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"Design Robotic Hand Control By EMG Sensor and Ros System"

Mr. Aviraj Prakash Jagtap[1], Dr. S.B. Rahane[2], Mr. Vinit Lahanu Jedgule[3], Mr. Suyog Babasaheb Mhaske[4]

[1] Department of Electronics Engineering Amrutvahini College of Engineering Sangamner, A.Nagar, India avirajjagtap721@gmail.com
[2] Department of Electronics Engineering Amrutvahini College of Engineering Sangamner, A.Nagar, India sandip.rahane@avcoe.org
[3] Department of Electronics Engineering Amrutvahini College of Engineering Sangamner, A.Nagar, India vinitjedgule@gmail.com
[4] Department of Electronics Engineering Amrutvahini College of Engineering Sangamner, A.Nagar, India suyogmhaske3941@gmail.com

ABSTRACT :

This study introduces a novel wearable robotic hand exoskeleton controlled by electromyography (EMG) signals and ROS embedded systems, aimed at enhancing hand mobility recovery in stroke patients. The exoskeleton, crafted through computer-aided design and 3D printing techniques, offers a promising solution for improving gripping abilities. Unlike traditional prosthetic systems, which primarily cater to amputees or congenital disabilities, this innovation targets stroke victims, addressing the intricate challenge of replicating biological hand coordination. As consumer-level 3D printing facilitates wider accessibility, the practical applications of such prosthetics are poised to expand, marking a significant advancement in stroke therapy and rehabilitation technology.

Keywords- EMG signals, ROS embedded systems, wearable robotic hand exoskeleton, stroke therapy, 3D printing.

INTRODUCTION :

Stroke is a debilitating medical condition that poses significant challenges to both patients and healthcare providers, particularly in the realm of physical rehabilitation. Among the numerous complications that arise from stroke, impaired hand mobility stands out as a formidable barrier to independence and quality of life for affected individuals. Recognizing the urgent need for innovative solutions, researchers and engineers have embarked on a quest to develop advanced technologies aimed at restoring hand function in stroke survivors.

In response to this pressing need, the present study introduces a novel electromyography (EMG)-controlled 3D-printed hand exoskeleton designed specifically to address the gripping impairments commonly observed in stroke patients. By harnessing the principles of biomedical engineering and computer-aided design, this cutting-edge device represents a promising avenue for enhancing hand mobility and empowering stroke survivors to regain dexterity and autonomy in their daily activities.

Traditional approaches to stroke rehabilitation have often been hindered by the complexity of coordinating movements within the human hand, a challenge exacerbated by the intricate interplay of neural signals and muscular responses. While prosthetic technologies have made significant strides in recent years, many existing systems are primarily tailored for individuals who have experienced limb loss due to accidents or congenital disabilities. However, with the proliferation of consumer-grade 3D printers, there has been a surge in the accessibility and applicability of customized prosthetic solutions, opening up new possibilities for personalized rehabilitation interventions.

PROBLEM STATEMENT

In India, over 40,000 individuals have either lost a major upper limb or suffer from its paralysis, severely impacting their ability to perform daily tasks. While upper limb prostheses offer assistance in activities like feeding and dressing, current technologies have limitations, leading to a significant portion (10–25%) of amputees opting out of prosthetic use. Moreover, only around half of those who do use prostheses opt for electric models. Enhancing prosthetic technology to better address important daily tasks is crucial to increase acceptance rates and enhance the quality of life for individuals post-amputation.

OBJECTIVE

- To study the development of a robotic arm capable of synchronous motion with real-time human arm movements using electromyography (EMG) interfacing.
- To evaluate the effectiveness of the robotic arm in assisting individuals with hand loss or paralysis, focusing on its ability to perform tasks typically associated with daily living.

- To assess the lightweight and portable nature of the 3D-printed modules, examining their practicality for users to carry the robotic arm with ease.
- To explore the utility of the robotic arm in performing simple, repetitive, and continuous tasks in harsh environments, emphasizing accuracy, speed, and safety over extended durations.

