RESEARCH PAPER

# Physiological Activity Tracking for Stroke Patients with Data Logging

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**ABSTRACT**

Stroke victims, providers must continuously monitor their muscle activity and movement, along with the patient's physiological parameters, to produce both effective and safe recovery. The Project presented here is an IoT-based Stroke Patient Recovery Tracking System using Motion and Muscle Sensors, which incorporates two innovations: real-time monitoring framework and intelligent assessment of recovery. The system will be implemented through the use of an ESP32 Microcontroller equipped with multiple sensors: an EMG (Electromyography) Sensor, Pressure Sensor, Temperature Sensor and GSR (Galvanic Skin Response) Sensor. These Sensors will measure muscle contractions, body pressure, body temperature and the level of stress an individual experiences due to emotional states. The resulting data collected will be displayed on an LCD device and transmitted via Wi-Fi to the ThingSpeak Cloud Platform for viewing and analysis at a remote location. In addition to being able to monitor and view all data values remotely, an automatic buzzer alarm will activate whenever an abnormal data value or fatigue symptom is detected, allowing for an immediate response. JSON is the primary format for ThingSpeak, and it can be used with machine learning (ML) and artificial intelligence (AI) to evaluate the patient's recovery, recommend post-recovery goals, and detect abnormal muscle activity. AI-generated insights will give physicians and caregivers individualized recommendations to maximize the benefit of therapy sessions, based on patient data. The proposed solution will provide an affordable, intelligent, and continuous method of tracking stroke recovery that uses IoT and AI technologies to deliver better patient care, promote faster recovery, and prevent relapses.

**Keywords:** IoT, Stroke Rehabilitation, ESP32, Tracking EMG Sensor, Pressure Sensor, Temperature Sensor, GSR Sensor, ThingSpeak, Machine Learning, Artificial Intelligence, Remote Monitoring, Patient Recovery

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## I. Introduction

Stroke has caused long-term disability around the world and, in most cases, impacts the individual as well as limited mobility and impaired motor skills - both neurological and physical will be restored. Historically, the way recovery from stroke is tracked has been through periodic clinical evaluations performed by therapists and therapist observation; this method has been time-consuming, subjective, and more importantly, had the potential for clinicians or therapists to make mistakes. Due to recent advances in the Internet of Things (IoT), there is now the opportunity to develop smart and automated systems that can continuously monitor patient recovery in real time, providing objective and data-driven criteria for assessing rehabilitation effort. A combination of biomedical sensors and IoT Technology provides a robust platform for longitudinal monitoring of the physical and physiological well-being of stroke patients.

Using data about muscle activity, movement and vital signs of a patient gives the doctor a way to see the patient's recovery process closely and find any problems early on. This project is about an IoT-Based Stroke Patient Recovery Tracking System Using Motion and Muscle Sensors. The main goal of the project is to track the patient's muscle activity, amount of pressure applied to different body parts, temperature of the body as well as how much emotional stress they are having using various sensors connected by the internet to keep track of this information continuously.

The ESP32 microcontroller serves as the processor and communication component of the system. Muscle contractions and muscle activity are recorded using EMG sensors. Pressure is applied to limbs and the amount of force being applied to the body is recorded with pressure sensors. The change in body heat is monitored with temperature sensors. The level of stress or emotional response is recorded with GSR sensors. The real-time measurement of the four metrics is displayed on an LCD and sent to the cloud-based ThingSpeak for permanent storage and continuous analysis. This cloud-based storage allows healthcare professionals to monitor patient rehabilitation progress remotely, identify any abnormal patterns, and assure timely treatment of any identified abnormalities, including abnormal muscle fatigue, abnormal levels of stress, and/or excessive heat. There is also an audible alarm system installed to provide patients and/or providers with immediate feedback when physiological conditions reach potentially unsafe levels. This will enhance the reliability and safety of the system for the purpose of home rehabilitation.

The JSON format of the cloud storage data allows for efficient handling, retrieval, and analysis of data and provides the means to utilize algorithms (machine learning and artificial intelligence) to analyze the collected data to identify trends, classify muscle activity, and make predictions regarding muscle recovery. Because of numerous insights through artificial intelligence, the system will develop individualised feedback and provide suggestions for therapy, which means that doctors/physiotherapists could adjust the rehabilitation programme to fit individual patients' needs.

