Using an Electroencephalogram and a Transcutaneous Electrical Nerve Stimulation (TENS) Unit to Develop a Noninvasive Neuroprosthetic for Quadriplegic Patients

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According to a study conducted by the Reeve Foundation, approximately 2% of the United States population lives with paralysis, excluding those suffering from various motor control disorders such as Alzheimer's, Parkinson's, and stroke. The consequences of paralysis can be severe, leading to significant limitations in an individual's ability to carry out basic daily activities such as dressing, bathing, and feeding oneself. This study aimed to develop an affordable, non-invasive neuroprosthetic device that can accurately translate electrical signals obtained from the brain via wireless electroencephalogram (EEG) into appropriate muscular movements via electrical stimulation of muscles using a transcutaneous electrical nerve stimulation (TENS) device. The research goals also included the training of a machine-learning model with an accuracy of 75% in identifying the correct muscular movement command from the EEG and a final product cost under $1000. The study involved the use of a machine-learning algorithm that was trained using data collected from 100 five-second recordings of a neutral state of the brain and 100 five-second recordings of the same command via EEG. The results indicate that the researcher achieved all of the aforementioned goals. The machine-learning model used a hybrid convolutional neural network and Long short-term memory architecture achieved a 90.4% accuracy rate, and all 30 trial tests involving pre-trained commands led to successful activation of the TENS unit, translating the brain signals into electrical stimulation of the nerve. With a cost of just $498.23, this neuroprosthetic device has the potential to significantly improve the lives of millions of individuals living with motor impairments, both presently and in the future.