**Thesis Project Portfolio**

# Machine Learning and Brain Computer Interfaces:
# Classifying Brain Signals for Upper Limb Prosthetics

(Technical Report)

## Impact of BCI-Integrated Prosthetics

(STS Research Paper)

An Undergraduate Thesis

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## Executive Summary

Brain-computer interfaces have enabled computers to read the minds of humans. My Technical Report proposes a project that will develop a machine learning (ML) model trained to classify brain signals based on the user's desired limb motion. This topic has the potential to advance the state of current prosthetic limbs and improve the standard of living for amputee patients. My STS research paper explores the impact of brain-computer interfaces and neuroprosthetics and their ability to return functionality to those with limb loss, along with how this technology will be received by society. This topic combines my interests in computer science and biomedical engineering in a way that seeks to create a positive impact on the world by helping those with limb loss. Brain-computer interfaces combine both the biomedical engineering aspects of connecting directly with the brain to capture nerve signals with the computer science aspects of machine learning to improve the recognition algorithms to create a product that is on the cutting edge of development in both fields. However, as with any technological innovation, there will be societal implications to its widespread adoption.

Brain-computer interfaces currently require extensive user training to effectively isolate and translate the desired brain signal characteristics into desired control signals for external devices. To simplify this process, I propose utilizing machine learning (ML) to decrease the amount of training time and improve recognition, classification, and prediction of the desired movement. Using electrocorticography (ECoG) or encephalography (EEG), data will be captured while a subject performs specific limb motions. This data will be used in an ML process to create a classification model able to be evaluated on real time inputs from test subjects.

The result of my proposal is a classification algorithm that can take an unknown brain signal as input and output a limb motion with a high degree of accuracy. Combined with a neuroprosthetic, this classifier would allow for further advancements in the prosthetic field. It

can also be further tuned to ensure compatibility with different individuals. Since current prosthetics cannot completely recover the lost functionality of lost limbs, this project will provide a method to narrow this gap, while also decreasing neuroprosthetic training time. Accessibility and viability of neuroprosthetics will then increase greatly.

Brain-computer interfaces are an emerging technology that allows for computers to interface directly with the brain. As with any new technology, brain-computer interfaces will have both intended and unintended effects. One of the ways BCIs will be utilized is by integration with prosthetics to create a "smart" prosthetic, or neuroprosthetic. BCIs will allow prosthetics to respond to their user's thoughts and act as if they had not lost a limb. This is likely to dramatically increase the quality of life for those with limb loss. To answer these questions, a literature review will compare the current state and shortcomings of current prosthetics to the effectiveness of current neuroprosthetics. Additionally, a document analysis will analyze how cyborgs are presented in media to predict how society will interact with people outfitted with a neuroprosthetic.

My research showed that current prosthetics were unable to fully restore the lost functionality of amputee patients post-surgery. Importantly, patients felt that they were still lacking the quality of life they had prior to their injury. Additionally, many patients were found to have abandoned their prosthetics due to reasons such as discomfort, difficulty of use, and lack of functionality. The data also showed that current neuroprosthetics have promise in assisting patients to regain more of the functionality they lost due to their injury. Lastly, neuroprosthetics have historically been portrayed negatively in popular media such as Doctor Who, Star Trek, and Star Wars. Brain-computer interfaces and neuroprosthetics have shown to have the intended

effects of replacing lost limbs, however, there will be unintended effects of their integration into society that will be discovered as their use become more widespread.