## II. Literature Survey

In recent years, stroke rehabilitation has seen significant improvements due to the adoption of Internet of Things (IoT), wearable devices, and machine learning techniques. These technologies have made it possible to continuously monitor patients, analyze their recovery progress, and provide personalized feedback.Yang *et al.* developed an IoT-based stroke rehabilitation system that uses a smart wearable armband equipped with surface electromyography (sEMG) sensors to capture muscle activity. The collected data is processed using machine learning algorithms to evaluate patient performance and provide real-time feedback. This system supports continuous monitoring and helps improve patient participation, which can lead to faster recovery [1].

Dhiman introduced a smart glove designed for stroke rehabilitation, which focuses on restoring hand movement. The glove contains sensors that track finger and hand motions and transmit the data for analysis. This allows healthcare professionals to monitor patients remotely and adjust therapy as needed, making rehabilitation more accessible and efficient [2].Electromyography (EMG) has become an important tool in rehabilitation. Al-Ayyad presented a detailed review of EMG-based systems, discussing their use in clinical settings, wearable devices, and signal collection methods. The study highlights that EMG systems are effective in measuring muscle activity, though issues such as signal noise and accuracy still need improvement [3], [17].A systematic review by Boukhennoufa *et al.* examined the role of wearable sensors combined with machine learning in post-stroke rehabilitation. The study shows that machine learning models can analyze movement data to assess recovery and improve therapy planning, leading to better rehabilitation outcomes [4].IoT-based monitoring systems have also been applied in patient rehabilitation. Gupta proposed a model that tracks patient movement during recovery from surgery, enabling continuous observation and better clinical decisions [5]. Similarly, Eskandar developed an IoT-based rehabilitation monitoring system that enhances patient supervision and remote healthcare services [15].Zhi *et al.* designed a wearable IoT system that uses EMG signals to assess hand function in stroke patients. The data collected from the sensors is sent to a cloud platform, where it can be accessed by healthcare professionals for evaluation and treatment planning. This system demonstrates the effectiveness of remote rehabilitation monitoring [6].Wearable devices with multiple sensors have also been explored. Spinelli developed a system that uses biomedical sensors to monitor different physiological parameters during rehabilitation [7]. Zhang further emphasized the importance of combining multiple sensing technologies to obtain more accurate and detailed information about patient recovery [16].

Cloud platforms play a key role in remote healthcare systems. Nnamdi proposed a system that uses IoT devices along with the ThingSpeak platform to monitor vital signs such as temperature and pulse rate in real time. This improves accessibility and allows timely medical intervention when needed [8], [18].Machine learning techniques have been widely used for evaluating rehabilitation exercises. Wang *et al.* introduced a system that uses wearable sensors and a lightweight 1D-CNN model to automatically assess patient exercises. The system provides real-time and objective feedback, which helps in improving therapy effectiveness, especially in home-based rehabilitation [9], [14], [19].Advanced artificial intelligence methods are also being applied. Lim *et al.* proposed a system based on ST-GCN attention mechanisms for analyzing patient movements in a home environment, enabling accurate remote assessment [11].Recent developments in sensor technology have improved wearable systems. Yang introduced a flexible and wireless sEMG sensor array that enhances comfort while maintaining accurate signal detection [12]. Maceira-Elvira reviewed the role of wearable technology in improving the diagnosis and treatment of upper-limb impairments in stroke patients [13].In addition to monitoring systems, biofeedback techniques have been explored to improve patient engagement. Kantan *et al.* proposed a framework that uses musical feedback to guide patients during rehabilitation exercises, making therapy more interactive and motivating [10], [20]. In [21][22][23] author describes fault classification, knee arthritis are discussed.