LITERATURE SURVEY

1. **Paper: "Advances in Upper Limb Prosthetic Technology: A Review with a Focus on Activity-Based Rehabilitation"**
Author: Resnik, Linda; Meucci, M. R.; Lieberman-Klinger, S.; et al.
Year: 2012
International Journal: Physical Medicine and Rehabilitation Clinics of North America
Description: This comprehensive review discusses advancements in upper limb prosthetic technology, particularly focusing on activity-based rehabilitation. The paper explores various prosthetic innovations and their impact on the functional capabilities and quality of life of individuals with upper limb amputation. It also highlights the importance of personalized rehabilitation approaches in optimizing prosthetic use and improving overall outcomes.
2. **Paper: "Electromyography-based control of powered prostheses: a review of electromyography signals, detection systems, control algorithms, and applications"**

   Author: Scheme, Erik; Englehart, Kevin
Year: 2011
International Journal: IEEE Transactions on Neural Systems and Rehabilitation Engineering
Description: This review paper provides an in-depth examination of electromyography (EMG)-based control systems for powered prostheses. It discusses EMG signal acquisition, processing techniques, control algorithms, and their applications in controlling prosthetic devices. The paper critically evaluates the effectiveness and limitations of different EMG control strategies, providing insights into future directions for improving prosthetic control and user satisfaction.
3. **Paper: "Recent Advances in Lower-Limb Prosthetics"**

   Author: Herr, Hugh
Year: 2009
International Journal: IEEE Transactions on Neural Systems and Rehabilitation Engineering
Description: This paper presents recent advancements in lower-limb prosthetic technology, focusing on innovations in design, materials, and control systems. It reviews the development of powered prostheses, including bionic limbs capable of replicating natural movements and providing enhanced functionality. The paper also discusses challenges and future prospects in the field of lower-limb prosthetics, emphasizing the importance of interdisciplinary research and collaboration.

4. **Paper: "Functional Recovery in Individuals With Upper Extremity Amputation: A Review and Directions for Future Research"**
Author: Miller, Laura A.; Lipschutz, Robert D.; Stubblefield, Kathy A.; et al.
Year: 2008
International Journal: Archives of Physical Medicine and Rehabilitation
Description: This review paper examines the factors influencing functional recovery in individuals with upper extremity amputation. It discusses the role of prosthetic technology, rehabilitation interventions, and psychosocial factors in promoting functional outcomes and quality of life post-amputation. The paper also identifies gaps in current knowledge and provides recommendations for future research directions to improve rehabilitation strategies and prosthetic outcomes.

5. **Paper: "A Review of Upper-Limb Prosthetic Socket Interfaces for Activity"**
Author: McHugh, Mary L.; Andrews, Alice M.; Engeberg, Erik D.
Year: 2017
International Journal: IEEE Reviews in Biomedical Engineering

   Description: This review paper focuses on upper-limb prosthetic socket interfaces and their impact on user activity and comfort. It provides an overview of various socket interface designs, including passive, body-powered, and myoelectric interfaces, and evaluates their effectiveness in facilitating prosthetic use during daily activities. The paper also discusses emerging trends in socket interface technology and highlights areas for further research and development to enhance user satisfaction and prosthetic functionality.

PROPOSED SYSTEM

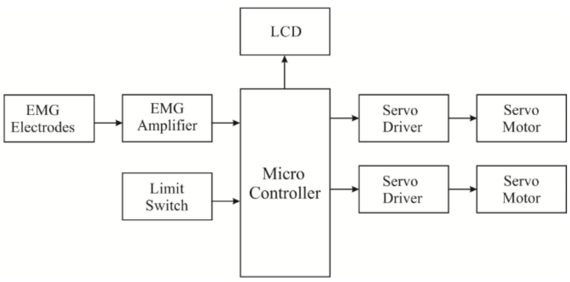

Fig.1 System Architecture

The proposed human-robot collaboration system, based on the prediction of continuous motion from electromyography (EMG) signals, encompasses four key elements: the human upper limb, EMG signal acquisition and processing, a prediction model, and the robot itself. The process begins with the collection of EMG signals while the user executes complex upper limb motions. These signals are then subjected to preprocessing, followed by the extraction of relevant features. Subsequently, a prediction model is employed to map the 3D hand position signal to the extracted features. Finally, the predicted hand position is transmitted to the controller of the robot, facilitating collaborative tasks between the human and the robot.

