School Of Computer Science and Electronic Engineering

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A telerehabilitation architecture for hand functional recovery of stroke patients

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Abstract:

In the previous 10 years, technology has evolved in every aspect of life. The Internet of Things is one technology that holds out a lot of potential for enhancing the lives of patients (IoT). In the UK, stroke affects around 100,000 individuals annually. Strikes do occur. A stroke happens every five minutes, according to one of the figures provided by the Stroke Association UK. The supply of rehabilitation services was hindered in 2019 as a result of the coronavirus illness. removing the (COVID-19) outbreak from public view. Telerehabilitation, one of the newest subspecialties of telemedicine, was developed in response to the demand for patients to continue their training outside of a typical medical environment while continuing under the guidance of a qualified professional. Costs are reduced, and workout regularity is encouraged. The approach of hand telerehabilitation for post-stroke patients that just uses a computer and cellular devices is the center of interest. The improvement of hand function in stroke patients receiving telerehabilitation is the aim of this study. It may be beneficial to give suffering a sense of worth, engagement, and satisfaction. The internet of Things (IoT) is a collection of electronic and sensor-enabled devices that enables the monitoring of a person's actual job, the regular monitoring of vital bodily functions, and the support of non-intrusive treatment recovery. The objective is to develop a stroke rehabilitation at-home system that will advise the patient to regain use of their hands and track the flexion and extension mobility of their wrists. There is a teletherapy component, which is used to track patients' progress. Force, angular rate, and occasionally the magnetic field will all be dealt with by means of the Raspberry Pi, servo motors, and an IMU sensor.

Index Terms: Exoskeleton, Cloud Technology, Hand Sensors, Internet of Things (IoT), Telerehabilitation, Stroke.

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Chapter 1: Introduction:

The main cause of adult disability is stroke, it necessitates the development of innovative technologies to support quick and effective stroke rehabilitation. When there is insufficient blood flow to a particular area of the brain, a condition known as a stroke occurs, which can result in death. Brain hemorrhage or a blocked artery are the most common causes. If the blood flow isn't steady, the brain cells in that area begin to die due lack of oxygen. In order to help individuals with these issues brought on by central nervous system injuries, therapeutic methods are used. With technological advancement, it has become easy to get the treatment at home. Therapeutic methods with significant guidance from the therapist can help the patient to recover fast in a comfortable environment. Numerous research using robot-assisted therapy demonstrate that in addition to conventional physical therapy, task-oriented repetitive movements can aid patients in regaining motor function, enhancing motor coordination, learning new motor techniques, and avoiding problems.

Early supported discharge (ESD) from hospitals eases the patient to continue the therapy at home after a stroke. It consists of services designed to speed up patient discharge following a stroke event and offer a degree of rehabilitation at the patient's home that is comparable to that of standard hospital care and discharge. This significantly lowers the quality of life and impacts brain and motor function domains. Because of the substantial risk of serious illness that geriatric patients face, the recent coronavirus pandemic has prompted questions about whether new methods should be used to provide post-stroke rehabilitation services.

Technologies have advanced in availability and cost over the past ten years as a way of delivering educational and health care services. The delivery of treatment programs over a telecommunications network and the internet is known as tele rehabilitation. The concept of applications exhibiting the potential for remote treatment and diagnosis using robot-aided tele rehabilitation is new other than, other disciplines which are more directly related to the subject of telemedicine. Regardless of the fact that the patient does not speak with the therapist personally, tele rehabilitation may nevertheless be able to improve the treatment session. increased workout time and severity for the patient's faster recovery, achieved without a similar increase in allocation of resources and through a more cost-effective application of intensive treatments.

- Continuous or real-time monitoring of the care session's, utilizing video communication.
- On-line adjusting of workout variables.
- Simultaneous monitoring of numerous treatment stations.

Stroke rehabilitation is a multidisciplinary field that combines neuropsychology, occupational therapy, speech and language therapy, and physical therapy. This is not the typical method for treating chronic post-stroke patients due to the high price of individual therapy sessions supplied by a professional. A system providing therapeutic sessions at home with correct and accurate guidance facilitates the patients.

Strokes can cause serious side effects leaving the body damaged. Motor function, speech, swallowing, vision, sensation, and cognition are frequently affected by stroke survivors' symptoms, and recovery can be slow and incomplete. These are very common in stroke patients and sometimes can leave permanent damage to the body. Majority of patients continue with their disability and are unable to participate in normal activities. To lessen these post-effects, patients are encouraged to participate in standard rehabilitation programs. But due to lack in basic needs such as, healthcare facilities, inaccessibility to rehabilitation services and remote living makes it difficult for the patient to recover from permanent damage. As a result, it become common for people to have trouble managing their activities and to participate less in activities at home and in the community. After being discharged from acute care facilities, half of stroke survivors receive some form of rehabilitation. Rehab programs frequently take a long time and require a lot of resources. As a result, providing stroke rehabilitation services in the most effective and efficient manner is a top priority.

One therapist (or sometimes several) works with a single patient in traditional rehabilitation. As a result, costs are high, especially for demanding patients like those who have brain injuries or injuries from surgery. There is presently no monitoring for the components of the therapy that the patient does at home. As a result, errors can occur when interpreting evaluated data or when data is missing because no online database can be used. Because manual data recording has a limited temporal granularity, such errors are both positional and temporal. Mechanical devices that are integrated into an augmented reality system can help facilitate repetitive training.

Patients' quality of life could improve if the healthcare system adopted the Internet of Things (Iota). The network of electronic and sensor-enabled devices known as the Internet of Things (IoT) allows for the continuous monitoring of vital body functions, tracking of physical activity, and rehabilitation physical therapy. An IoT-based arrangement of this sort could be utilized in the two clinics and homes, considering an independent recuperation process that would dispense with the requirement for devoted clinical staff.

The Internet of Things (IoT) is an innovative technology that has the potential to improve healthcare by modifying or displacing current medical practices. The ability of connected intelligent IoT devices to carry out measurements on their own and act in response to the results is one of the advantages of employing IoT devices to monitor physical parameters over conventional ones. Traditional therapies are passive, which restricts their clinical efficacy, especially for hand function, which is thought to be the most difficult portion of stroke rehabilitation. Numerous illnesses of the nervous system, musculoskeletal system, cardiovascular system, and others are known to benefit from telerehabilitation as a kind of treatment.

The Internet of Things (IoT) uses smart devices and the internet to come up with creative solutions to problems those businesses, governments, and public/private sectors all over the world face. IoT is consistently filling in significance and is presently unavoidable all through our regular routines. IoT, as a whole, is a technological advancement that combines a wide range of smart systems, frameworks, smart objects, and sensors. Additionally, it benefits from quantum and Nano - technology in ways that were previously unthinkable in terms of storage, sensing, and processing speed. To demonstrate the potential effectiveness and applicability of IoT changes, extensive research studies have been conducted and are available in the form of scholarly articles, press reports, both via the online and in the format of printed materials.

The application of the internet of things (IoT) to the healthcare system has the enormous potential to enhance patients' quality of life. The network of electronic and sensor-enabled devices known as the Internet of Things (IoT) allows for the continuous monitoring of vital body functions, tracking of physical activity, and rehabilitation physical therapy.

The use of this application for post-stroke rehabilitation has sparked an increase in interest in the creation of new telerehabilitation technologies that allow the monitoring and delivery of rehabilitation services across telecommunications networks and the Internet from a distance. By providing interactive, repetitive, and task-specific activities that can be customized to the user's needs and by promoting motor learning through the use of neuroplasticity, the most recent advancements in robot-assisted rehabilitation can also benefit telerehabilitation without the constant supervision of a therapist.

In an effort to boost patients' independence at home, various telerehabilitation technologies have been created in recent years to enhance patients' activities of daily life. Robot-assisted telerehabilitation systems can be divided into two classes: unilateral configuration systems and bilateral configuration systems.

The robot is only connected to the patient in a unilateral setup; However, the therapist is able to communicate with both the robot and the patient via remote access. It is not necessary for the patient and the therapist to communicate in real time; instead, data are sent to the therapist interface after a predetermined amount of time to verify the therapy's results and, if necessary, adjust the treatment plan.

To create a stroke rehabilitation tool that may be used at home, this project combines motor learning, neuroscience, and information technology. One of the most dangerous effects is hand paralysis. The Home Stroke Rehabilitation System is created to ascertain if the enhanced function and reorganization of the brain observed in a prior study or in the clinical situation whether the patient's home setting might imitate the treatment, and whether the enhanced function and brain reorganization is brought on by mental processing linked to repetitive motion or acquiring appropriate finger movement techniques. In a pilot study, stroke patients were taught to monitor target waveforms on a computer screen with their paretic index finger in a variety of conditions over the course of 18–21hours. The rehabilitation training sessions conducted using a single finger movement tracking program. A physical therapist was in charge of this therapy in a clinic. In the experiment functional magnetic resonance imaging was used to determine which brain regions were involved in finger tracking tasks.

