EMG-CONTROLLED LOWER LIMB EXOSKELETON STIMULATOR FOR HEMIPLEGIC PERSON

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Introduction:

An EMG-controlled lower limb exoskeleton stimulator for hemiplegic individuals is a device designed to aid in rehabilitation and mobility by using electromyography (EMG) signals to control the movement of the exoskeleton. Hemiplegia, often caused by conditions like stroke or traumatic brain injury, results in partial or complete paralysis on one side of the body, limiting the ability to perform daily activities. Traditional rehabilitation methods focus on physical therapy exercises to retrain movement, but these can be limited in effectiveness, particularly for long-term recovery.

Objectives:

- **Develop an Assistive Lower Limb Exoskeleton:** Design and construct an exoskeleton tailored for individuals with hemiplegia, incorporating sensors and actuators to support controlled lower limb movement.
- **Implement EMG-Based Control:** Use EMG sensors to capture muscle signals, allowing the exoskeleton to respond directly to the user's muscle contractions and enable intuitive control over movements.
- **Integrate Gesture and Fall Detection:** Utilize an accelerometer sensor to detect gestures and monitor fall events, enhancing safety by recognizing unintended movements and triggering alerts when necessary.

- **Provide Real-Time Feedback:** Display relevant system information on an LCD screen to keep users informed about device status and operation, ensuring ease of monitoring during usage.
- **Enable Remote Monitoring and Alerts:** Implement NodeMCU to connect the system to Telegram, sending notifications to caregivers or emergency contacts in the event of a fall or other critical incidents.

Methodology:

The EMG-controlled lower limb exoskeleton operates through a coordinated system that involves muscle signal detection, data processing, and motor actuation, enabling intuitive control of movement for individuals with hemiplegia.

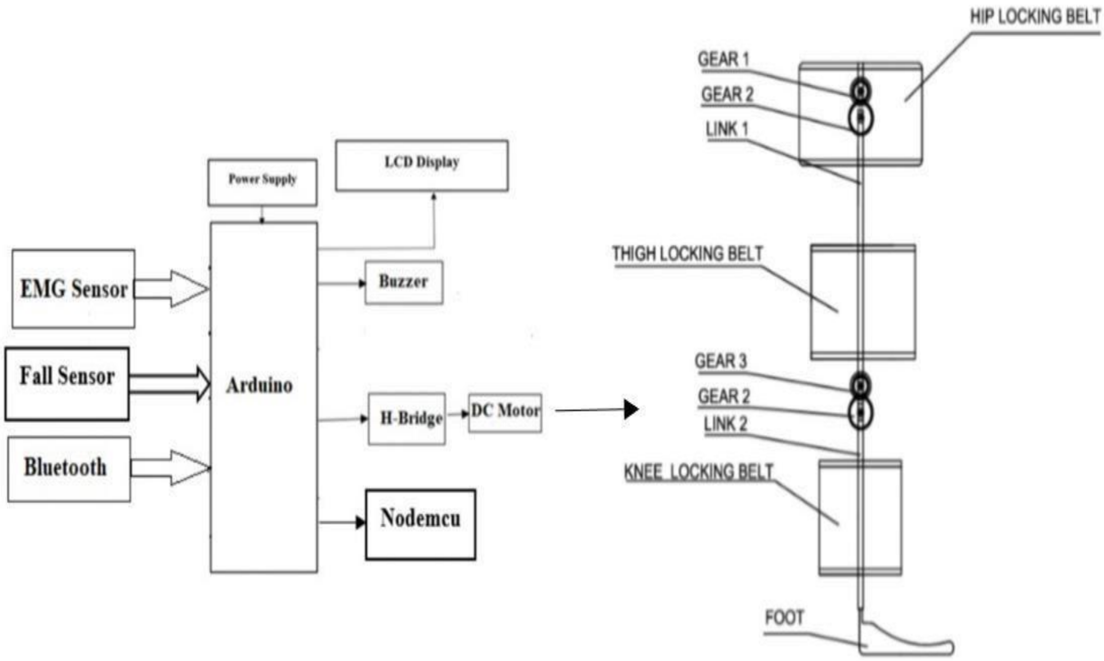

Figure 1: Block Diagram of EMG controlled lower limb exoskeleton stimulator for hemiplegic person

The working mechanism can be broken down into the following key components:

1. Muscle Signal Detection EMG Sensors: The exoskeleton is equipped with surface EMG sensors placed on the residual limb of the user. These sensors detect electrical signals generated by muscle contractions during voluntary movements.

Signal Acquisition: The EMG sensors convert these electrical signals into analog data, which is then transmitted to the Arduino microcontroller for processing.

2. Data Processing Microcontroller Processing:

The Arduino processes the incoming EMG signals in real-time. It employs signal processing techniques, including filtering and amplification, to enhance the clarity of the muscle signals.

