Development of a Smart IoT Glove for Assistive Hand Motion Rehabilitation in Quadriplegic Patients

S.VINOTH
Department of Biomedical Engineering
KIT – Kalaignarkarunanidhi Institute of Technology
Coimbatore, India
Vinothselvamani@gmail.com

R.GOWTHAMI
Department of Biomedical Engineering
KIT – Kalaignarkarunanidhi Institute of Technology
Coimbatore, India
gowthamiregula@gmail.com

S.NISHALINI
Department of Biomedical Engineering
KIT – Kalaignarkarunanidhi Institute of Technology
Coimbatore, India
nishalinisuresh1981@gmail.com

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S.SUBHASHINI
Department of Biomedical Engineering
KIT – Kalaignarkarunanidhi Institute of Technology
Coimbatore, India
selvansubashini2@gmail.com

***Abstract*, Paralyzed patients are using gesture guards and Internet of Things (IoT) technologies. IoT sensors can detect vital health signs in real time, such as movement, temperature, and pulse. Patients can show themselves to a gesture guard by using simple hand or finger motions. Health information will be sent online to physicians and caregivers. When an emergency or undetermined change in health occurs, the system sends out fast messaging notifications to the doctors and care givers. More patient safety, and fast access for medical treatment, it may provide more patient independence are all comfort by this. The integration of Internet of Things and gesture guard enhances well- organized healthcare for paralyzed patients and their caretakers.**

Keywords— Gestures, ESP32 microcontroller, flex sensors, Accelerometers, Glove.

I. INTRODUCTION

This People who are paralyzed and unable to move their bodies as they would like. In addition to frequent health examinations, people with paralysis require assistance with daily duties. When you employ standard care, it might be challenging to constantly monitor patients and act fast in an emergency. Better care for these individuals may be possible thanks to the Internet of Things. Sensors that monitor temperature, movement, and heart rate in real time are connected by the Internet of Things. This information may be accessed remotely by medical professionals and caretakers, allowing them to monitor the patient's condition and take quick action as needed[1,6].

Another useful feature is provided by gesture guard technology. It enables patients to interact with devices or communicate using basic hand or body gestures without having to speak or move completely. Patients with paralysis benefit from increased safety and independence as a result[3,7].

II. KEYS FEATURES

A. Gesture-Based Communication

30% represents the largest portion, highlighting that a key feature of the system is allowing patients to communicate using simple gestures. This is crucial as it helps patients express their needs without relying on speech or extensive movement[1,4].

B. Vital Sign Monitoring

30% is equally important, making up another 30%. This involves keeping track of patient health metrics like pulse, temperature, and other body signs, ensuring patients' physical health is continuously observed [5]

C. Real-time Alerts & Notifications

20% take up a significant part of the system, meaning the system can quickly notify caregivers or medical staff if there is an emergency or abnormal health condition, which supports prompt responses[5].

D. Remote Access for Caregivers/Doctors

20% shows that part of the system's goal is enabling healthcare providers and family members to monitor the patient's condition and communicate with them from distance, providing support even when they are not physically present[2].Together, these features create a balanced system focusing equally on communication and health monitoring while also emphasizing safety through real-time alerts and remote caregiver access. This design ensures paralysis patients are not only able to communicate their needs but are also kept safe with continuous health monitoring and instant support options [2,4].