Numerous examples of unilateral robotic systems are also available; they are briefly described. In order to give upper limb robotic therapy, Thera Joy, and Thera Drive, two force-reflecting devices, are combined with Uni-Therapy, a universal software platform that may be customized. A wrist trainer system is based on inexpensive commercial force feedback which is the Java-Therapy system13 is also utilized. A therapist uses a low-cost web camera and teleconference software for remotely monitoring and controlling the system, guiding the patient to desired movements.

The system then vibrates the tendon of the antagonist muscle while the agonist muscle is performing the desired action, the aided movement with enhanced sensation (AMES) robotic device makes it possible to perform exercises for the wrist or ankle at home. The Rutgers

Master II (RMII), created by Popes cu et al.25 (Simonetti D, 2017) , uses tele therapy to help stroke patients regain their hand strength. The patient can communicate with the immersive virtual environment that makes up the virtual driving environment by using a variety of kin-aesthetic interfaces, which is a force-feedback steering wheel that is commonly used in video games.

The fact that participants had to travel to the clinic for training sessions was a disadvantage of the pilot experiment. This put a strain on the participants' bodies and minds. Modern mass practice rehabilitation theory asserts that longer training sessions are advantageous, despite the fact that in-clinic sessions can last up to 60 minutes. A monitoring system for training sessions that were held in the homes of the participants without the presence of a therapist was developed using the promising findings of the pilot study. The systems require that the patient perform a concentration-intensive tracking exercise by moving their wrist and handmade motor relearning possible.

Telerehabilitation might be most useful for diagnosing MSK injuries that don't require a lot of physical examination or for treating conditions that have already been diagnosed. When using synchronous telerehabilitation, studies found that between 36% and 67% of diagnoses were consistent, and between 73% and 89% were similar to those made in person. Telerehabilitation that was guided by a remote practitioner was in the lower range, while telerehabilitation that was provided to patients in their own homes was in the upper range. In addition, the same pain generator was found in 94% of knee pain patients who participated in telerehabilitation from home as in those who received traditional in-person assessments. Cottrell et al. (Cottrell MA, 2017) conducted a meta-analysis and systematic review of synchronous telerehabilitation for MSK conditions concluded that Telerehabilitation may yield superior outcomes for physical function improvement, reduction of disability, and similar improvement of pain when compared to conventional care. Telerehabilitation, which is provided to patients at home and in remote facilities, is specifically supported by convincing evidence for the diagnosis and management of conditions such as hand, knee, and hip osteoarthritis (OA) as well as shoulder and spine pathologies.

The aforementioned limitations might be overcome via telerehabilitation-based programs. This type of telemedicine enables the patient's home to receive remote rehabilitation services. Access barriers to quality care, such as the difficulty of travelling for in-patient therapy and the associated fees, scheduling conflicts, and a lack of qualified therapy providers, can be overcome through technology.

When task-focused, delivered in big doses, intensely, with numerous repetitions, and continuously, rehabilitation therapy has demonstrated effectiveness in facilitating relearning. The outcomes are inversely correlated with the training duration. Improvements in arm function, for instance, have been attained after sessions totaling 3 hours or more per week. Traditional exercises that are given to patients to perform at home after they are discharged have a low adherence rate due to motivation loss, a lack of enjoyment from exercising, and assignments that are either too difficult or too simple.

The cited obstacles might be removed by programs based on telerehabilitation. Remote rehabilitation services can now be delivered directly to the patient's home through this type of telemedicine. The necessity of traveling for inpatient therapy, the associated costs, scheduling issues, and a lack of trained therapy providers are just a few of the obstacles that technology can remove from accessing high-quality care. In addition, tele-rehabilitation systems have been shown to boost brain plasticity and improve post-stroke rehabilitation outcomes by encouraging treatment adherence. In addition, a rehabilitation service that is provided from a distance may have a positive impact on the number of clinics that are available to patients because it makes it possible to choose care providers who are far away from home. Another technological solution that works well with telerehabilitation and may increase patient engagement during therapies is the use of serious games.

A telerehabilitation system that creates interactive, personalized home-based physical therapy by utilizing a wearable muscle sensor and Microsoft Kinect is presented in this project. Early experiments and pilot implementation results confirm the feasibility and efficacy of the proposed IoT-enabled telerehabilitation system.

The same range of exercises as traditional physical therapy should be included in telerehabilitation therapy, albeit without the physical presence of a physiotherapist. To be able to help a patient through a therapy session, the system needs a virtual assistant in the form of a web-based application as well as a set of games made just for the patient.

The IoT-based architecture of a telerehabilitation system is divided into two sections:

- A locally situated fragment and
- cloud based Programming as a Help section

Privately arranged segment calls for components like the Kinect body following sensor and muscle sensor to be shown to the patient and the game plan to be implemented in their living environment. A personal computer with an Internet connection is also required for the patient to receive therapy sessions and send sensor data.

The device forced the user to move their hand and wrist while doing a tracking task that called for focus, which is a necessary step in the process of motor relearning. The main goal of the design was to make the system simple to use so that it could be used independently at home without the need for technical knowledge. In order to track, aid, and encourage the patient's development, the system also required a telecommunication mechanism that would allow for occasional real-time connection with a remote physical therapist. The pilot study established the fundamentals of the tracking job. Transferring the assignment to a home-based system that could be used without a therapist present was the difficult part of this endeavor.

1.1 Aims and Objectives:

- To describe the various stroke rehabilitation therapies that are delivered through TR and to determine whether TR is as effective as conventional in-person outpatient therapy in enhancing patient satisfaction and reducing post stroke residual deficits such as disability, speech, and motor function.
- This work aims to develop a specific strategy for creating a telerehabilitation platform for stroke patients using consumer technologies and no ad hoc devices.
- The main objectives are to examine home stroke rehabilitation technology and to present findings from subjects who used the system in their own homes. The design of

a telerehabilitation system based on the Internet of Things (IoT) is described here. This system will make it possible to deliver effective physical therapy from a distance and provide information about the patient's recovery to trained medical professionals. Clinical results will be made accessible at a later time.

- To determine whether stroke survivors receiving telerehabilitation are better able to perform activities of daily living than those receiving in-person rehabilitation, in which the patient and clinician are in the same location and rehabilitation is provided face-to-face, or neither rehabilitation nor regular care.
- Secondary objectives included determining whether telerehabilitation outperformed in-person rehabilitation or no rehabilitation in terms of mobility, balance, health-related quality of life, depression, upper limb function, cognitive function, or functional communication. Additionally, our goal is to write about the cost-effectiveness, user satisfaction, adverse events, and feasibility of telerehabilitation interventions.
- By reporting on the individual studies' participant eligibility requirements and recruitment strategies. And to inform stroke patients about the viability of telerehabilitation.

1.2 Motivation:

In the United Kingdom, stroke is the fourth leading cause of death and the second leading cause worldwide. Over 113,000 strokes occur annually in the UK, leaving many of the more than 950,000 stroke survivors with severe and permanent disabilities. Death from a stroke within a year, multiple strokes, or acute ischemic attacks, with long-term physical and mental consequences, according to the Stroke Association (2016).

There may be a telerehabilitation approach created specifically for physical therapy. Metrics used in rehabilitation include things like heart rate, breathing rate, blood pressure, and oxygen saturation. The measurements themselves may be used to derive indicators of a patient's health status.

One of the main benefits of telerehabilitation is that it gives isolated individuals the chance to obtain rehabilitation treatments. This function is especially helpful in large nations like Canada and Australia, where many residents live far from specialized rehabilitation facilities. People who live in rural and distant locations may not have access to rehabilitation clinicians at all, let alone teams with stroke-specific experience. People with extremely limited mobility who find it difficult or impossible to travel might also benefit from not having to travel to rehabilitation facilities. Telerehabilitation is also probably advantageous in low-resource environments where access to medical experts is limited but access to tools like smart phones is widespread.

In physical therapy, muscle sensors are used to track and stimulate muscle activation. Electromyography (EMG) data from skeletal muscle can be collected using a muscle sensor-equipped Arduino microcontroller at a reasonable cost and with little power consumption. EMG has long been used in the study and diagnosis of neuromuscular dysfunction. Whether using telerehabilitation improves stroke survivors' capacity to complete everyday activities when compared to in-person rehabilitation (where the patient and the therapist are in the same physical area and the rehabilitation is provided face-to-face); or not using rehabilitation at all.

Secondary objectives included comparing telerehabilitation to in-person rehabilitation and no rehabilitation to see if it improved mobility, health-related quality of life, upper limb function, cognitive function, or functional communication, as well as increased independence in self-care and domestic life. Additionally, it also includes the report on any adverse outcomes, cost-effectiveness, practicability, and levels of user satisfaction associated with telerehabilitation interventions.

1.3 Limitations of Project:

The system has some limitations on which the work is being done. There are many possible and optimal solutions to it, which are being investigated. The system is quite expensive, the work is being done to make it relatively inexpensive. This study, is also limited in terms of technology discovery, searched the literature for clinical outcomes linked to telerehabilitation for stroke patients' hand functional recovery. Technologies that were published in academic papers, technical journals, or gray literature were not included in the current analysis. This suggests that the included studies did not examine potential telerehabilitation technologies that had not been clinically tested or studied on people to determine their clinical relevance. The purpose of this study was to highlight technologies that have been through clinical trials as well as those that are currently available for purchase or are on their way to becoming available.

