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IoT AND sEMG BASED GLOVE FOR ASSISTIVE HAND REHABILITATION

Dr. Smitha B, Department of Electrical and Electronics Engineering, NSS College of Engineering Palakkad, Kerala, India.
Amruthavarshan P H, Department of Electrical and Electronics Engineering, NSS College of Engineering Palakkad, Kerala, India.
Dhrisya S, Department of Electrical and Electronics Engineering, NSS College of Engineering Palakkad, Kerala, India.
Anjitha T V, Department of Electrical and Electronics Engineering, NSS College of Engineering Palakkad, Kerala, India.
Diyu Ahammed, Department of Electrical and Electronics Engineering, NSS College of Engineering Palakkad, Kerala, India.

ABSTRACT :
About 70–85% of people who get a stroke suffer from partial hand paralysis. In this paper, we have designed a soft exoskeleton hand rehabilitation glove that works in two modes: IoT mode and sEMG mode. The IoT mode helps in an easy way of using the glove for physiotherapeutic exercises, as well as a grip mode to help in gripping things with the help of a touch sensor for the feedback of the object for gripping. The sEMG mode helps in assisting and encouraging the use of muscles for better and faster rehabilitation of the partially paralyzed hand.
Keywords: sEMG-Controlled Rehabilitation, IoT-Enabled Assistive Glove, Adaptive Hand Mobility Aid

INTRODUCTION:
According to the World Health Organization, around 15 million people worldwide experience a stroke every year [1]. Partial paralysis of the upper extremities is a common condition among people affected by stroke, spinal cord injuries, and muscular dystrophy. Since 2004, approximately 610,000 new stroke cases have been reported annually in the USA, with this number expected to rise due to the aging population [2]. Physical rehabilitation plays a crucial role in restoring functionality and mobility after a stroke [3]. However, due to the time and the frequent need for patient to be hospitalization led to significant healthcare and social expenses [4]. As a result, there is increasing interest in developing innovative technologies to improve patients' daily lives while reducing rehabilitation costs.
In recent years, soft gloves have been made by researchers to help in hand rehabilitation at home itself. The exoskeletons are becoming more efficient, less costly, and easy to use for common people. The significance of soft wearable ex- skeletons in physiotherapy is increasing, allowing treatment anytime and anywhere. In [5], the authors present a rigid hand exoskeleton for both passive and active rehabilitation therapy, utilizing motor impedance. Additionally, Popov et al. [6] introduces a portable glove actuated by motors, designed to assist with ADL. Soft solutions for hand rehabilitation also include glove-based devices. In [7], a soft robotic glove based on pneumatic actuators and controlled by a Brain- Computer Interface (BCI) was tested with 10 patients, with five patients testing only the glove and another five testing the glove controlled by BCI. Although no significant difference was found between the two groups, in the case of the BCI- controlled glove, the authors mentioned a probable trend of prolonged improvements.
Surface electromyography (sEMG) is widely used in rehabilitation to assess muscle activity and facilitate assistive therapies. It enables real-time monitoring of neuromuscular function, aiding in the development of rehabilitation devices such as exoskeletons and prosthetic control systems. sEMG-based rehabilitation has shown promise in improving motor recovery, enhancing muscle coordination, and reducing recovery time by providing personalized therapy based on muscle activation patterns [9].

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In this paper, we have designed and made an sEMG and IoT-based soft glove which is used for intuitive and portable hand rehabilitation soft glove. In this paper, we have designed and made an sEMG and IoT- based soft glove, which is used for intuitive and portable hand rehabilitation. The sEMG detects signals from hand gestures and muscle movement. This signal triggers the two motors to run in a cycle of rotation, resulting in the flexion and extension of fingers. In this way, the user is encouraged to move their muscles, eventually helping in hand rehabilitation. The IoT mode comes with a grip, as the motor will move according to the command given from the Bluetooth-connected phone. When the glove detects an object during flexion via the touch sensor, the motor stops after a delay so the user can use it for grip.

METHODOLOGY :

The glove operates in two modes: an intention-based mode utilizing surface electromyography (sEMG) and a Bluetooth- controlled mode as shown in the block diagram Figure 1. The signals or commands in both modes are processed by the microcontroller board and operate the two DC motors connected to the L298N drive accordingly. One can easily switch between these modes by operating a simple switch. When the switch is ON, the glove operates in intention- assisting mode. In sEMG mode, electrodes are placed either on the inner forearm or biceps to collect EMG signals. The two main electrodes are placed at the start and end of the target muscle, and a reference electrode is placed on a bony part like the elbow as shown in Figure 2 [image ref]. The EMG signals collected during muscle contraction by the electrodes in the range of micro volts are processed by the muscle sensor board. Advanced sensors are available nowadays to measure, filter, amplify, and rectify these micro signals so that they are easily processed by the microcontroller.

