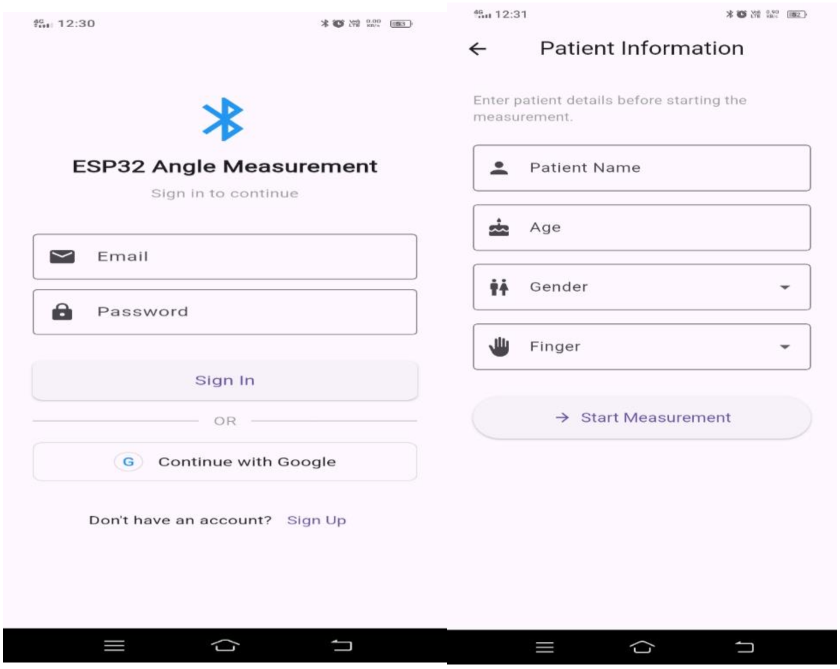

Figure 3: Sign In screen and Patient Form screen

Once the patient starts, the app shows the live angle, a real-time graph, a countdown timer, and an animated side-view of the hand with the selected finger lifting upward.

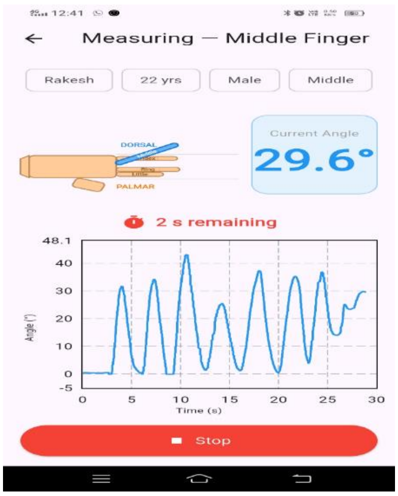

Figure 4: Measurement Screen

After 30 seconds, the session ends and the results — average, minimum, and maximum angles — are shown on screen.

Figure 5: Results Screen

(4) Cloud Storage and History:

All session results are saved to Firebase Firestore under the patient's account. The History screen shows bar charts of the patient's progress over 1 day, 1 week, 15 days, or 1 month, filtered by finger.

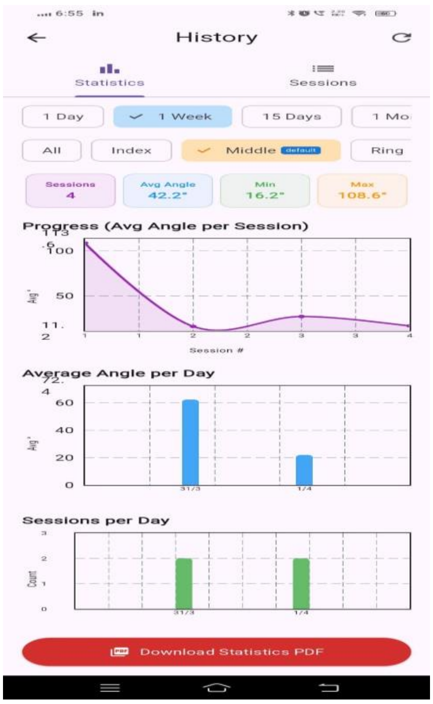

Figure 6: History Screen

The patient can also download a PDF report with all the details.

Result and Conclusion:

Result:

- The MPU6050 sensor successfully measured the dorsal flexion angle of the finger in real time and transmitted the data wirelessly to the Android app via Bluetooth using the ESP32 microcontroller.
- The Flutter-based Android app displayed the live angle on screen along with a real-time graph and an animated hand visualization showing the selected finger lifting toward the dorsal side during measurement.
- A 30-second guided measurement session was completed successfully, computing the average, minimum, and maximum angles at the end of each session and saving the results to Firebase Firestore under the patient's account.
- The History screen showed session-wise statistics with bar charts filtered by time period (1 day, 1 week, 15 days, 1 month) and by finger, allowing easy tracking of rehabilitation progress over time.
- A downloadable PDF report was generated containing patient details, angle measurements, and chart images, which can be shared with physiotherapists for clinical review.

Conclusion:

The project successfully developed a low-cost, portable wearable device combined with a cloud-connected Android application for real-time finger rehabilitation monitoring. The system accurately measured dorsal finger flexion angles using the MPU6050 IMU sensor and ESP32 microcontroller, overcoming the limitations of traditional goniometers. Patient data was securely stored in the cloud, and progress was tracked through visual graphs and downloadable reports. The system proved to be a practical and effective tool for stroke patients and their caregivers to monitor finger mobility improvement during rehabilitation, fulfilling all the objectives stated in the project proposal.

References:

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Future Scope:

The future scope of this project includes:

1. **Multi-Finger Measurement:** Multiple sensors can be added to measure all fingers at the same time, making the assessment faster and more complete in a single session.
2. **Better Sensor Accuracy**: The current MPU6050 sensor can be upgraded to a more advanced IMU with higher precision and lower drift, giving more accurate angle readings during rehabilitation.
3. **Machine Learning for Recovery Prediction**: The angle data collected over multiple sessions can be used to train a smart algorithm that predicts how fast a patient is recovering and suggests personalized exercise plans based on their progress.
4. **Remote Monitoring by Doctors:** A web dashboard can be built so that physiotherapists and doctors can view their patients' session data and progress charts from anywhere, without the patient needing to visit the clinic every time.
5. **Compact Wearable Design:** The current prototype uses a breadboard and loose wires. A small custom circuit board with a 3D-printed casing can be designed so the device is comfortable to wear on the finger during daily activities.