1.4 Scope of Project:

The majority of stroke patients who are discharged from fully recovered post-stroke rehabilitation still suffer from persistent motor dysfunction in their upper limbs, particularly in the distal joints (the wrist and fingers), which severely limits their ability to perform daily activities. Physical training can, according to more recent studies, lead to significant motor gains in the long-term following a stroke if it is as rigorous as the training given to those patients. This is in contrast to the conventional approach to rehabilitation after a stroke, which maintained that significant motor recovery occurred primarily within the first six months after a stroke.

Outpatients with chronic stroke require consistent and ongoing physical therapy to restore wrist and hand function. For stroke recovery, the paralyzed limb must be trained to close to normal muscle coordination with maximal voluntary motor effort and reduced compensatory movements. Nonetheless, the current worldwide medical services framework doesn't give sufficient compelling wrist/hand recovery treatments for short term patients with stroke.

The majority of outpatients do not have access to the necessary training intensity for wrist and hand therapies because of factors such as a worldwide shortage of specialists and an increasing stroke population. Due to the limitations on social distancing during the COVID-19 epidemic, home-based telerehabilitation with minimal assistance and remote supervision by professionals is a promising strategy for sustaining physical treatment after discharge and improving the accessibility of rehabilitation resources to improve discharged patients' wrist/hand motor functions.

As a result, the purpose of this project is to investigate whether or not outpatients with chronic stroke could benefit from home-based self-help training aided by the EMG-driven WH-ENMS and its rehabilitation benefits. Individuals who received EMG-driven WH-ENMS-aided home-based self-help telerehabilitation training would have motor improvements in the distal joints, improved muscle coordination of the paretic upper limb, and a decrease in compensatory movements when performing limb tasks, according to our hypothesis.

Chapter 2: Literature Review:

For medical professionals, IT specialists, patients, and biomedical engineers, the field of telerehabilitation is still "a promised land." Telerehabilitation is a form of remote rehabilitation that is available to all patients who were treated initially in a hospital but now need to continue their care at home. It has a lot of potential to cut down on the cost of providing healthcare to people who live in small towns away from big cities. The majority of them are unable to attend a rehabilitation center due to various disabilities or deformities, but they can perform the exercises at home under the supervision of a specialist from a distance.

During the COVID-19 pandemic, telerehabilitation was used to ensure that care continued to be provided, but people with physical disabilities and movement impairments didn't know how to use it safely and effectively. For the purpose of developing an online toolkit and training package, the goal of this service evaluation was to collect data on practitioner and patient experiences, obstacles, and facilitators, and examples of best practices. The cloud is the ideal platform for telerehabilitation systems that don't require users to set up their own preferences. One of the most important IoT development areas is the use of portable self-monitoring technology to track one's personal health and wellness.

The use of telerehabilitation, or the delivery of rehabilitation through information and communication technologies2, was frequently utilized in an effort to lessen the effects of the pandemic and guarantee that care would continue to be provided.1 In a relatively short period of time, there was a significant rise in the number of appointments for remote healthcare that were held via video or telephone.

Overall quality of the current rehabilitation services may also be improved and supplemented by using telerehabilitation services. Stroke survivors are concerned about the absence of long-term assistance and continued unmet rehabilitation demands (Ullberg, 2016).By assisting patients as they continue their daily lives after being released from inpatient facilities, telerehabilitation may be able to close some of these gaps. Additionally, it would be conceivable to offer telerehabilitation as a way to carry on the therapy program and to relieve patients from hospital rehabilitation centers early. Additionally, telerehabilitation might offer a way to boost therapeutic dosage without increasing in-person supervision.

Additionally, telerehabilitation may save costs in a number of ways. Clinical staff who see patients in their homes may be able to schedule more appointments in a day due to the reduced travel time.

Ambient assisted living and well-being solutions are two examples of healthcare IoT applications. The usage of IoT in physical therapy hasn't received much research or testing, though. It is anticipated that the Internet of Things (IoT) will deliver the resources required to generate results that are actionable based on pre-established algorithms frameworks. This paradigm for physical therapy rehabilitation uses several sensors.

Telerehabilitation has the potential to alleviate the growing problem of rehabilitation for stroke patients and lessen the strain on the healthcare system. One of the newest subfields of telemedicine, telerehabilitation was developed because of patients' need for ongoing training outside of the medical facility but still under specialist supervision. It helps keep exercises consistent and cuts costs. Papers present professional and advanced telerehabilitation systems; however, minor systems that provide therapeutic values and are more accessible to individuals have not yet been developed.

Muscle sensors that measure electrical potentials in the muscles were developed for the healthcare business, tracking and sensing systems for the bones and muscles to gauge their success of the exercises. modifying interactive physical therapy and developing new exercises based on the needs of the patient and sensor readings are also taken into account.

The mHealth app, created by the UK-registered charity Physiopedia, is an example of a commercial telerehabilitation home-based solution. Healthcare practitioners might start providing care in a novel, remote manner as technology develops. Recently, the use of mobile devices like smartphones and tablets in both medical and public health settings has been referred to as "mHealth." MHealth is viewed as a change agent around the world because of its broad reach and low cost.

Therapeutic compliance has been a clinical issue since the 1970s because of how frequently treatment and rehabilitation programs are not followed. Preventico's Body Guardian, a sensor patch that resembles a band and is applied to the patient's body for physiological monitoring, is another commercial example of tele rehab. The patient may roam around thanks to batteries inside the sensor, which also connects via Bluetooth to a smartphone. A cloud-based health platform receives data from a smartphone, analyses it, and notifies medical staff of any relevant findings.

For medical professionals, IT specialists, patients, and biomedical engineers, the field of telerehabilitation is still "a promised land. Telerehabilitation is a method of providing rehabilitation services at a distance to patients who were initially treated in a hospital but need to continue their care at home. It has a lot of potential to cut down on the cost of providing healthcare to people who live in small towns away from big cities. The majority of them are unable to attend a rehabilitation center due to various disabilities or deformities, but they can perform the exercises at home under the supervision of a specialist from a distance.

The cloud is the ideal platform for telerehabilitation systems that don't require users to set up their own preferences. One of the most important IoT development topics is the use of wearable self-monitoring devices to measure one's own health and wellbeing.

Permanent and ubiquitous health monitoring for patients is a key objective of telemedicine. Hospitals and other providers of healthcare are under increasing pressure to increase efficiency and cut costs as a result of the strained financial situation in the sector. Healthcare organizations are motivated by these trends to implement novel IT-based supportive processes.

Although this research gave valuable insight into the effects of cutting-edge technology, doctors do not have easy access to these intervention programs. Purpose-built telerehabilitation systems are becoming more sophisticated as technology advances, and it is expected that these features will spread over time. Examples of these capabilities include vital sign tracking and synchronization with medical data. Contrarily, numerous studies that include interventions like counselling, main objective, and care plan employ more straightforward communication techniques. It is obvious that various therapy modalities necessitate the employment of various telerehabilitation systems. However, the suggested approach uses mobile phone technology in low-resource situations to provide rehabilitation services to many people at a minimal cost.

2.1 Project Background:

The most common cause of severe, long-term disability is a stroke. Rehab is hindered by costs, transportation, a lack of skilled personnel, and equipment. Telerehabilitation (TR) has emerged as a promising strategy for lowering expenses, broadening access, and preserving patient autonomy. Because TR allows therapy to be delivered remotely, previously underserved areas might now have access to it.

In adults, stroke is a common cause of disability. After a stroke, it's common for people to have trouble doing things like walking, taking a shower, getting dressed, and participating in activities in the community. Many people need rehabilitation after a stroke; in most cases, medical professionals in a clinic or hospital provide this. The feasibility of using telephones or the Internet to communicate with healthcare professionals from the comfort of one's own home has recently been the subject of recent research. Telerehabilitation, also referred to as this strategy, may be a more convenient and cost-effective strategy for rehabilitation. Telerehabilitation can be used to improve a variety of outcomes, such as mood and physical functioning.

Telerehabilitation is a brand-new, innovative approach to treating stroke patients with motor and cognitive impairments. Even if there are specific devices that can track a patient's movements to evaluate the rehabilitation exercises, they have completed, these devices need specific settings to be used correctly and simply at the patient's home. If the current pandemic and lockdown conditions, which made it difficult to access these products, are taken into consideration, stroke patients may not be able to perform home rehabilitation.

Numerous research projects were started in this area despite the fact that telerehabilitation proved to be a useful resource in the clinical setting. Dodakian et al.'s study demonstrate that a platform for remote rehabilitation may provide patients with sections devoted to clinical education and doctor-patient interaction in addition to the rehabilitation service.