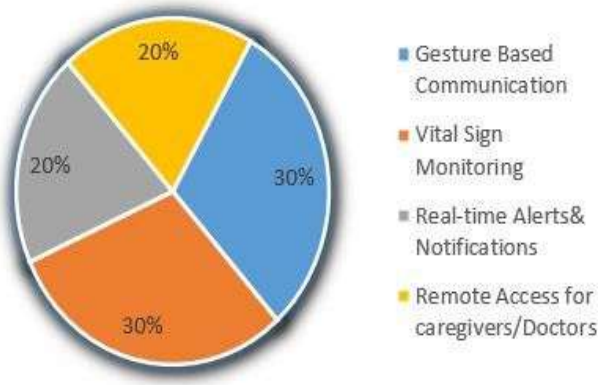


Fig 1: Key Features Analysis in Paralysis Patient Health Care System

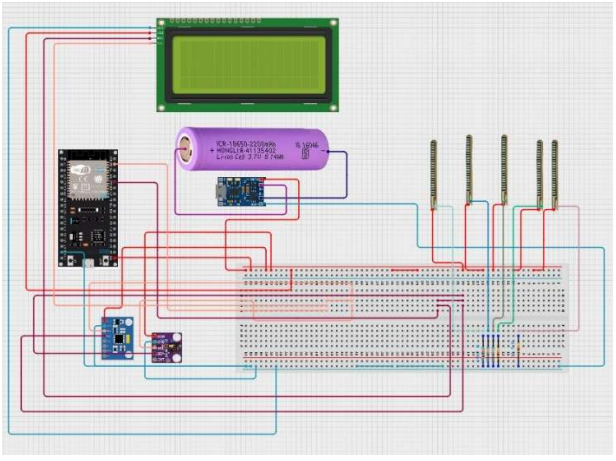
TABLE.1 ANALYSIS OF GESTURES

S.NO	KEY FEATURES	PERCENTAGE
1	Gesture based communication	30%
2	Vital sign Monitoring	30%
3	Real-time & Notifications	20%
4	Remote access for caregivers	20%

III. LITERATURE SURVEY

Several studies have shown that the significant benefits of using IoT technology in the treatment of paralyzed patients. IoT uses sensors for continuously track vital signs like temperature, movement, and heart rate, and transmits this information to medical professionals and caregivers from a distance. This may give better health tracking and quick medical responses. Patients are also being assisted in communicating through the use of gesture guard technology. Simple finger or hand movements are tracked by this technology, which then translates them into commands or messages[7]. It increases the independence of patients who are unable to communicate or move this gesture will enable them to express their needs and operate devices. Some systems offer easy communication and health monitoring by combining gesture guard and IoT. These systems frequently consist of wrist or glove devices that have wireless modules, microcontrollers, and sensors.These may sends alert messages to the care givers and doctors when they are in emergency situations[5].

Fig.3. Circuit Diagram



IV. METHODOLOGY

A wearable gadget, like a glove or wristband, with sensors to identify basic hand movements or gestures is used by the gesture guard healthcare system for paralyzed patients. The patient can easily express their needs with these gestures, such as requesting water, phoning for assistance, or Showing discomfort. Through the use of sensors, the device recognizes a patient's gesture and notifies a caregiver via a notification on a phone, display, or alarm. This makes everyday care more comfortable and less stressful for patients and caregivers by enabling patients, even those who struggle with speech, to express themselves quickly and clearly[4].seeks to use the cloud to discreetly monitor vital signs, translate small, dependable gestures into obvious actions, and promptly notify caregivers. The design prioritizes IoT connectivity for ongoing support at home and in clinics, low- cost sensors, and on-device processing for speed.[1]

V. FUNCTIONAL BLOCKS

Patient Gesture Detection: The patient, who is wearing flex sensors, initiates the system. By reacting to the patient's hand or finger movements or bends, these sensors successfully record their gestures.

Movement Sensing with Sensors: Electronic sensors, such as accelerometers (more especially, the MPU6050) and gyroscopes, then gather comprehensive movement data. The system can comprehend the patient's hand or arm movements thanks to these sensors' sensitivity to changes in motion and orientation[3].

Signal Processing: The ESP32 microcontroller receives the data that the sensors have collected. By processing the signals and deciphering the patient's gestures, this device serves as the system's brain[1].

Display Unit (7-Segment LCD): An LCD may optionally show status or pertinent information once the ESP32 has detected a gesture. The detected gesture in this system may be represented by a code or symbol on a 7-segment display[1,4].

Alert Notifications: Lastly, the system sends out an alert if specific gestures indicate that assistance is required. A doctor or caregiver receives this message, guaranteeing prompt attention to the patient's needs. An SMS, an IoT dashboard, or other linked notification systems can be used to send the alert[5,3].

