From Thought to Movement

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Parkinson’s disease is a progressive neurodegenerative disorder that impairs voluntary movement due to disrupted basal ganglia function. Existing treatments, including medication and deep brain stimulation (DBS), often provide only partial or temporary relief and do not restore true voluntary motor control. Yet even in advanced Parkinson’s patients, the neural intention behind a movement often remains intact. This project investigates whether such motor intentions can be decoded directly from EEG signals using a transformer-based AI model and translated into movement by bypassing the damaged nervous system entirely. The motivation is deeply personal: my own father lives with Parkinson’s.

A comprehensive literature review was conducted to establish the scientific foundation. Seven different AI architectures were tested, with a multimodal transformer model ultimately selected for its balanced precision, suitability for sequential signals, and strong future potential. EEG signals were originally recorded using a self-built, galvanically isolated EEG-circuit and now with professional hardware sponsored by OpenBCI. In the initial version, electrodes were placed at C3, C4, and Cz; now a full 8-channel headset is used. Additional signals are collected from EMG and IMU sensors to capture muscle activity and movement dynamics.

Data were collected from both a healthy subject (myself) and in the future a Parkinson’s patient (my father), across a range of motor tasks and resting conditions. Two real-time transformer models were trained to classify discrete motor intentions from EEG signals. The decoded outputs, simple binary values, are transmitted to a 6-axis robotic arm, enabling full end-to-end control: from thought to movement.

The project has potential to successfully demonstrate real-time decoding of voluntary movement intentions using non-invasive biosignals and AI. It integrates neuroscience, machine learning, signal processing, and embedded systems into a functional brain-computer interface. The next step is to replace the robotic output with direct muscle activation via EMS and FUS. This could enable direct activation of paralyzed muscles and open new avenues in intelligent, non-invasive neuroprosthetics for neurodegenerative diseases - and hopefully help my father in the near future!