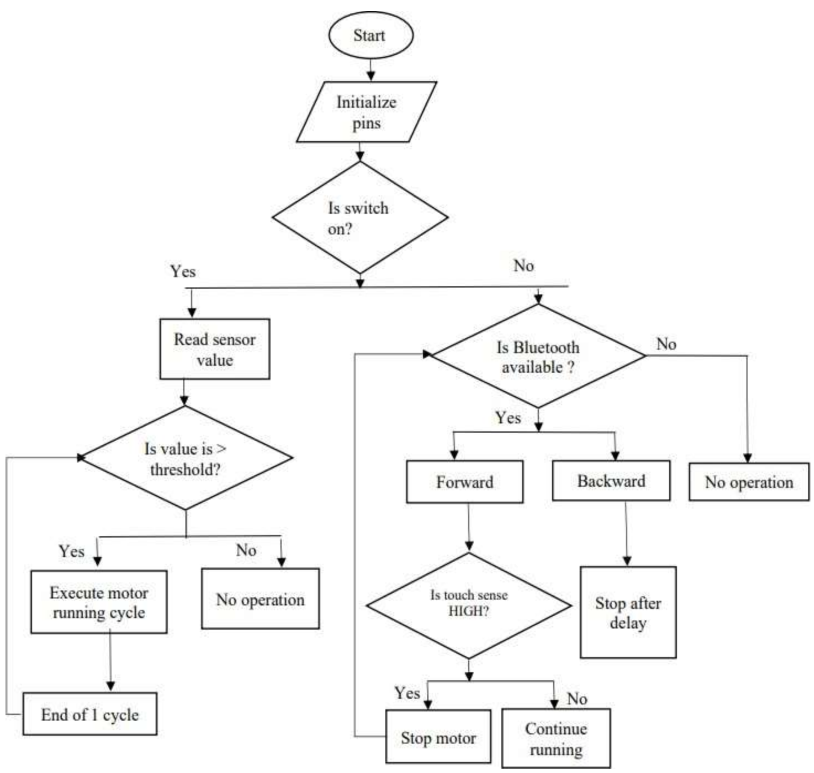

Figure. 1. Flowchart of Proposed system

Here, the Arduino UNO will process the signals and output a value between 0- 1023. We have set a threshold, for which the motors will start to complete one full cycle, which constitutes one finger flexion and extension movement, so the patient has to try to induce muscle contraction voluntarily, at least with enough strength to cross the threshold, to experience the fingers moving. Once one cycle is complete, the motors stop, and the patient has to try again to start another cycle.

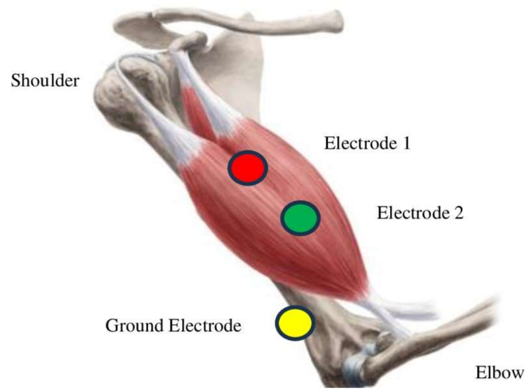

Figure. 2. Electrode Placement

The flow chart of the code we used is shown in Figure 3. When the switch is OFF, the glove can be operated in Bluetooth-controlled mode. The caregiver or therapist can connect the glove to their smartphone using the Bluetooth module incorporated into the glove. Once connected, one can start sending commands to control the glove.