### A. Novelty and technical contribution:

This new system has a different way of looking at how we help people recover from their stroke by putting together different types of measuring devices like EMGs, pressures, temperatures, etc., on one device that is able to track the patient's physical condition as well as their emotional stateby measuring the amount of sweat on their hands with a GSR. The real-time collection of data via the internet will allow doctors and physical therapists to closely monitor the patient's physical and mental well-being from anywhere. As part of the project goals, artificial intelligence and machine learning technologies will be utilized to evaluate injury and recovery patterns to generate tailored recommendations for each individual patient. This provides the system with a much greater level of sophistication and flexibility compared to other comparable systems in existence.This work describes developing an application that is an IoT (internet of things) based embedded system to collect and communicate various types of data efficiently. This is accomplished by using the ESP32 microcontroller as the foundation of the embedded system and attaching many different biomedical sensors to the microcontroller to measure and record real-time data that has been retrieved from the sensors (ie. measuring muscle activity, body pressure, body temperature, and stress levels). Data was displayed locally on an LCD screen and sent to and stored in the ThingSpeak cloud platform for remote monitoring via Wi-fi (Wi Fi). An additional buzzer was used to provide an alert in case any of the data collected from the sensors were outside of normal ranges to ensure the safety of patients.In addition, this system allows you to log data and to perform advanced analytics. Sensor data can be exported as JSON (javascript object notation) files for use with machine-learning applications. AI-based methods can identify anomalies, document recovery, and assist in making better decisions by personalizing your rehabilitation experience. The entire system is designed with the intent to be affordable, portable and scalable, so it can be implemented into real-time health care application and provide monitoring of recovery from home for stroke patients.

## III. Methods and Materials

### 1. Existing method:

The traditional rehabilitation approach to stroke recovery involves the regular use of manual monitoring techniques, namely the patient's attendance to physiotherapy sessions, as well as periodic evaluation by the physiotherapist in the clinic. The physiotherapist assesses the level of muscle activity, movement and the overall level of recovery that a patient has had based on observation and patient feedback. Because of this reliance upon the experienced judgement of the physiotherapist, there is potential for subjective or inconsistent measurement of progress. In addition, there are many times that a physiotherapist will not be able to continuously monitor a patient's rates of recovery or potentially identify any complications as they occur. The lack of measurement accuracy will also make it difficult for clinicians and patients alike to identify small gains within the recovery period over time.

The lack of continuous medical monitoring makes rehabilitation at home significantly more difficult for patients. Patients can encounter difficulties with muscle fatigue, poorly executed motions, and excessive amounts of stress, and these problems may go unnoticed for a long enough period that it hampers their recovery or makes additional complications

worse. Patients usually need regular visits to the hospital in order to receive accurate evaluations, but this is both a lengthy and expensive process for the patient and the caregiver.

Many current monitoring systems utilize sensors to gather information about various parameters; however, these systems are typically quite limiting and self-contained, lacking adequate internet connectivity and/or cloud integration to share collected data with medical professionals for evaluation as well as to allow real-time monitoring or longitudinal analysis of patient progress. The absence of records & remote access to gathered data significantly contributes to the ineffectiveness of these systems as effective tools for ongoing monitoring of patients.

Additionally, the majority of current systems do not have sophisticated technologies, such as AI and/or ML, which makes it hard to evaluate vast quantities of data to forecast recovery patterns or give individualized rehab recommendations. The lack of automatic alerts raises the chance of missing significant medical problems. In general, current rehabilitation approaches lack automation, real-time tracking, intelligent evaluation, and ongoing feedback to enhance the quality and effectiveness of recovery in stroke victims.