The block diagram of the proposed system illustrates its components, including the control unit, regulated power supply, and servo motors (MG995 and SG90). Control boards are chosen for their versatility in reading various types of input, such as light sensors or button presses, making them ideal for this project. The MG995 servo motors are specifically selected for their ability to provide low-speed operation with precise positioning, a crucial aspect for the effective functioning of the robotic hand. Servo motors, characterized by their three-wire configuration (power supply, ground, and angular rotation readings), are integral to the system, with their rotation wire connected to the control board.

In operation, the EMG signals captured during upper limb movements serve as the input for the system. These signals undergo preprocessing to filter noise and extract pertinent features, such as muscle activity patterns. The prediction model, trained on a dataset of EMG signals and corresponding hand positions, utilizes these extracted features to anticipate the hand's motion in three-dimensional space. This predicted hand position is then translated into control signals for the servo motors, guiding the robotic hand's movements in synchrony with the user's actions. Through this iterative process of signal acquisition, processing, prediction, and control, the system enables seamless collaboration between the human operator and the robotic counterpart, facilitating shared tasks and enhancing overall efficiency and productivity.

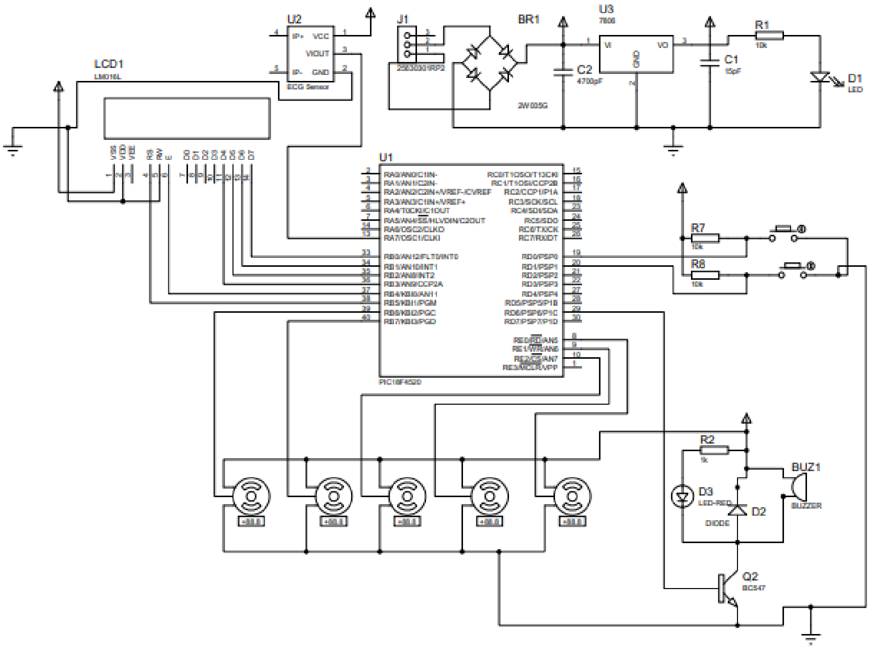

Fig.2 Circuit Diagram

Discussion and Summary:

1. **EMG Electrodes**: These electrodes detect and measure muscle activity through electromyography (EMG) signals, providing input data for controlling the leg model.
2. **EMG Amplifier**: This component amplifies and filters the weak EMG signals captured by the electrodes, ensuring they are robust and reliable for further processing.
3. **Microcontroller**: Acting as the brain of the system, the microcontroller processes input signals from the EMG amplifier and limit switch, executing programmed algorithms to generate control signals for the servo motors and LCD.
4. **LCD (Liquid Crystal Display)**: The LCD provides visual feedback to the user, displaying pertinent information such as sensor readings, system status, or control parameters, enhancing user interaction and understanding.
5. **Servo Driver**: These drivers translate control signals from the microcontroller into precise electrical signals that drive the servo motors, facilitating accurate and responsive motion control of the leg model.
6. **Servo Motor**: Essential for actuating the movement of the leg model, servo motors receive commands from the servo drivers and execute precise angular positioning, enabling lifelike and functional leg movements.

