International Scientific Journal of Engineering and Management (ISJEM) ISSN: 2583-6129
Volume: 04 Issue: 05 | May – 2025 DOI: 10.55041/ISJEM03568
An International Scholarly || Multidisciplinary || Open Access || Indexing in all major Database & Metadata

Paralyzed Hand Strength and Mobility Enhancer

**Prof. Anil Bavaskar, *Ms. Vaishnavi Giradkar, *Ms. Yeeyakshu Deo, *Ms. Sejal Anjankar, *Ms. Shruti Kukde, *Ms. Samruddhi Ingole

**Faculty Guide - Dept of Electronics and Telecommunication, Cummins College of Engineering for Women, Nagpur

* Dept. of Electronics and Telecommunication, Cummins College of Engineering for Women, Nagpur

***Abstract*— In the modern era of technological advancement, the integration of biomedical engineering with assistive technology has become a crucial area of research. This paper discusses the development of a Paralyzed Hand Strength and Mobility Enhancer, an assistive system designed to improve hand mobility and restore partial functionality in individuals suffering from hand paralysis. The proposed system incorporates neurostimulation and sensor-based technology to facilitate controlled muscle activation. By converting neural impulses from the brain into electronic signals, the device stimulates paralyzed muscles, enabling movement through targeted electrical impulses. The proposed solution is expected to reduce dependency on caregivers, improve quality of life, and promote rehabilitation in patients suffering from hand paralysis.**

Future developments aim to enhance the accuracy of neural signal detection, improve the system's responsiveness, and integrate the device with other assistive technologies to create a more comprehensive rehabilitation tool.

Keywords—electrophysiology, neuro science, Hand model

I. Introduction

Paralysis due to brain injuries in India has increased significantly since 2000. Stroke cases surged from 650,000 in 1990 to over 1.25 million in 2021, with the incidence rate rising from 76 to 88 per 100,000 individuals. Traumatic brain injuries (TBI) affect 1.5 to 2 million people yearly, causing nearly 1 million deaths annually. Spinal cord injuries (SCI) also remain a concern, with 44% caused by road accidents and 38.3% by falls between 2012 and 2022. Despite medical advancements, rehabilitation services remain insufficient, increasing the burden on patients and families.

Muscle movement is controlled by neural signals relayed from the brain to the muscles via a complex network involving the brain, spinal cord, and nerves. Damage to any part of this neural relay system can result in impaired muscle function or paralysis[1]. Neurological conditions, such as spinal cord injuries or nerve damage, disrupt the transmission of these signals, leading to a loss of voluntary muscle control. One promising field addressing this issue is neuroprosthetics and hand to hand interface which focuses on designing devices that interface with neurons to restore movement or provide sensory substitution.

However, for individuals with intact muscles but damaged neural pathways, a complementary approach known as
functional electrical stimulation (FES) has emerged. FES involves directly stimulating the muscles using electrical impulses, bypassing the damaged neural connections. This technique has shown potential in restoring limited movement, such as helping individuals stand, walk, or regain control of paralyzed limbs.

By combining electrophysiology setups with electrical stimulation, researchers can capture neural pulses, convert them into electronic signals, and use these signals to generate controlled electrical discharges to stimulate paralyzed muscles. This review will explore the current advancements in neuroprosthetics and FES, highlighting their application in rehabilitating paralyzed individuals and their potential to improve motor functions and quality of life.

This study presents the development of a Paralyzed Hand Strength and Mobility Enhancer, an advanced assistive device engineered to augment grip strength and restore functional hand movement in individuals with partial paralysis. By integrating principles of biomechanics, neuromuscular stimulation, and intelligent actuation, the proposed system aims to facilitate controlled hand mobility, thereby enabling users to perform essential daily tasks with greater ease.

Through an interdisciplinary approach combining medical rehabilitation, robotics, and human- centered design, this research seeks to create an innovative, cost-effective, and adaptable solution tailored to the diverse needs of individuals with impaired hand function.