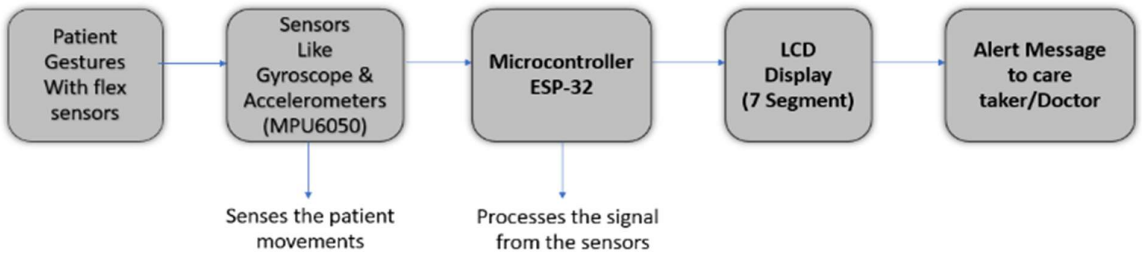


Fig 2: Block diagram of Gesture Guard

VI. PROBLEM STATEMENT

In their everyday lives, people who are paralyzed frequently run across significant difficulty. Communicating their needs is a main challenge for them, particularly when they talk and movement abilities are small. Because of this,

people become anger and depending on others to do even simple things like moving around, drinking water, or

for support[3,4].Accordingly for communication, it's crucial to continuously check on their health because paralysis can carry high risks like sudden changes in heart rate, temperature. Sadly, a lot of the systems in use today lack real-time health data and quick methods for notifications to caregivers of emergencies. There may occasionally be major outcome from this delay[5].Thus, a user-friendly system that enables paralyzed patients to communicate with ease using simple, natural gestures they can still make is extremely needed. Additionally, such a system must to continuously monitor critical health signs and instantly notify family members or medical personnel when necessary. This would guarantee quick medical attention and peace of mind for patients and caregivers, in addition to improving their independence[1,5] .

VII. EXISTING WORK

The majority of the current paralysis patient care systems use wearable gloves with sensors, such as flex sensors and gyroscopes, to identify hand and finger movements. With the use of these gloves, patients can use gestures to communicate basic instructions, which a microcontroller—typically an Arduino or ESP32—will translate. To make sure that the patient's health status is continuously monitored, many current models also contain basic vital sign monitoring, such as temperature and heart rate[5]. To send data continuously to caregivers or healthcare providers, these systems incorporate communication modules such as Wi-Fi and GSM. To proper detected gestures or emergency alerts, alert mechanisms like buzzers, vibration motors, or small displays will give. Even though they work well, the majority of current solutions have accuracy issues with gesture recognition accuracy, wearable device comfort, and real-time health tracking. Many do not incorporate Advanced AI methods or smart home control features[6].

VIII. FUTURE ENHANCEMENT

The Gesture Guard system will be improved in the future to become more intelligent, flexible, and user-friendly. A more complete picture of the patient's health may be obtained by including extra sensors, such as oxygen saturation monitors and pressure sensors. The process of understanding gestures may be improved by artificial intelligence and machine learning, which would enable the system to better comprehend faint or less movements and adjust to the particular conditions of each patient[8].Caregivers will be able to continuously monitor patients in real-time via computers or smartphones thanks to integration with IoT cloud platforms, and they will receive automated alerts in the abnormal situations of an emergency. The system could be extended to enable gesture-based control of smart wheelchairs, home appliances, and emergency response equipment, similarly increasing patient independence[5].