A novel approach to providing rehabilitation services is offered by telerehabilitation. Information and communication technologies are utilized to facilitate communication between a healthcare professional and a patient in a remote location. As communication technologies advance in speed and sophistication, telerehabilitation is becoming more practical. However, the efficacy of this model of care in comparison to rehabilitation that is provided face-to-face or as an addition to standard care is currently unknown.

Chapter 3: Methodology:

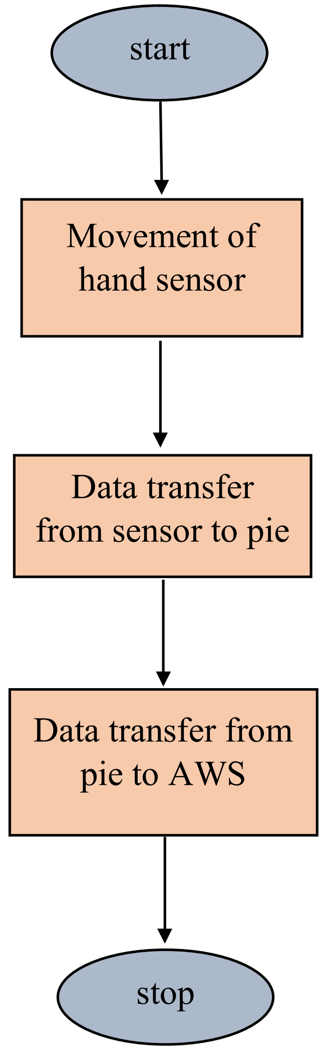
It is intriguing to develop a methodological strategy for the creation of telerehabilitation platforms that has both advantages and disadvantages in order to maximize the advantages of the remote method and minimize the disadvantages.

In order to reach this point, a system must be developed that enables clinicians to remotely monitor the progress of patients receiving effective and stimulating treatments. The objective is to investigate low-cost and user-friendly technologies for the development of a platform that is patient and medically centered.

There are numerous ways that can be used cloud-based architecture to transmit signals from the exoskeleton to the software. MQTT is one of the protocols that is utilized in this situation. MQ telemetry transport is referred to as MQTT. It is an open communications system for the Internet of Things that is compact and lightweight (IoT). Additionally, it is built to link remote devices using the least amount of bandwidth and code possible.

MQTT will assist us in sending messages through remote connection devices and has the ability to work in both directions. Because it makes it simple to encrypt messages using TLS, MQTT is also particularly helpful for creating secure connections between cloud-to-cloud devices.

The basic working of the project is explained in brief. All the necessary sensors are calibrated with raspberry pie. The pie itself is a microcontroller and a central processing unit. The exoskeleton is the used to send the coordinates of the movements of the hand. The pie then takes in the input readings from these sensors and save them. As the project is calibrated on app and web interface the values are then passed to them. These values are saved as well as displayed on their respective interfaces. As it’s a real time interface, the values are continuously altering with minimum display on the interface. Through the use of virtual base therapy, the results are to accurately deliver telerehabilitation to the patient in this study. The therapy will be administered to the patient by a robotic arm (exoskeleton), with the therapist monitoring the hand movements and rotation from a seat on the other side.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Movement of hand sensor
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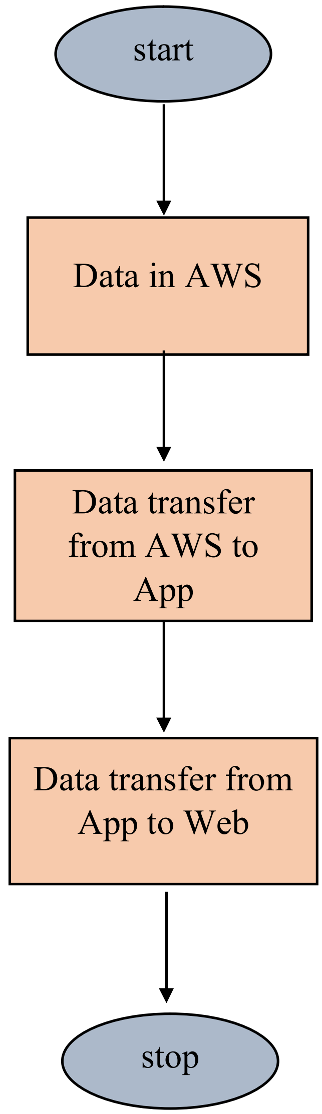
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Data transfer from App to Web
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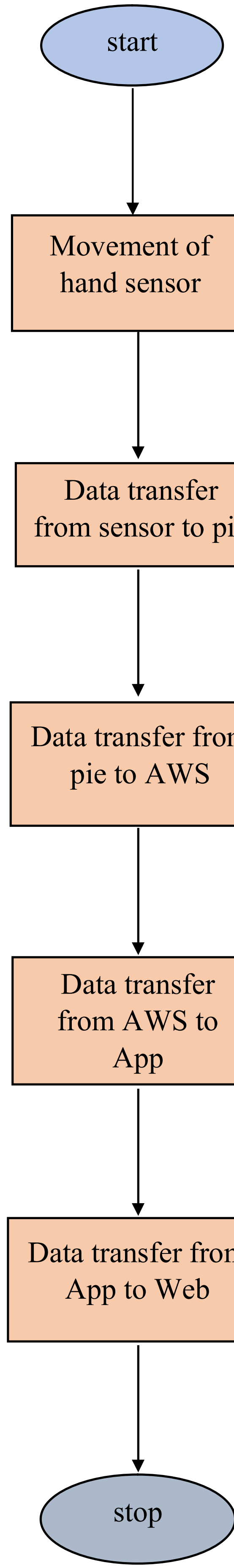
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Movement of hand sensor
Data transfer from sensor to pie
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stop

3.1 Hardware Requirements:

The system requires a variety of hardware tools in this study, including a robotic skeleton (exoskeleton), motion sensors, and sensors for measuring muscle activation. We're going to employ an IMU sensor, also known as an inertial measurement unit, in this situation. Using one or more accelerometers and gyroscopes, it helps to detect linear acceleration and rotational rate. An accelerometer, gyro, and magnetometer are typically used in a standard setup for each of the three main axes: pitch, roll, and yaw.

Servo motors are another piece of hardware that are intended to use. In reality, a servo motor is an actuator that controls rotation or linear motion with relation to velocity and acceleration. It has a suitable motor with accurate angular and linear position control that is also connected to a sensor for the position feedback.

3.1.1 Raspberry pi:

The Raspberry Pi is a device that is roughly the same size as the Arduino boards that are currently intended for introductory use. The Raspberry Pi is a credit card-sized minicomputer that can communicate with any input and output hardware device, such as a monitor, television, mouse, or keyboard. This effectively makes the setup a low-cost, full-featured PC. Raspberry Pi is a tiny board with a microprocessor that functions as a mini computer and can carry out a number of tasks. The Raspberry Pi contains a built-in operating system, allowing users to explore computing and develop programming skills in languages like Python. The Arduino that is intending to utilize initially is simply constrained by the straightforward instructions that the IDE provides to them.

Raspberry Pi is a programmable gadget. It does not include any peripherals or internal storage, but it does include all of the essential components of a typical computer motherboard. So it will need to insert an SD card into the provided slot to set up the Raspberry computer. The computer cannot start without the operating system installed on the SD card. Linux OS is compatible with Raspberry computers. This fosters diversity while simultaneously lowering memory requirements.

Raspberry Pi can be connected to output devices like computer monitors or a High-Definition Multimedia Interface (HDMI) television after the operating system has been set up. Additionally, input devices like mice and keyboards should be connected. Depending on the buyer, this minicomputer can be used for various purposes.

The Raspberry Pi 4 Version B is the most recent model in the well-known Raspberry Pi computer line. Compared to the Raspberry Pi 3 Model B+ of the previous generation, it offers revolutionary improvements in system performance, multimedia capability, memory, and connection while still maintaining backward compatibility and consuming a level of power that is comparable to that of the previous generation. For the user, this module's desktop performance is comparable to that of entry-level x86 PC systems.

Figure 1:Rasberry Pi

Some of the main features of this product include a higher 64-bit quad-core central processing unit, hardware video decoding at up to 4Kp60, dual-display support at resolutions up to 4K via two micro-HDMI ports, up to 8GB of RAM, dual-band 2.4/5.0 GHz wireless LAN, Bluetooth 5.0, Gigabit Ethernet, USB 3.0, and PoE capability.

3.1.2 Arduino:

In 2005, the Interaction Design Institute Ivrea (IDII) in Italy developed the Arduino platform. At the time, the design students at IDII needed an easier way to create their projects because microcontroller boards were more suited to engineers than makers. Interestingly, the name Arduino comes from the bar where the company's founders used to meet.

An Arduino is essentially a microcontroller board practically a complete computer on a chip at its core. A single chip houses the processing core, memory, and controls for the input and output. However, there is more to the board than just the chip. The actual microcontroller chip also known as an integrated chip or IC as well as all of the extra nerdy bits necessary to make it work such as power management, timing modules, input, and output headers, and so on are contained within the Arduino microcontroller.