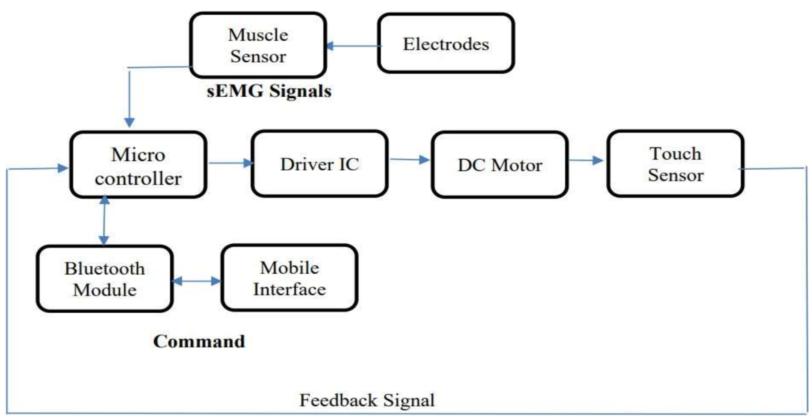

Figure.3. Block Diagram

The command 'F' will make the motors run in a direction to contract the fingers, and the command 'B' will move the motors in the other direction, causing the extension of the fingers. The interface of the app is shown in the Figure 4 To get the experience of holding; a touch sensor is provided. When the fingers close and the touch sensor output goes HIGH if something is held, the motors will stop after a delay to tighten the grip.

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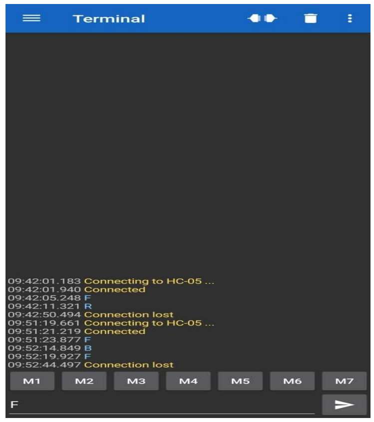

Figure. 4. App Interface

RESULTS AND DISCUSSION:

This smart glove employs a dual-control system to assist individuals with limited hand mobility, particularly those re- covering from strokes. The primary control method utilizes surface electromyography (sEMG), where electrodes attached to the arm detect minute electrical signals generated by muscle contractions. When these signals surpass a predetermined threshold, indicating an intended movement, the glove's internal motor activates. This motor manipulates internal strings, facilitating finger flexion for gripping or extension for hand opening. Crucially, the glove incorporates brief pauses between movements to ensure accurate signal interpretation and prevent unintended actions, directly responding to the user's neurological intent. The final output of finger flexion and extension is shown in the figure 5. For individuals with severely weakened or inconsistent muscle signals, a supplementary smartphone application provides an alternative control pathway. Users can input commands like" F" to trigger hand closure (flexion) or" B" for hand opening (extension). This app-based control offers precise, pre-programmed movements, allowing for targeted rehabilitation exercises even when muscle activity is minimal. A built-in sensor acts as a safety mechanism, preventing excessive force application and safeguarding the user's hand from potential injury. This feature is paramount, ensuring that the glove provides assistance without causing harm, this touch sensor also help in providing grip to hold on to object as shown in the Figure 6.

Figure. 5. Finger Flexion and Extension

The combined functionality of EMG-based and app- controlled movements positions this smart glove as a promising tool for rehabilitation. By directly responding to neurological signals and offering a controlled, programmable interface, the glove facilitates repetitive exercises essential for motor recovery. This dual approach addresses a wide range of patient needs, from those with residual muscle activity to those requiring external control, ultimately enhancing hand function and promoting independence.

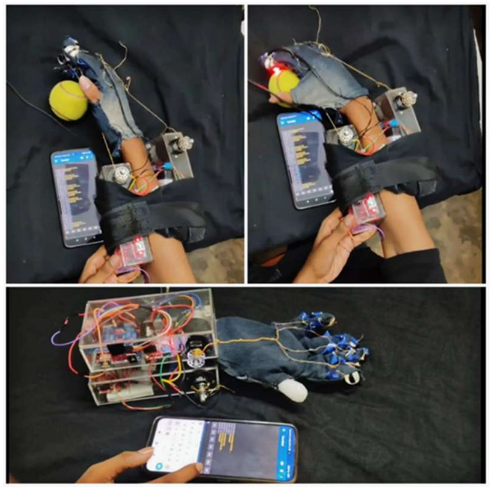

Figure. 6. Grip mode testing

CONCLUSION

The physiotherapeutic soft glove for hand rehabilitation was successfully tested in both IoT and sEMG modes. The final output was recorded, demonstrating the effectiveness of the system in assisting hand movements through muscle signal detection and remote-control operation. The integration of sEMG-based intention detection and Bluetooth-controlled actuation ensures flexibility in rehabilitation, allowing users to regain motor functionality with minimal external assistance. The final output had some flaws as the threads were tangling, future improvements may focus on enhancing signal processing accuracy and optimizing user comfort by using smaller motor and components and comfortable material for the box.

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