II. LITERATURE REVIEW

The impaired mobility and restricted freedom faced by individuals paralyzed due to spinal cord injuries or neurological illnesses pose significant challenges to their daily lives. The lack of customization, rigidity, and high cost of traditional prosthetic solutions prevent paralyzed people from recovering their usual hand movements. The considerable customization needs of current prosthetic devices provide issues that drive up costs and lengthen wait times[2].Many people suffer from paralysis because of damage in their nervous system, especially the spinal cord, or due to Amyotrophic Lateral Sclerosis (ALS). With the loss of motor functions, these individuals are forced to be dependent on others for fulfilling their daily needs and

care. Unfortunately, this leads to a lower quality of life for them. Although there exist human-computer interfaced systems that allow the paralyzed to control [3].Direct Brain Interface (DBI) technology enables voluntary control of devices through brain activity, offering potential for restoring hand mobility in paralyzed individuals. It uses cross-correlation of trigger-averaged electrocorticogram (ECoG) segments (“ERP templates”) with continuous ECoG to detect event- related potentials (ERPs) linked to specific movements. This method, proven effective in EEG and ECoG studies, is simple, robust, and suitable for real-time application[4].These methods highlight the effectiveness of eye-based interfaces, which can inspire innovative solutions for enhancing hand strength and mobility in paralyzed individuals through intuitive, non-invasive control systems [5].

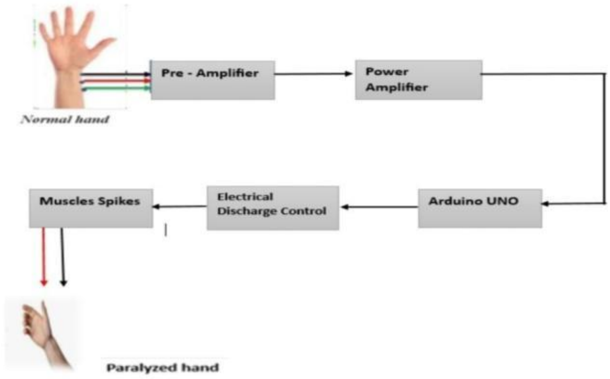
III. PROBLEM DEFINATION

The motivation behind this project is to assist individuals with hand paralysis caused by strokes, spinal cord injuries, or neurological disorders, which limit mobility and increase dependency on caregivers. Traditional rehabilitation methods are slow and require external assistance, making recovery challenging. To address this, the Paralyzed Hand Strength and Mobility Enhancer is developed as a wearable device that restores hand function using neurostimulation and sensor technology. By converting brain signals into electrical impulses, the system stimulates paralyzed muscles, enabling movement and improving grip strength. This solution promotes independence, supports rehabilitation, and adapts to individual needs. Future advancements will enhance neural signal accuracy and system responsiveness for more effective recovery.

IV. Working Principle

The EMG Spiker Shield circuit consists of multiple stages designed to extract useful information from raw EMG signals. The primary functions of the circuit include signal acquisition, amplification, filtering, rectification, and interfacing with microcontrollers or external devices. The system operates by receiving weak electrical signals from muscles via surface electrodes, which are then processed for further analysis or control applications.

Fig. 1 Functional Blocks of the EMG SpikerShield Circuit



1. **Input Stage (EMG Signal Acquisition)**

The circuit's input comes from an EMG sensor, which detects electrical activity generated by muscle contractions. These signals are typically in the microvolt range and require significant processing before they can be used effectively. The input stage ensures proper signal capture and transmission to the amplification section.

2. **Signal Amplification and Bandpass Filtering**

Filtering Since raw EMG signals are very weak, they pass through an initial gain stage where they are amplified to a usable level. A bandpass filter (typically 80Hz–250Hz) is implemented to eliminate unwanted noise, such as low-frequency motion artifacts and high-frequency interference from external sources.

International Scientific Journal of Engineering and Management (ISJEM) ISSN: 2583-6129
Volume: 04 Issue: 05 | May – 2025 DOI: 10.55041/ISJEM03568
An International Scholarly || Multidisciplinary || Open Access || Indexing in all major Database & Metadata

3. Envelope Detection and Rectification

The amplified and filtered signal undergoes envelope detection, which extracts the overall energy of the EMG signal. This stage also includes rectification, which converts the bipolar AC signal into a unipolar DC signal, making it easier to analyze and interpret the muscle activity.

4. Signal Conditioning and Output

After rectification, the signal is further conditioned using a divider and buffer stage to ensure proper scaling for external devices. The circuit supports interfacing with smartphones and other external systems for real-time monitoring and data analysis.