The open-source platform is used to create electrical projects. The open-source prototype platform Arduino is built on software and hardware that are simple to use. It consists of a circuit board that can be programmed (a microcontroller) and pre-made software known as Arduino IDE (Integrated Development Environment), which is used to write and upload computer code to the actual board. With Arduino, you can write and upload programming code to an Arduino consists of circuit board using a software application called the IDE (Integrated Development Environment), which runs on your computer. In order to load new code onto the Arduino, there is no need for a separate piece of hardware known as a programmer; all things considered, you can do as such by utilizing a USB link, rather than most of prior programmable circuit sheets. Additionally, the Arduino IDE employs a simplified version of C++, making programming easier to learn.

Open-source hardware and software make Arduino an easy tool for electronics prototyping. You can use Arduino to control motors, accept inputs from buttons, read data from sensors, blink LEDs, and perform a wide range of other "Microcontroller"-related tasks. In essence, Arduino is a microcontroller development board. That initially is intending to construct the model with an Arduino that will be guided. The IDE's built-in commands. As opposed to Raspberry Pi, it doesn't support the internet does.

Depending on the microcontrollers used, there are many distinct kinds of Arduino boards to choose from. However, one thing unites all Arduino boards: The Arduino IDE is used to program them.

The number of inputs and outputs—the number of sensors, LEDs, and buttons that can be used on a single board—speed, operating voltage, form factor, and other factors all play a role in the differences. It would need to purchase a separate programming interface (hardware) because some boards are made to be embedded. While a 3.7V battery can power some, others require at least 5V.

3.1.3 AHRS (Attitude Heading reference System)

In response to the demand for inclusive and cost-effective antenna pointing, aiming, and stabilizing applications, Inertial Labs began manufacturing its MEMS-based, IP-67 sealed, MIL-STD-810G qualified, multiple interfaces and COM ports Attitude and Heading Reference System in 2001. A high-precision Fluxgate Magnetometer and Tactical or Industrial-grade Inertial Measurement Unit (IMU) developed by Inertial Labs are included in each INS.

Attitude and Heading Reference System, or AHRS for short, is a motion sensor. It includes an IMU with three gyroscopes, three accelerometers, and three magnetometers as well as a CPU with the embedded Extended Kalman Filter. Notwithstanding roll, pitch, and yaw, this empowers exceptionally precise mentality and heading estimations according to attractive north. This sensor fusion allows vectors like gravity and the Earth's magnetic field to compensate for gyroscope drift.
To enhance its performance, the sensor can be connected to an external GNSS receiver. Indeed, AHRS with GPS assistance provides additional navigation

An inertial measurement unit (IMU) made up of microelectromechanical system (MEMS) inertial sensors is used by an attitude and heading reference system (AHRS) to measure the angular rate, acceleration, and Earth's magnetic field. An estimate of the object's attitude can then be derived from these measurements.
The IMU is given a central processing unit (CPU) by an AHRS. It incorporates the Extended Kalman Filter, which provides information regarding attitude and heading. The heart of every aircraft are its inertial systems. They supply nearly every avionics system and flight-critical

component, including radars, flight controls, displays, flight management systems, and heads-up displays.
(Hayward, 1999, June)
Unmanned aerial vehicles constitute the typical market for heading reference systems. UAV navigation, UAV-based surveying, and other aerospace applications are the most common uses for GPS-aided AHRS sensors. There is a component of the aerospace electronic system during flight and is frequently installed in aircraft. They can be used in any application that integrates motion tracking and monitoring, like instrumented buoys or camera orientation, because they function as a motion unit. Depending on the application's need for accuracy, IMUs or GPS-aided inertial navigation systems with dead reckoning would be ideal for the market for unmanned ground vehicles.

3.1.4 Accelerometer MPU6050 and Gyroscope Module

Micro Electro-Mechanical Systems (MEMS) called the MPU6050 have an accelerometer sensor and a 3-axis gyroscope. This makes it easier for us to quantify a system's or object's velocity, acceleration, position, displacement, and many other motion-related parameters. Additionally, this module contains a (DMP) Digital Motion Processor, which is strong enough to do complex calculations and free up the Microcontroller's time. Two input pins on the panel can be used to connect external IIC modules, such as a magnetometer, but doing so is optional. The AD0 pin can be used to interface and over one MPU6050 detector to a microcontroller because the component's IIC address is programmable.

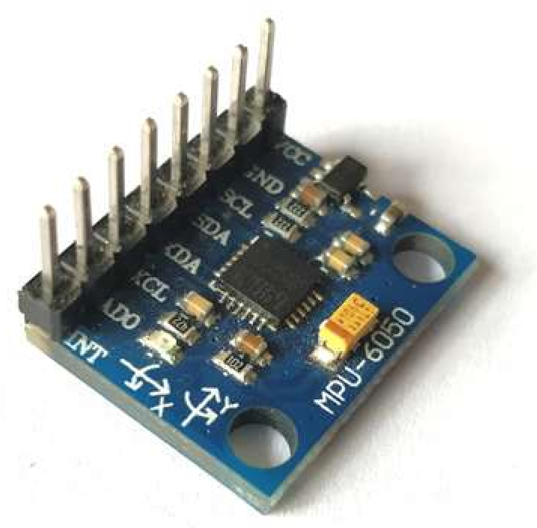

Figure 2: MPU6050

Typically, an MPU consists of:

1. Gyroscopes is to supply an indication of angular rate.

2. Accelerometers is providing a specific force/acceleration measurement.
3. Magnetometers are an option. measurement of the system's surrounding magnetic field

There are several distinct kinds of sensors: the one that is based on a FOG (Fiber Optic Gyroscope), the RLG (Ring Laser Gyroscope), and the IMU that is based on MEMS technology. This technology ensures performance while simultaneously lowering costs and power consumption. Therefore, systems based on MEMS combine extremely low power consumption with high performance in a smaller unit.

There are a number of performance levels. Based on the characteristics of the accelerometer and gyro, they fall into one of four categories: Industrial Grade, Tactical Grade, Navigation Grade, and Consumer/Automotive Grade

The basic principle of MPU6050 is to measure the acceleration and motion of a body. They are used to maintain the angle of a body at a certain level. The main aim to use this sensor is to track the movements of the hands so that the patients' hands can move according to therapist. This also helps the doctor to track the patients record of how much improvements are made.

It is used almost everywhere in fact. Smartphones for instance. A type of technology known as micro-electromechanical systems (MEMS) is inside the majority of smartphones, and it houses an IMU sensor. Additionally, numerous tablet devices include it. Because they make it easier to determine the orientation and position of a vehicle, IMU sensors are also widely used in the aerospace and automotive sectors. (Jalal, 2021)

3.1.5 Servo Meters

A servo motor is a type of motor that can rotate precisely. The control circuit of this kind of motor typically provides feedback on the motor shaft's current position. Servo motors can rotate very precisely due to this feedback. When you want to rotate an object at a certain angle or distance, you use a servo motor. A straightforward motor that is controlled by a servo mechanism is all that is required.

Servo engines have been around for quite a while and are used in numerous applications. Despite their diminutive size, they are extremely energy efficient. These elements permit them to be utilized to work remote-controlled or radio-controlled toy vehicles, robots, and planes. In addition, pharmaceutics, food services, industrial applications, robotics, in-line manufacturing, and servo motors are utilized.

The servo circuitry is built right into the motor unit and has a position-able shaft that typically has a gear on it (as shown below). The amount of movement of the shaft is controlled by an electric signal that controls the motor.

A gear arrangement is typically included with servo motors, enabling us to obtain servo motors with extremely high torque in lightweight and compact packages. They are being used in a wide range of fields, including robotics, toy cars, and RC planes and helicopters.

Sending an electrical pulse of variable width, or PWM, through the control wire is how servos are controlled. There is a repetition rate, a minimum pulse, and a maximum pulse. A typical servo motor can only rotate 90 degrees in either direction for a total of 180 degrees. The servo has the same amount of potential rotation in either the clockwise or counterclockwise direction when it is in the neutral position of the motor. Based on the duration of the pulse that is sent through the control wire, the position of the shaft is determined by the PWM that is sent to the motor. As desired, the rotor will rotate. Every 20 milliseconds (ms), the servo motor should see a pulse, and the length of the pulse will determine how far the motor turns. For instance, a pulse of 1.5 milliseconds will cause the motor to rotate 90 degrees. Any time it takes longer than 1.5 milliseconds, the servo will be turned counterclockwise toward the 0° position. Any time it takes longer than 1.5 milliseconds, the servo will be turned clockwise toward the 180° position.

There are three parts to it:

- Controlled device
- Output sensor
- Feedback system

In this closed-loop system, motion and the shaft's final position are controlled by a positive feedback system. In this case, the device is directed by a feedback signal that is generated by comparing the output signal to the reference input signal.(Stojanoski, 2017)

3.1.6 Actuator

An actuator is a component of a machine or device that converts electrical, air, or hydraulic energy into mechanical force to facilitate physical movement. To put it another way, it is the part of any machine that makes it possible to move. Characterized basically, an actuator is a gadget that changes over energy, which might be electric, water driven, pneumatic, and so on to mechanical in a manner that allows for control. The amount and the idea of information rely upon the sort of energy to be changed over and the capability of the actuator. For example, electric and piezoelectric actuators use an electric current or voltage as their input, while hydraulic actuators use an incompressible liquid and pneumatic actuators use air as their input. Mechanical energy is always what comes out.