Threshold Detection: The Arduino uses predefined thresholds to determine when a muscle is sufficiently activated to initiate movement. This involves comparing the processed EMG signal to a set threshold value that indicates muscle activation.

3. Motor Activation DC Motor Control:

Based on the processed EMG signals, the Arduino activates the DC motors that drive the joints of the exoskeleton. The control algorithms ensure that the motors respond in a coordinated manner to mimic natural walking patterns.

Movement Coordination: The system is designed to allow simultaneous control of multiple joints, facilitating smooth and coordinated movement. For example, flexing the knee and ankle simultaneously when stepping forward.

4. User Feedback LCD Display:

The exoskeleton features an LCD display that provides real-time feedback to the user, such as the level of muscle activity detected and the status of the exoskeleton. This feedback helps users understand how to modulate their muscle activation for improved control.

User Engagement: By offering feedback on muscle activity, the system encourages users to engage actively in their movements, enhancing the rehabilitation process.

5. Safety Mechanisms Emergency Stops:

The exoskeleton is equipped with emergency stop buttons that allow users or caregivers to immediately halt the system in case of any malfunction or discomfort.

Limit Switches: These switches prevent the motors from moving beyond safe operational ranges, reducing the risk of injury during use.

Result and Conclusion:

Fig 2 : Exoskeleton of Lower Limb

Fig 3: Movement of Lower and Upper limb of Exoskeleton

Fig 4: Display of Fall Detection in LCD

Fig 5: Display of Gesture Detection in LCD

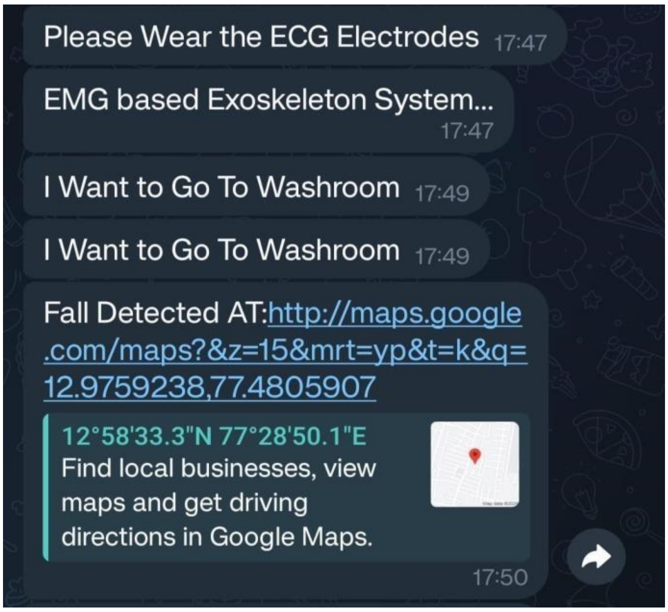

Fig 6: Message of Fall detection and Gesture detection to Care Take in Telegram

In conclusion, this project successfully developed an EMG-controlled lower limb exoskeleton designed to assist hemiplegic individuals in regaining mobility and improving rehabilitation outcomes. By integrating an Arduino microcontroller, EMG sensor, accelerometer for gesture and fall detection, DC motor for actuation, and a Node-MCU module for remote notifications via Telegram, the exoskeleton provides a user centered approach to rehabilitation. The system allows intuitive, muscle driven control, enhancing movement fluidity and enabling personalized rehabilitation in both clinical and home settings. Initial testing indicates that the exoskeleton responds effectively to muscle signals, facilitating natural leg movement and accommodating user-specific needs

Future Scope:

The future scope of this project includes:

1. Integration with Rehabilitation Programs: Long-term use of EMG-controlled exoskeletons could promote neuroplasticity, encouraging the brain to rewire itself and compensate for damaged areas. Over time, this could lead to improved muscle function, potentially even recovering some voluntary control over the affected limbs.
2. Energy Efficiency and Wearability: Future exoskeletons will likely focus on being more lightweight, flexible, and ergonomic. The development of soft robotics or soft exoskeletons, which use textiles and flexible actuators, could make the device more comfortable for prolonged use, reducing the strain on users and enhancing their everyday mobility.
3. Broader Applications in Healthcare: Though currently focused on hemiplegia, this technology could expand to assist other conditions like cerebral palsy, multiple sclerosis, or spinal cord injury. This would enable a wider group of individuals with neurological impairments to regain mobility and improve their quality of life.
4. Advanced Materials and Lightweight Design: The incorporation of soft robotics could allow for more comfortable and unobtrusive exoskeletons that work alongside the user’s natural movements. This could enable a wider range of motions and more seamless integration into the user’s daily life.