Motor Imagery EEG Speller: Validation

# Description

For people with various neuromuscular degenerative diseases and muscular dystrophy, communication, especially via keyboard, is very difficult if not impossible. Because of this, EEG spellers based on the P300 oddball paradigm have been made and researched upon for many years. Current EEG spellers are quite slow (~50 bits/min with NLP optimizations) [1] [2] . Our proposal uses a grid system (like traditional P300 spellers). However, each row and column would have a numerical id (1-6), and we would map each number to a hand gesture. A letter is selected by imagining the appropriate gesture for each hand (left controls rows, right controls columns). This ensures that it takes 1 operation to choose each letter (current systems take at least 3 operations per gesture from our initial research). NLP would allow many cases where the user wouldn't have to type the full word, boosting the bit rate as well.

[1] <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3679217/>

[2] <https://www.ncbi.nlm.nih.gov/pubmed/12853169>

# 1. Is the idea novel?

Motor imagery and NLP have been used to control EEG spellers before, but they were based on moving cursors for selection and require multiple operations to select a letter. We are proposing using a 'sign language' to use exactly operation to select elements on a grid, which hasn't been done in the context of an EEG speller before.

<http://presage.sourceforge.net/sites/all/files/dalbis.pdf>

# 2. Is it an improvement over existing solutions?

Yes. Current EEG spellers are very slow (14 characters / minute). We estimate that with training, one could reach speeds comparable to those of a keyboard with our speller, due to only one operation being needed to control which letter to choose. NLP would ensure that most of the time, only two to three letters would need to be chosen for a word to be chosen.

# 3. Does it have a market niche? If not, would it be well-liked by the general public?

Yes it does; it would help people who can't communicate due to having experienced severe neuromuscular deterioration. In addition, it could pave the way for 'mind-typing', getting rid of the need to type or swipe on a touch screen for mobile devices (and allow for much faster typing on AR devices such as the Hololens). Our EEG speller would be a precursor to brain-typing devices that companies such as Facebook are currently researching: <https://techcrunch.com/2017/04/19/facebook-brain-interface/>

# 4. Is there raw data (ie EEG) that would allow us to develop and test this idea?

Yes; however the data is rather rudimentary (ie only 4 classes of motor imagery) and would only serve for initial testing.

<http://bnci-horizon-2020.eu/database/data-sets>

<https://sites.google.com/site/projectbci/>

# 5. Is it a project we can complete in 4 months?

The project is definitely feasible. Motor imagery has been studied extensively, and has been used for gestures in mind-controlled robots in real time and for EEG spellers:

<http://presage.sourceforge.net/sites/all/files/dalbis.pdf> (EEG Speller)

<http://iopscience.iop.org/article/10.1088/1741-2560/10/4/046003/pdf> (Hand-gesture based mind-controlled robot)

<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3036745/> (info about imagined hand movements can be continuously decoded)

The above two studies, however, use very simplistic imagined actions (ie left hand open vs right hand open, and nothing else). The following study has show the ability to extract imagined thoughts of more complex actions that would make our EEG speller possible:

<http://ieeexplore.ieee.org/document/6943840/?reload=true>

Given these studies, we can say that it would be possible for us to create a finished product in four months. However, it will be ambitious, and if we don't stick to a tight schedule and put in a lot of time there is a chance that we might not be able to use the more complex gestures we want to use, and have to stick to simplistic gestures that would improve over current motor imagery-based spellers.

# 6. How much would it cost?

This project would essentially be free. We would need to wire the OpenBCI with spiky electrodes (which we have to do at some point anyways). If we want to enable mobile support for our speller, we may need to purchase an Apple or Android Developer's License to publish our app to their respective app stores.