5. Microcontroller Interface (Arduino Shield)

One of the key features of the EMG SpikerShield is its ability to interface with an Arduino microcontroller. This allows to switch on/off relay circuit according to the amplified signals received from amplifier on analogs pins of Arduino UNO.

6. Muscles Spikes

Relay circuit attached with TEN250 devices enables the flow of electrical discharge in the paralyzed hand. TEN250 is used here to release electrical discharge in paralyzed hand which on output makes movement. TENS250 is controlled using relay circuit.

V. TOOL AND TECHNOLOGY

1. Arduino Uno
2. TENS 250
3. EMG Sensor

a) An Electromyography (EMG) sensor is a device used to measure the electrical activity of muscles by detecting signals generated during muscle contractions. It operates by placing electrodes on the skin over a targeted muscle group, capturing electrical impulses that range from microvolts to millivolts. These signals are then amplified, filtered, and processed to remove noise before being analyzed. EMG sensors have various applications, including *medical diagnostics, rehabilitation, prosthetics, and human-computer interaction. In healthcare, they assist in diagnosing neuromuscular disorders and aiding physiotherapy, while in robotics, they enable the control of bionic limbs and exoskeletons.

RESULT

The project successfully demonstrates a functional approach to enhancing the strength and mobility of a paralyzed hand by using bio-signals from a healthy hand. The system works by capturing electromyographic (EMG) signals from a normal hand through surface electrodes.

These signals are first amplified using a pre-amplifier and power amplifier, ensuring they are strong and clean enough for further processing. The amplified signals are then transmitted to an Arduino UNO microcontroller, which processes the data in real time and converts them into control signals.

These control signals are sent to an electrical discharge control unit that generates corresponding stimulation pulses for the muscles of the paralyzed hand. As a result, the paralyzed hand receives artificial muscle spikes that mimic the activity of the healthy hand. This induces movement in the paralyzed hand based on the motor intention of the normal hand. The system effectively transfers voluntary motion signals from the functioning hand to the impaired one, aiding in functional rehabilitation, muscle reactivation, and strength recovery.

The integration of hardware components such as amplifiers, microcontroller, and electrical stimulation ensures a closed- loop system capable of promoting neuroplasticity and motor learning. This project offers a cost-effective and efficient prototype for neuromuscular rehabilitation, potentially aiding individuals recovering from stroke or nerve injuries.

ACKNOWLEDGMENTS

“This project aims to explore the potential of hand-to-hand interfaces through neuroprosthetics in the field of Biomedical Engineering. The invaluable guidance and supervision of Prof. Anil Bavaskar are deeply appreciated. We also extend our sincere gratitude to the faculty members of the ETC Department at Cummins College of Engineering for Women for their unwavering support throughout the course of this research.

REFERENCES

[1] Anil Bawaskar, & Nishat Sheikh, (2020). Hand to Hand Interface for Paralyzed Person. Studies in Indian Place Names, Volume 40, 3410-3412.

[2] Md Tariquzzaman Azad, Md Farhad Hossain, Safin Rahman, Mohammad Shidujaman, Mengru Xue (July 2024). "Investigating the Functionality of Prosthetic Hand Movements for Paralyzed Individuals.'I. Boglaev, “A numerical method for solving nonlinear integro- differential equations of Fredholm type,” *J. Comput. Math.*, vol. 34, no. 3, pp. 262–284, May 2016, doi: 10.4208/jcm.1512-m2015-0241.

[3] Imran Ali Mirza, Amiya Tripathy, Sejal Chopra, Michelle D'sa, Kartik Rajgopalan, Alson D'sauja, Nikhil Sharma, "Mind-Controlled Wheelchair using EEG Headset and Arduino Microcontroller", (ICTSD-2015), Feb. 04-06, 2015, Mumbai, India.

[4] Simon P. Levine, Jane E. Huggins, Spencer L. BeMent, Ramesh K. Kushwaha, Lori A. Schuh, Mitchell M. Rohde, Erasmo A. Passaro, Donald A. Ross, Kost V. Elisevich, Brien J. Smith, "A Direct Brain Interface basrd on Event-Related Potentials", IEEE Transactions on rehabilitation engineering. June-2000.