Wearable technology enhancement will highly concentrate on making gadgets more comfortable, wireless, and lighter for long time daily use. Future Generations should classify emergency features like voice assistance, medication reminders, and fall detection. The goal of this pathway is to offer a thorough, in dependable, and user-friendly sy IV. RELATED WORK

The goal of many research projects is to use wearable sensor- based devices to help paralyzed patients communicate and recover some degree of independence. A glove equipped with flex sensors and inertial measurement units (IMUs), such as gyroscopes and accelerometers, is one of the most widely used instruments. Microcontrollers like the ESP32 process the hand and finger movements that these sensors record in order to identify particular gestures. Commands like requesting assistance, turning on lights, or operating appliances can be represented by these gestures.[8]Early research showed that even in patients with limited motor control, flexible sensors worn on the fingers in connection with IMUs can accurately identify patient gestures. This combination gives the difference between spontaneous, natural movements and careful commands. For instance, particular finger bending patterns can improve communication for patients with speech impairments by setting off alerts or sending messages to caregivers.[1]These gesture systems have been enhanced with health monitoring in recent years. The gadgets continuously check vital signs and check gestures using sensors for body temperature, oxygen saturation, and pulse rate. The system automatically sends out alerts via GSM or Wi-Fi networks when health parameters show abnormalities, such as high body temperature or abnormal heart rate. Caregivers can respond to emergencies more quickly thanks to this real-time data sharing[3].Remote monitoring via cloud platforms or mobile apps is made possible by the communication component, which frequently uses wireless modules like Wi-Fi and GSM. Regardless of their location, caregivers or medical personnel can receive alerts instantly, enhancing safety and enabling quick intervention. The patient receives confirmation that their command or alert has been processed through feedback features such as buzzers, vibrations, or tiny displays. [7]

Even with these developments, there are still certain problems that must be resolved. Because gloves can be heavy and difficult to wear for extended periods of time, many systems have poor comfort. Depending on finger strength and movement patterns, the accuracy of gesture recognition can change, resulting in missed commands or false triggers. In order to improve this, scientists are investigating machine learning techniques to customize gesture recognition for every patient, increasing the dependability and flexibility of systems[8].Additionally, for patients with severe hand mobility issues, alternative control methods such as head movements, eye gestures, or facial expressions are being investigated. For an all-encompassing communication tool, these techniques can also be combined with glove-based systems.[6] Current advancements show that sensor-based systems have the potential to manually improves the quality of life for individuals with paralysis; however, more work is required to make these devices ,and more usable, affordable, and comfortable for daily use[1].

IX. RESULT AND DISCUSSION

The Gesture Guard medical system's dependability in identifying hand gestures and tracking vital signs like body temperature and pulse rate was evaluated. Patients were able to express their needs in a clear and timely manner thanks to the system's good accuracy in identifying preset gestures. The overall accuracy was increased by using flex sensors in combining with the MPU6050 motion tracking sensor to distinguish between planned and unplanned hand movements[1]. Vital sign sensors were able to continuously

measure temperature and heart rate, giving real-time access to vital health data. The system ensured that the caregiver received quick attention by sending alerts to their Blynk app when abnormal conditions such as fever or a high pulse were detected. " For paralyzed patients who might not be able to vocally request assistance, this feature has the potential to similarly shorten emergency response times[5]. In order to minimize confusion and repeated attempts, feedback mechanisms such as buzzer alerts and display messages successfully verified to the patient that their gestures or health alerts were processed. The Blynk app integration made it possible for doctors and caregivers to keep an eye on patients from a distance, which improved convenience and peace of mind for everyone[6]. Simple gestures were also used to test smart home controls, allowing patients to call for family members or turn on or off lights and fans without exerting themselves. This ability improves daily living quality and encourages independence[1].There are still certain difficulties, especially when it comes to adjusting gesture recognition to each patient's unique capabilities because muscle control varies greatly. Adaptive machine learning classification may be used in future developments to better capture weak or subtle movements. In order to make the device suitable for extended use, future iterations will also address the glove's wearability and comfort. All things considered, the system fills a critical gap in individualized home healthcare by combining health monitoring, intelligent gesture control, and quick communication with caregivers to help paralyzed patients[3].

X. CONCLUSION

The Gesture Guard system offers a significant remedy for a number of issues that paralysis patients encounter. It allows patients to express themselves without the need for speech or complicated movements by allowing basic hand and finger gestures to control household appliances or communicate critical needs. By continuously monitoring temperature, heart rate, and indications of distress, vital sign monitoring provides an essential extra degree of security[4]. When stem that

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