Figure 1 - Existing block diagram

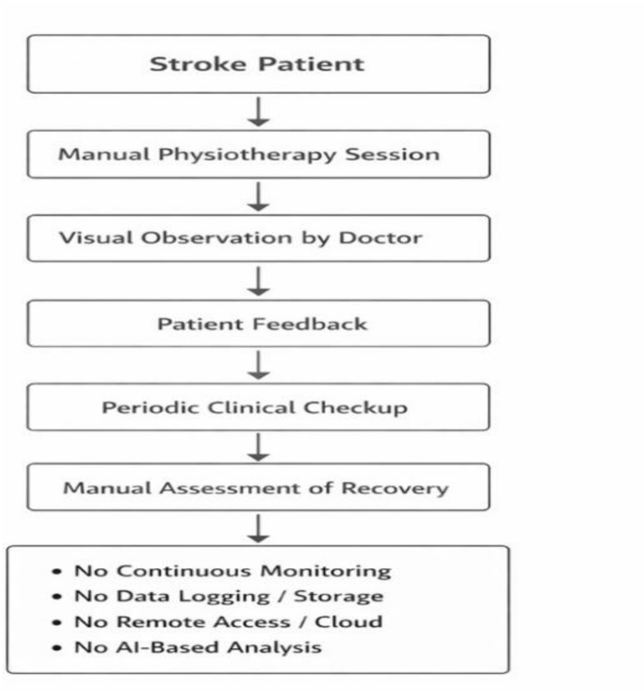



**Figure 1** - Existing block diagram

### 2. Proposed method:

This paper presents an IoT-based Stroke Patient Recovery Tracking system. Patients are continuously monitored in real time during the rehabilitation process. An overview of how this system differs from conventional methods, such as being automated/intelligent and cloud-connected for accessibility,is provided in Figure 2. The multidimensional improvements associated with this system occur in the precision of recovery tracking as well as reduced need for therapists to perform manual tasks. Finally, both the patient and the physician have the ability to evaluate the patient's degree of recovery at any point in time.

As the primary processing unit, the main processing unit for this system is the ESP32 microcontroller, which processes and collects the data from various sensors efficiently. The ESP32 was chosen because it has both low power consumption and great performance as well as Wi-Fi capability, which is essential for establishing a wireless data connection between the respective sensors and the cloud, providing reliable and seamless data transmission. The system utilizes several bio-sensors in order to monitor various physiological markers including EMG, pressure, temperature, GSR, and pulse sensors. An EMG sensor is used to measure electric impulses of muscle activity/strength, whereas a pressure sensor detects externally applied forces when someone is moving themselves or another object. A temperature sensor measures a person's body temperature and a GSR sensor measures emotional stress. Lastly, a pulse sensor monitors someone's heart rate. When all of these sensors work together, they give a complete picture of a patient's physical/emotional health.

A system for alerting has been added to enhance patient safety. When abnormal values or fatigue conditions occur, a buzzer automatically activates to alert caregivers. This system can deliver immediate assistance and may prevent serious medical problems from occurring. Also, there's an LCD display that provides real-time sensor data, enabling patients and their caregivers to monitor their current health status without having to access the cloud.Wi-Fi enables the ESP32 to send data it collects to the cloud. For storing and visualizing data, it employs ThingSpeak, a cloud-based platform. Through Wi-Fi, doctors and therapists can access patient data from the cloud at any time, eliminating the necessity of frequent visits to hospitals. The stored data is in JSON format, so it can be analyzed in the future and used for long term monitoring of progress during rehabilitation.

In addition, Machine Learning (ML) and Artificial Intelligence (AI) methods are employed for analyzing the obtained data sets. The algorithms allow for the identification of trends in recovery, the prediction of how much progress a patient has made, and for the detection of any abnormality at an early stage. After performing this analysis, the system delivers individualized recommendations for improving rehabilitation. The suggested system changes the way that individuals are rehabilitated from a well-established process to a smart, efficient, data-based rehabilitation process that will improve patient care and thus make better-informed clinical decisions.This cloud-based system also has continuous data logging capability (see Fig 2), which enables doctors to monitor a patient's health by referencing their historic health records. All of the data taken from different sensors is saved on the cloud for the patient and their physician to view over time so they can track the patient’s recovery progress by analyzing past data. Long-term data analysis gives physicians the ability to identify trends, such as increased or decreased muscle strength or decreased perceived levels of stress, which aids them in making appropriate medical decisions regarding patient care, including adjusting rehabilitation plans to meet the specific needs of the patient.

