ACKNOWLEDGEMENT

The satisfaction and euphoria that accompanies the successful completion of any task would be incomplete without complementing those who made it possible and whose guidance and encouragement made my efforts successful. And my sincere thanks to all those who have supported me in completing this technical Seminar successfully.

My sincere thanks to **Dr. M. U. Aswath**, Principal, BIT and **Dr. D G Jyothi**, HOD, Department of AI & ML, BIT for their encouragement, support and guidance to the student community in all fields of education. I am grateful to our institution for providing us a congenial atmosphere to carry out the Technical Seminar successfully.

I would not forget to remember **Prof. Shobha Y**, Associate Professor and Technical Seminar Coordinator, for her encouragement and more over for her timely support and guidance till the completion of the Technical Seminar Coordinator.

I avail this opportunity to express my profound sense of deep gratitude to my esteemed guide **Prof. Yamini Sahukar P,** Assistant Professor, Department of AI & ML, BIT, for their moral support, encouragement and valuable suggestions throughout the Technical Seminar Coordinator.

I sincerely thank all the department faculty members and non-teaching staff for supporting me directly or indirectly in completing this Technical Seminar.

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1BI20AI055

ABSTRACT

Brain-computer interface (BCI) controlled functional electrical stimulation (FES) represents a promising integration of technologies aimed at enhancing the quality of life for individuals with disabilities resulting from spinal cord injuries (SCI). This study evaluates the efficacy and feasibility of a BCI-FES system in both healthy subjects and SCI patients to restore voluntary motor control and promote neuroplasticity.

The study was divided into two primary phases. The first phase involved training and testing with twenty healthy participants to calibrate the BCI system and refine the FES protocols. Participants engaged in a series of tasks that involved imagining or attempting specific limb movements while their brain activity was recorded via EEG. The BCI system was designed to detect these intent-driven neural patterns and trigger corresponding FES to induce the desired limb movement.

In the second phase, ten patients with varying degrees of SCI were enrolled to assess the therapeutic potential of the BCI-FES system. Participants underwent a six-week intervention where they used the BCI to control FES-assisted movements. Key outcomes measured included the accuracy of BCI decoding, the functional improvement in limb movements as quantified by the Fugl-Meyer Assessment (FMA) and changes in muscle strength.

This study underscores the potential of BCI-FES systems in rehabilitation and the restoration of function. By providing real-time feedback and enabling active participation of patients in their recovery, such technologies not only enhance motor recovery but also facilitate cortical reorganization. Future research should focus on long-term usage and integration of BCI-FES systems in everyday life activities, exploring adaptive algorithms that can cope with the day-to-day variations in EEG signals and refining the system for better individual customization.

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