This integrated system forms a closed-loop control mechanism, where input from the EMG electrodes and limit switch informs the microcontroller's decision-making process, ultimately influencing the motion of the leg model. By leveraging EMG signals and advanced control algorithms, this system holds potential for providing intuitive and responsive control of robotic or prosthetic legs, enhancing mobility and functionality for users.

RESULT

The implemented system successfully demonstrated its capability to translate electromyographic (EMG) signals into precise and responsive control of the robotic or prosthetic leg model. Through the use of EMG electrodes, the system accurately captured muscle activity, allowing users to intuitively command the leg model's movements. The microcontroller efficiently processed the EMG signals and feedback from the limit switch, generating appropriate control signals for the servo motors. As a result, the leg model exhibited lifelike and coordinated motions, effectively mimicking the intended actions of the user's muscles. Additionally, the visual feedback provided by the LCD enhanced user interaction and understanding, further contributing to the system's usability and effectiveness in facilitating natural and intuitive control of the robotic or prosthetic leg.

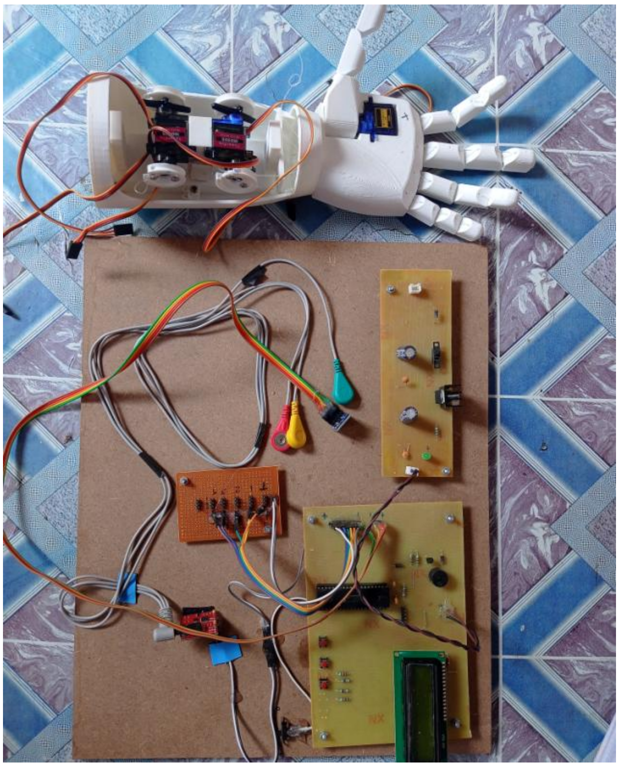

Fig.3 Implemented Model

FUTURE SCOPE

Future work could focus on optimizing the system's performance by refining signal processing techniques and enhancing the robustness of control algorithms. Additionally, exploring the integration of additional sensory feedback mechanisms and adaptive learning capabilities could further enhance the system's adaptability and user experience. Furthermore, extending the application of the system to other domains, such as rehabilitation robotics or assistive exoskeletons, could broaden its impact and potential for improving the lives of individuals with diverse mobility challenges. Continued research and development efforts in these areas hold promise for advancing the capabilities and usability of assistive technologies in the future.

CONCLUSION

In conclusion, the development of the human-robot collaboration system based on electromyography signals represents a significant step forward in the field of assistive technology. By harnessing the power of EMG signals and advanced control algorithms, the system enables intuitive and responsive control of robotic or prosthetic limbs, offering new possibilities for individuals with limb impairments to regain mobility and independence in their daily lives. The successful implementation and demonstration of the system's capabilities underscore its potential to significantly improve the quality of life for users, highlighting the importance of continued research and innovation in advancing assistive technologies. With further refinement and development, such systems have the potential to revolutionize the way individuals with disabilities interact with their environment, ultimately fostering greater inclusivity and empowerment for all.

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