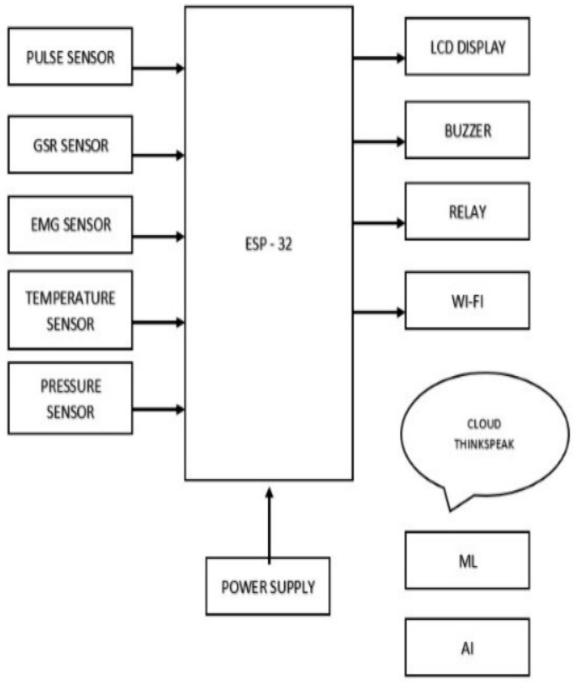



**Figure 2** - Proposed block diagram

In addition, Figure 2 shows a versatile and scalable architectural design to enable future improvement to the system. If necessary, additional sensors and/or modules could readily be incorporated into the system to allow for expanded monitoring of more health parameters. In addition, with the use of IoT and AI technologies within the proposed system, there is great potential for upgrading with more features like mobile app support, alerts in real time, and predictive analytics associated with healthcare — making the proposed system not only functional for today, but adaptable for change with advancements in smart health care systems in the future.

## 3. Methodology

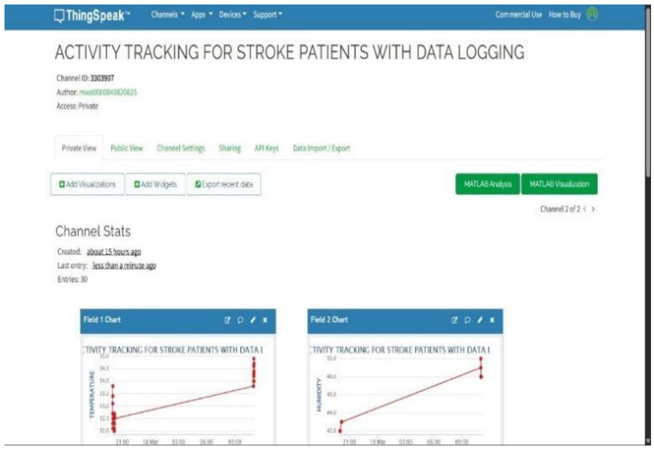
The figure above demonstrates how data is gathered from stroke patients via various biomedical devices as part of their treatment plan. Each device measures different physiological functions—electric signals from muscles (using the EMG sensor), the amount of force generated when moving or exercising limbs (using the pressure sensor), and an overall monitoring of body temperature (using the temperature sensor). In addition, all sensors help assess the overall health of a patient by gathering information on various body interactions including movement, activity and wellness.An ESP32 microcontroller will be the central processor for the system by collecting telemetry data from all of the sensor devices. The ESP32 will also generate real-time results through reading and processing sensor information. The ESP32 was chosen due to it is built-in Wi-Fi communications, processing speed and low power usage. Once the microcontroller has processed the data, it organizes and prepares it for transmission. Additionally, the ESP32 also controls how the system interacts with other devices/components like the LCD and buzzer. By controlling these devices, the ESP32 will allow for an uninterrupted flow of operations from sensing to processing and output.

The ESP32 uses Wi fi to send processed data to a cloud service (ThingSpeak) where it uploads data continuously for real-time monitoring and can also be retrieved at a later date. With access to the data remotely, both doctors and caregivers have the ability to review historical data, and the information is displayed on an LCD screen locally so it can be viewed right away. If the information retrieved provides an indication of danger or abnormal patterns (e.g., low muscle activity or elevated stress levels), the buzzer alert is activated, so immediate attention is given; therefore, reducing potential consequences from an unattended dangerous situation.
The exported data is in JSON format and is available for Machine Learning (ML) and Artificial Intelligence (AI) analysis. The algorithms review both real-time and historical data to find patterns of recovery and anomalies during the recovery process. After performing these analyses, the system is able to predict how well a patient will recover from a stroke based on past performance and offer recommendations for improving the patient's therapy. This allows for the creation of a individualized rehabilitation plan for each patient. The methodologies will provide real-time monitoring, smart analysis and data-driven decision making throughout the entire recovery process from stroke.