In contrast to artificial intelligence and machine learning, actuaries are not something you would typically read about in the media on a daily basis. However, the fact of the matter is that it plays a crucial role in the modern world like no other device has ever done before.

An electric straight actuator is a contraption that makes a development by changing over energy and signs going into the system. It can rotate or move in a straight line. As their name suggests, electric straight actuators produce direct movement. This indicates that linear actuators can move forward or backward on a predetermined linear plane—the amount of time they can travel in either direction before they need to stop. Rotating actuators, on the other hand, produce rotary motion, indicating that the actuator revolves around a circular plane. In contrast to the linear actuator, the rotary actuator does not have a predetermined path, so it can continue to rotate in the same direction for as long as necessary.

3.2 Software Requirements:

the aim of the project is to use a cloud-based model to store the movements that the sensors capture (SaaS). To do this, we'll try to create a cloud server that can send, receive, and store data. In addition, we'll work to create applications for end users.

The computer used by the therapist, such as a laptop or mobile tablet, will have this software installed. We're intending to use the Android OS first. Because the user can understand the GUI much more easily.

The project also includes the development of software that will allow patients to receive data in the form of tasks to complete while recovering their hand movements in accordance with the therapist's instructions.

For a wide range of purposes, cloud-based data storage, computation, software, platform, and computing infrastructure are widely used today. Buying hardware and installing and maintaining software saves time and money when using cloud-based content and services. Health monitoring systems become inexpensive, platform-independent, and quick to deploy with cloud infrastructure. Cloud-based applications can be easily updated without requiring patients to install any software, making system maintenance quick and inexpensive.

The cloud-based Software as a Service segment serves several purposes:

- provides software for telerehabilitation therapy,
- When each patient has received treatment, feedback is gathered.
- Analyses collected data and represented it in comparative and progressive form, and
- permits physiatrists to remotely monitor and manage patients' conditions.

The set of features an application offers so that a consumer may input data into and receive results from the program is known as an application interface. All the data is collected by sensors, showing the movements of the hand is stored and displayed. The application interface helps in guiding the motion of the hand, resulting in improvements by the motion. IOT plays a significant role in this, as all the data received by the sensors are computed and sent to our application, which the displayed in the application interface. This helps the user to tackle weather he or she are coping in the right direction. The web portal was also utilized in this simulation. Using a Web desktop application or Web app, a user can interact with data or software running on a remote server using a Web browser. The client interfaces with the substance on an internet browser, what capabilities as a client, in the wake of downloading it from the web server. Because of the scattered nature, it is feasible to store the substance on a far-off server, and the openness of the substance is made conceivable by the far and wide utilization of Internet browsers.

3.2.1 Web Interface:

For the web server integration, the amazon web server is used. AWS offers a variety of unique cloud computing products and services. Processors, communication, remote computing, mail, mobile development, storage, and security are offered by Amazon's wildly successful sector. S3, Amazon's storage system; EC2, Amazon's virtual machine service; and Glacier, a cost-effective cloud storage service, are the three core categories of AWS. AWS has greatly outpaced its competitors because of its scale and significance in the computing sector.

One of the main reasons of using AWS web interface was its availability. There are 81 operational zones that AWS uses for the placement of its servers. These served districts are divided up to provide customers the choice of putting regional limits on their services (if wanted) and to boost security by dispersing the service areas. AWS covers 245 nations and territories overall.

In this case of a web application, access to the system is granted through authentication and authorization. The best strategy is to have a communication hub that handles user information management and lets users log in to the system. Depending on their profile, users will be able to access the services after logging into the system. The database stores information about the services each user uses.

The rehabilitation exercises are carried out by the user in one of two execution models:

• Patient alone When the patient is by himself or herself, he or she must access the authorization and communication services.

• Patient administered

During the oversight cycle the patient needs to distinguish himself and access the correspondence administrations to draw in with the advisor.

Additionally, patient performance assessments should be able to access the data collected for each patient. In this model, the communication hub is responsible for implementing the database and interface for data collection as well as the APIs for data retrieval. The Therapist UI contains the options that the therapist uses to monitor and issue commands. Manager UI lets the manager let the therapist and manager do therapies together. It oversees communication among the various software components as well as user authentication for the communication hub.

3.2.2 App interface:

The set of features that an application provides to allow a user to provide input to the program and receive output from it is known as an application interface or user interface. Consider the application interface of Microsoft Word as an example. It has a central area where you can type and add feedback to the screen.

Standard protocols and service-composition technologies are used to implement a wide range of applications and interfaces in the application–interface layer, including RFID tag tracking and smart home. The applications heavily influence the application–interface layer requirements.

Android Application platform is used to create android apps for the android mobile devices. It also supports machine learning models to deploy in applications and can be used in real-time as well as offline for the classification and detection of different objects. The tensor flow allows the use of the trained model for the deployment.

To connect to the internet and communicate with the cloud-based software, it was intended to provide to the therapist and attempted to implement the raspberry pi.

The figure below displays the data that has been passed to raspberry pie and displayed on the app interface. The below readings show the coordinates of the hand movements. The Ay is the x-coordinates, ay is the y-coordinates and Az is the z-coordinates. The coordinates here are used to track the movements of the hand. Whereas the Gx, Gy, and Gz are the acceleration calculated by the movements of the hands x-coordinates, y-coordinates, and z-coordinates respectively.

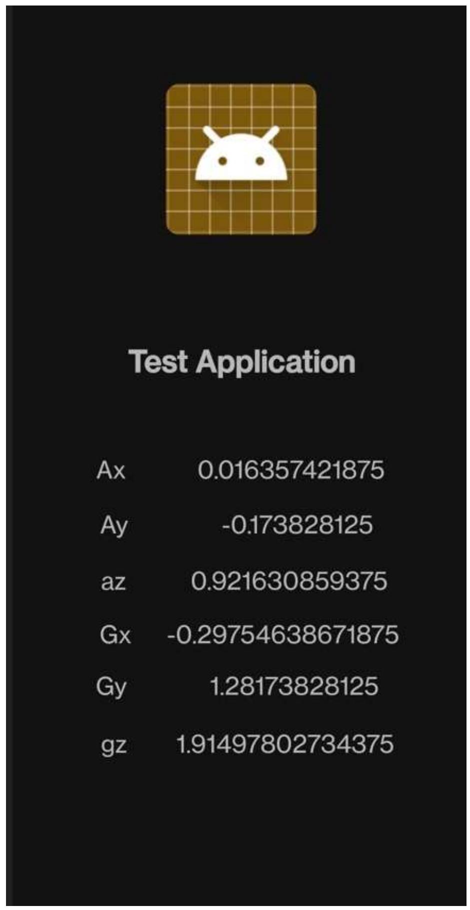

Figure 3: App Interface

The front-end and back-end are divided into two sections for the suggested system. Web applications are used to make client mode. Client uses webcams to take pictures

3.2.2.1. Use case:

These diagrams explain how the system functions. The user performs the tasks, as portrayed in use case diagram, where user works on system's eternal entities and use case diagrams for its components and working.

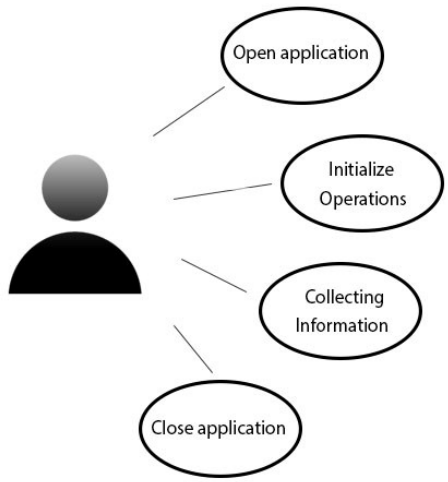

Figure 4: use case diagram

3.3 Proposed Method:

The exercises that are performed in virtual physical therapy ought to be identical to those that are performed in physical therapy settings, but without a physiotherapist present in person. A virtual assistant in the form of a web application and a number of games tailored to the patient are required for a patient to be able to navigate a therapy session. The IoT-based telerehabilitation framework is comprised of locally established and cloud-based sections.

The pilot model device exoskeleton, which will be attached to the hand of the stroke patient, will be used for telerehabilitation in this instance. The exoskeleton is outfitted with sensors like IMU to measure the force, angular rate, and magnetic fields produced by the subject's hand. A sensor fusion algorithm, also known as an IMU, or sensor combination, provides orientation and heading measurements. In addition to the sensors, the actuator was also a part of the project. Telerehabilitation will be done with the pilot model device exoskeleton, which will be attached to the stroke patient's hand. Servo motors are being used as an actuator in this instance. It will precisely spin and push various machine elements. Servo motors are frequently used for defined velocity, acceleration, and angular or linear position.

