

Convolutional Neural Networks for a Cursor Control Brain Computer Interface

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Introduction: A Brain-Computer Interface (BCI) platform can be utilized by a patient to control an external device without making any overt movements. This can be beneficial to a variety of patients who suffer from paralysis, loss of limb, or neurodegenerative diseases. We decode brain signals using EEG during imagined body kinematics to control an on screen cursor. Convolutional neural networks (CNNs) are already a popular choice for image-based learning problems and are useful in EEG applications. The major advantage of CNNs is that they can generate features from the signal automatically and do not require as much domain driven feature engineering as a traditional machine learning approach. We implement a CNN to perform multivariate regression over the EEG signal to predict intended cursor velocity.

Materials and Methods: Data from thirty-two subjects were collected in ten trials per subject, five horizontal (HO) and five vertical (VE), where subjects were instructed to imagine they were moving a cursor on a screen as it followed predefined path ranging from -25-25 meters per second. The data was collected using a 14 channel EEG headset at 128 samples per second. A low bandpass filter at 1hz was used to remove noise. Horizontal and vertical models were trained separately for each subject using five-fold cross validation (4 trials used for training, 1 trial used for testing with rotation). A shallow network structure was used with only one hidden layer with 1x10 filters into a 1x3 pooling layer. The models were evaluated using mean absolute error (MAE).

Results and Discussion: With the current CNN structure, we achieved average MAE of (11.69 HO, 16.04 VE) across all subjects with a max of (17.35 HO, 17.88 VE), a min of (7.67 HO, 11.92 VE), and a standard deviation of (3.15 HO, 2.13 VE). Some subjects' models exhibited excellent prediction of intended cursor velocity whereas others exhibited anywhere from average to poor prediction. In addition to this prediction of horizontal trials were on average better than those for vertical trials.

Conclusions: The result is a model that can be used for a real time cursor prediction system. Subjects who showed good prediction accuracy during offline analysis would be able to control external devices by wearing an EEG headset and imagining the desired direction of travel. Future work will include further development of the network structure, extracted features, and hyperparameters.

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Reference:

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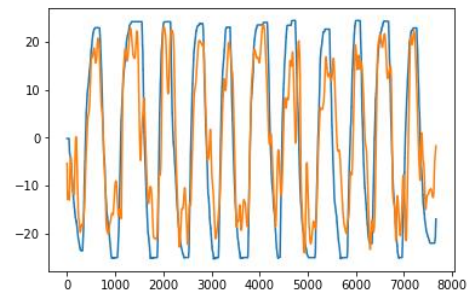


Figure 1. Predicted velocity (orange) over actual velocity (blue) for one subject and one horizontal trial with a MAE of 7.89