## IV. Results and Discussion

The research indicates that the IoT-Based Stroke Patient Recovery Tracking System (RPTS) effectively delivered real-time information regarding the rehabilitation parameters of stroke patients, as well as provided intelligent evaluation of the data being collected. The combination of gyroscopic, electromyographic (EMG), pressure, temperature, and skin galvanic response (GSR) sensors used in the RPTS provided sufficient data to reflect the physiological measures and motion measurements of the individual. The RPTS utilized an ESP32 microcontroller to process the data and wirelessly transmit the information via Wi-Fi to the ThingSpeak cloud platform. Once on the cloud, the data was made available in a user-friendly and easily interpreted graphically representation. The RPTS utilized an LCD to provide real-time feedback on a person's location and a buzzer alert system to notify a caregiver when an abnormal reading was detected (e.g., low muscle activity, high levels of stress, etc.). The continuous connection of the patient module to ThingSpeak provided for an uninterrupted/consistent experience for the caregiver and patient with remote monitoring of the person, without any apparent delays or data loss.

**THINGSPEAK PLATFORM:**

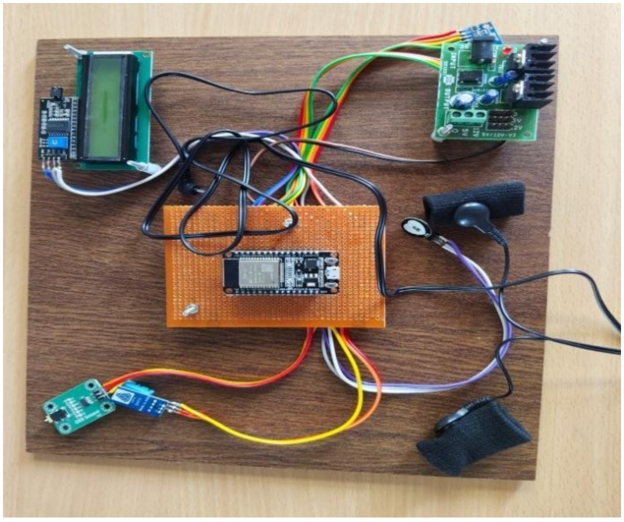



The data in ThingSpeak was also examined with the help of Machine Learning (ML) and Artificial Intelligence (AI) algorithms to assess the personal rehabilitation patterns. The AI models took in the data that is in the JSON format to categorize muscle responses and forecast recovery. The system was effective in identifying normal and abnormal recovery patterns, which gave real information that can be incorporated by the doctors to modify therapy sessions according to the actual information presented in real time. The findings of the experiments indicated that AI integration significantly improved the accuracy of prediction and response time to identify irregularities in comparison with the conventional methods of monitoring.

**MONITORING DASHBOARD:**


This dashboard allows real-time monitoring and analysis of Stroke Patients. The dashboard provides continuous measurements of important vital signs (i.e., body temperature, ambient temperature, heart rate, GSR (amount of sweat), SpO2 and falls). Graphs of the measurements allow caregivers/medical professionals to look at trends and variations over time, allowing for timely decision-making. Use of multiple sensors greatly improves the accuracy of the data collected, and the central display offers improved accessibility for caregivers/medical professionals to use when monitoring the patient. In general, this system provides a safer environment for the patient, offers support for monitoring recovery, and enables healthcare professionals to proactively manage patient care.

**HARDWARE OUTPUT:**



All in all, the created system was a resourceful, low-budget, and smart stroke recovery monitoring system. It enhanced patient safety by monitoring and providing early warning regularly, and providing healthcare professionals with information-driven insights to maximize therapy. Combining IoT and AI technologies, the system helped not only to improve rehabilitation results but also to reduce the need to oversee the process manually, which created the prerequisites of smarter, connected, and more efficient healthcare solutions.

## V. Conclusion

The IoT Stroke Patient Management System has lots of future application opportunities. For example, adding many more types of sensors that measure motion, like accelerometers and gyroscopes, will allow the system to provide even better information about how the patient moves and balances, thus providing even better information about patient mobility and rehabilitation progress than is currently available. The system can also enable real-time tele-consultation with physicians and therapists, who can direct rehab sessions remotely and make immediate changes to rehab, based on real-time data. Further exploration of AI and ML with predictive analytics may add the capability of detecting early potential complications and providing individualised therapy recommendations. There are plans to expand the platform into both Mobile and Web applications used by support network members such as Caregivers and Family members. These applications would provide real-time access to recovery data and alerts. As IoT, Cloud Computing, and AI continue to develop, an entire Intelligent Rehabilitation Ecosystem could emerge, to track recovery progress as well as provide active programmes of Adaptive Rehabilitation to the Patient, ultimately resulting in improved long-term outcomes and quality of life for Stroke Survivors.

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