The project also includes cloud servers to store the dispersed data generated by the exoskeleton and for automated management in order to provide a flexible method for scaling programs across a large network of connected computers or devices. The cloud-based methodology the model also utilizes a software to the customer is known as software as a service (SaaS). Instead of buying and installing an application, SaaS consumers subscribe to it. SaaS is preferred because it allows users to access the application from any compatible device via the internet.

Chapter 4: Result and Simulation:

The study's goal is made quite clear: it aims to aid in the recovery and functional restoration of those who have experienced hand strokes. As after the investigation is conducted, the suggested study can help us get an accurate result.

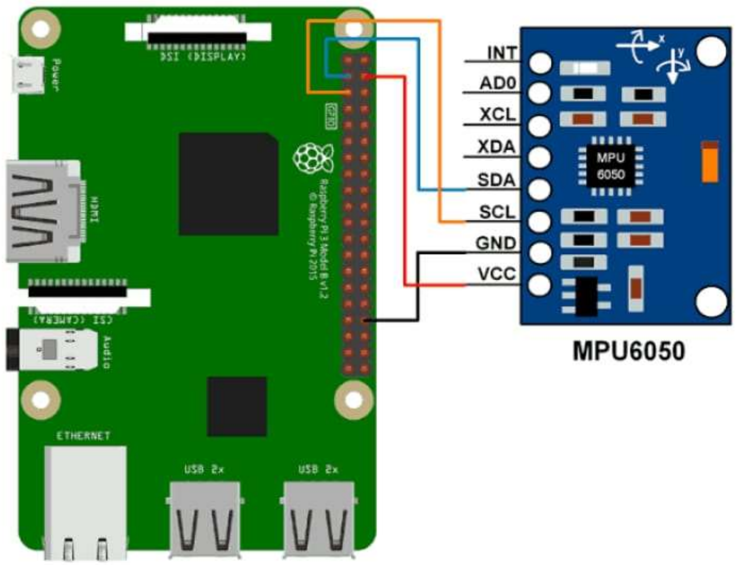

Figure 5:Simulation of MPU6050 with Raspberry pie

To ensure the success of our research, the solution utilizes variety of techniques and tools. The equipment we'll be working with, including the IMU sensor, Servo Motor, and Arduino microcontrollers, is specifically designed for developing Internet of Things (IoT) applications that are smart (IoT). These techniques and tools have already been employed in significant projects, and they were effective.

However, the construction of a robotic skeleton (Exoskeleton) that can take commands automatically and respond in accordance with user requirements is our main goal for this project.

4.1 Simulation:

Following below is the stepwise simulation of the project. The project process is briefly explained from the software and hardware end. Below are the results of how the simulation was conducted and desirable results obtained.

Step 1: -

The first step is to integrate all the sensors with the Raspberry PI . After the sensors are connected with Raspberry PI , the PI is check ensuring the secure and safe connection. First figure displays the user application window. After opening the PI its configuration mode is selected from the preferences. After that a tab is opened named Raspberry PI Configuration is opened. Then the interfaces mode is selected. In the interface mode the SSH and I2C port are selected showing Sensor connection and enabling I2c port .This indicates the serial connections of sensors with PI. the

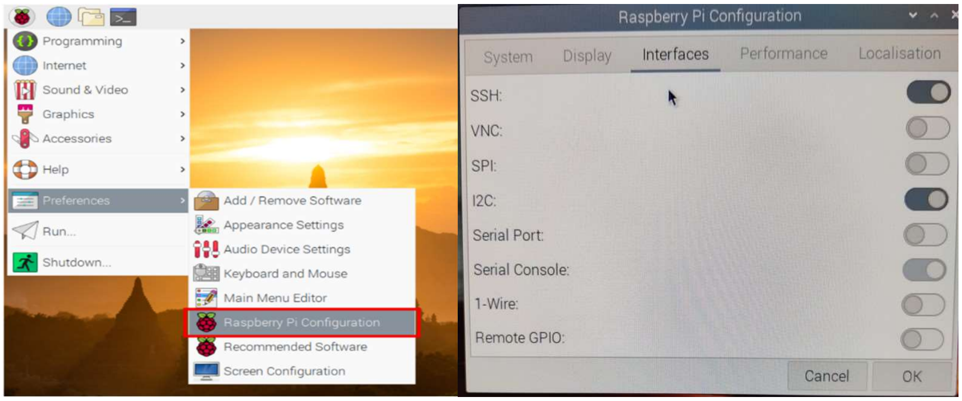

Figure 6: Integration with Raspberry Pie

Step 2: -

The figure displays the troubleshooting of Raspberry PI. After the pi is integrated the first thing checked is the secure connection with sensors. The PI command window displays the dummy values which indicate the connection. The below figure shows the results from the sensors.

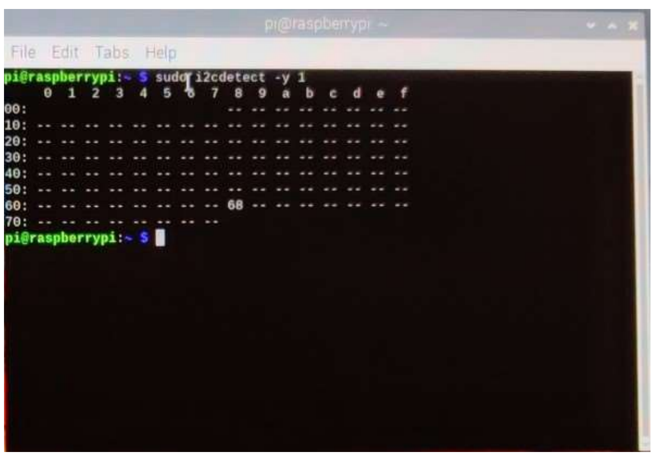

Figure 7:Troubleshooting Pi

Step 3: -

After successful integration of PI with sensors. The PI is then integrated with the web server and Application. Figure displays the Integration of Raspberry PI with AWS Cloud. After the integration the data collected from the sensors is then sent AWS Cloud.

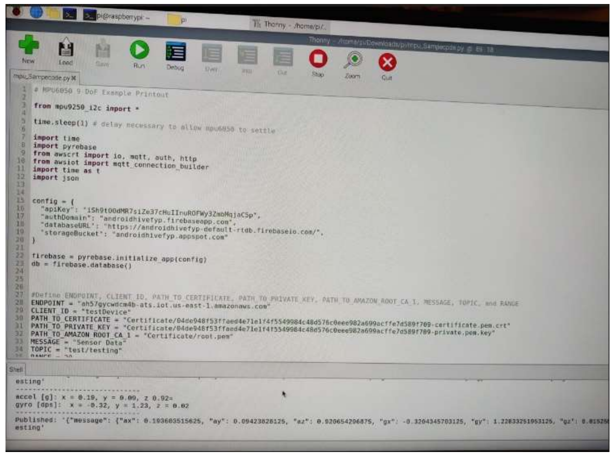

Figure 8: Integration with AWS Cloud

Step 4: -

This step indicates the Data receiving on AWS Cloud. Then MQTT Test Client topic name "test/testing" is utilized for testing and receiving data.

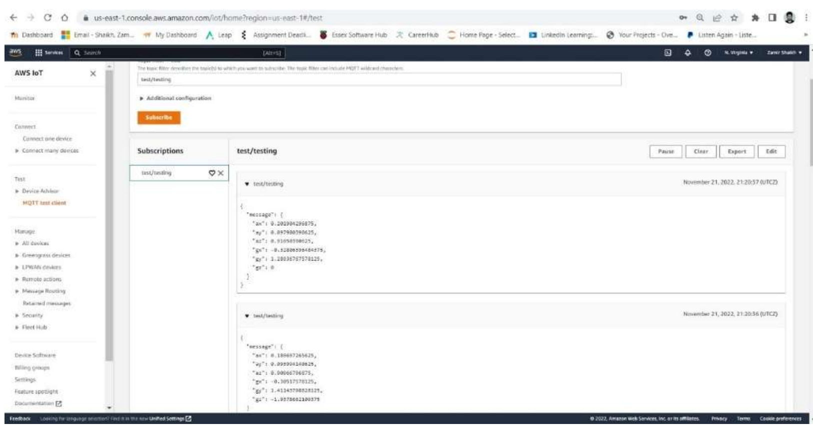

Figure 9:MQTT Test

Step 5: -

The second interface utilized is application interfacing with the module. Below figure illustrate Building up the mobile application for displaying the data from AWS to application .apk. In the figure the AY,X,AZ are the coordinates whose data is received from the sensors.

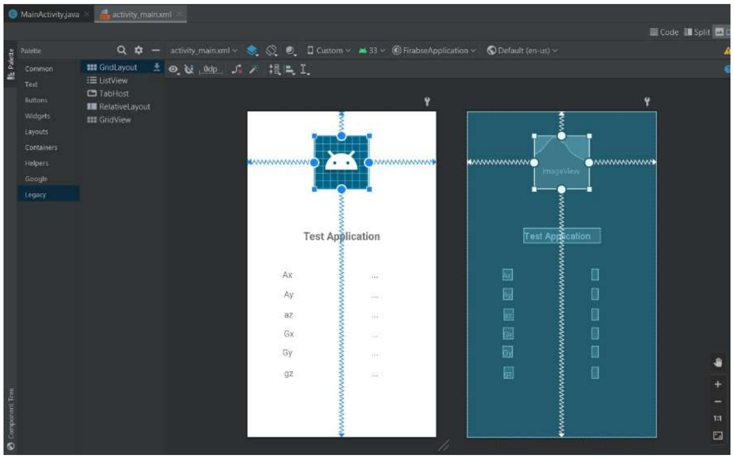

Figure 10:Mobile application Development

Step 6:-

Finally, the figure displays the Data received from the AWS Cloud in real time on the mobile application. The application is finally connected and is displaying the readings from the hardware. This is then the readings are predicted accordingly for the improvements.

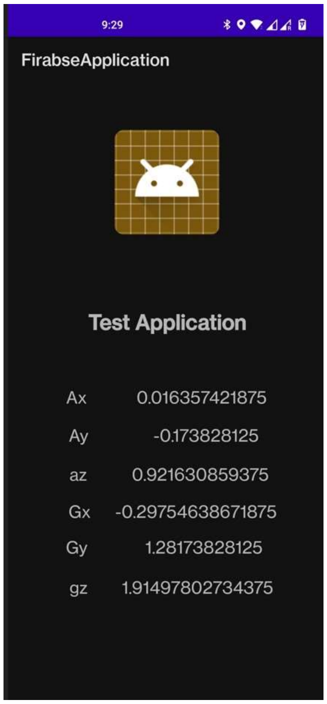

Figure 11:Mobile Application

Chapter 5: Discussion:

Telerehabilitation therapy is a very useful and meaningful approach towards hand stroke patients. In this project, we were focused on how we can help the people who have basic facilities, infrastructure, and support. The patients who are not able to reach the hospitals or clinics on time due to which the hand functions may cause a serious issue. We are aiming to help those patients who can be anywhere in the world and can connect to the doctor or a medical representative from wherever they are. According to the research, although this is just an approach, we have tried to implement in the working base model is inspired by the research we have done in the domain of telerehabilitation. We did not expect the results which we have gained in this approach. We were successfully able to transfer the readings from Raspberry PI to our AWS cloud and which were recorded live. Also, we planned to make a small application to make the readings display on the application over phone in which we got success.

Chapter 6: Conclusion:

With the help of this proposal, the objective is to look into virtual treatment utilizing the Internet of Things (IoT). Our solution may be used by anyone who has finished their basic therapy in a hospital and needs hand rehabilitation to continue at home. The ability to measure performance using reports that are automatically generated at the end of each training session and the simplicity with which each person's demands and skills may be modified are two of the main advantages. In order to achieve effective results in this project, it is vital to mention that collaboration between IT specialists, therapists, and patients was crucial. A variety of tools are used and recommended for changing the accuracy of the output and enhancing the functionality of our model. Though from the suggestion in which the module created a pilot model with sensors, actuators, and a microcontroller. The models can be employed as telerehabilitation for hand functional recovery, it is concluded, for the individuals with stroke. Such models will be widely used because of their effectiveness once they have been developed and put into use. The use of the Raspberry Pi will enable us to undertake artificial intelligence tasks in the future, which will be more beneficial and allow this model to become more advanced.

The technology that was given was utilized to develop a web and app platform for stroke patients that is entirely consumer-based and clinical knowledge-based. Telerehabilitation may be an effective substitute for traditional rehabilitation for post-stroke patients in underserved or rural locations. The health-related quality of life and cost-effectiveness of the continuous developments in telerehabilitation networks need to be evaluated by larger research.

Patients who have survived a stroke can recover faster thanks to the telerehabilitation paradigm presented in this research. The Kinect gadget is a sensor for identifying and following bodily motions. Muscle strength is captured using a muscle sensor. Building a telerehabilitation system that is scalable, dependable, affordable, and user-friendly is made possible by the cloud architectural concept. With the help of this telerehabilitation system, a patient may complete post-stroke rehabilitation therapy from home, which lowers the cost of care by doing away with the requirement that the therapist be there at all times. The therapist has access to the patient's virtual records, and at any time, he or she can check on the patient's actions and remotely direct the therapy. This model, which was created for study and experimentation, will be the basis for a product that will be extensively utilized in post-stroke telerehabilitation and assessment of the degree of recovery.

Patients who used it said that their interactions with it were cordial; they saw it as an addition to their therapy that may enhance medical care; and they exhibited a propensity to utilize the system again. Consequently, the addition of these additional inputs would allow the system to expand its capacity for reasoning and data processing.

Chapter 7: Future Recommendations:

The use of one-to-many virtual treatment means a decrease in the amount of time the therapist spends with patients. Such interactions could occur less frequently or only at the beginning and the conclusion of each session. As a result, the patient could focus without being distracted by technology on carrying out the prescribed motor task. Real-time video and voice communication may be helpful primarily when carrying out the activity, and only then for providing feedback on the achieved performance and maintaining patient desire. Because it could combine a rise in treatment response with a current decline in health expenditures, this method would have a greater likelihood of success. Future study will focus on quantitatively assessing patients' compliance with the recommended regimen. The capacity to provide engaging motor tasks that are specifically tailored to the patient's capacity should help to increase their motivation, which will increase compliance and engagement.

Future study will focus on quantitatively assessing patients' compliance with the recommended regimen. The capacity to provide engaging motor tasks that are specifically tailored to the patient's capacity should help to increase their motivation, which will increase compliance and engagement.

7.1 The burden of stroke today and in the future:

This article provides an overview of the global, regional, and country-specific burden of stroke by sex and age groups, as well as trends in stroke burden from 1990 to 2013, based on the GBD (Global Burden of Disease) 2013 Study. It also outlines recommended measures to reduce stroke burden. It demonstrates that, despite a decrease in stroke incidence, prevalence, mortality, and disability-adjusted life-years rates between 1990 and 2013, there has been an increase in the global stroke burden in terms of the total number of people affected by or who remain disabled as a result of a stroke in people of all ages. This makes a strong case that primary stroke prevention using "business as usual" is not effective enough. There is strong evidence that substantial stroke prevention is practicable, despite the fact that the prevention of stroke is a complicated medical and political issue. It is urgently necessary to expand the primary prevention measures.

Looking at the estimates of the current burden of stroke and projected the future burden over a longer time period with expert opinions on probable future trends in the numbers of first-time strokes (stroke incidence) and survivors (stroke prevalence) each year.

The potential future costs of stroke over the next ten to twenty years (at prices of 2015) and updated estimates of the current societal costs of stroke are reviewed and the following costs were considered:

The National Health Service (NHS), personal social services (PSS), such as public and private-paying care homes, informal (unpaid) caregivers like family and friends, and the public in terms of productivity losses caused by stroke survivors losing or losing employment.

7.1.1 Stroke's current toll:

The range of the yearly expected number of new cases of stroke is between 113,400 and 119,100. The number might theoretically range from 85,800 to 147,600 if the incidence rate ranges given by several individual research are used 12 Patel et al., 2020, Stroke's monetary impact in the UK. For our different computations, it utilized the mid-point gauge of 117,600 (Stewart et al.,1999).

In the UK, there were between 950,000 and 1.3 million stroke survivors (stroke prevalence) aged 45 and older in 2015. The range could be between 797,000 and 1.4 million when the low and high figures from several individual research are taken into account. For our various computations, the mostly utilized estimate is of 950,200 (Geddes et al., 1996).

7.1.2 Future stroke costs:

Whether the incidence of stroke would go down or up in the future was a subject of disagreement among experts. Their opinions on prevalence were more in line with one another, pointing to no change or slight increases in prevalence among those aged 40–74 and a moderate to significant increase among those aged 75–100. When these perspectives are applied to the rates of stroke incidence and prevalence at the present time, they reveal projections of demographic trends and a significant future burden from a stroke.

The number of people 45 and older who have their first stroke in the UK will rise by 59% from 117,600 in 2015 to 148,700 in 2025 and 187,000 in 2035. Incidence rates for people between the ages of 45 and 84 are anticipated to stay the same until 2035, while incidence rates for people 85 and older are predicted to rise by 0.5 percent annually, based on expert opinions. Depending on whether annual incidence rates rose or fell by 1%, the incidence rates in 2035 would either be 228,000 or 153,000.

From 117,600 in 2015 to 148,700 in 2025 and 187,000 in 2035, there will be a 59% increase in first-time strokes among people 45 and older in the UK. It is assumed, based on expert opinions, that incidence rates for people aged 45 to 84 will remain the same until 2035, while incidence rates for people 85 and older will increase by 0.5 percent annually.

The method that was put into action is a novel idea for designing a multifunctional system that can telerehabilitation stroke patients. The proposed strategy demonstrates how selecting specific open-source development tools can speed up and make these products more successful.

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