Alternative Algorithms in "Face Versus House" Discrimination Basing on Event Related Potential

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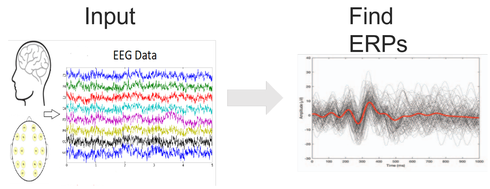
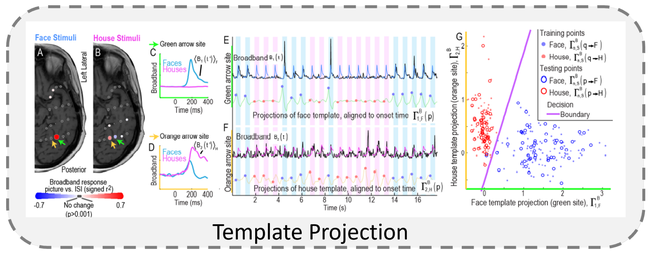
Introduction

- The link between object perception and neural activity in visual cortical areas is a problem of fundamental importance in neuroscience.
- Electrical potentials from the ventral temporal cortical surface in humans have been showed to contain sufficient information for spontaneous and near-instantaneous identification of a subject's perceptual state.
- The EEG reflects thousands of simultaneously ongoing brain processes making the brain response to a single stimulus not usually visible.
- Event Related Potential (ERP) data is extracted from EEG signal: Finding the mean of EEG epochs for the same repeated event.



- The "Faces v. Houses Discrimination" is an existing work [1], in which the classification method was just linear. The main work in this project is developing alternative classification methods.

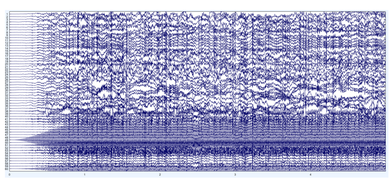


Template Projection

- Our method propose to use these projections are used in our method to create images to train convolutional neural network (CNN).
- Two CNN were trained [2] to discriminates the Event Related Potential (ERP) signals, which are responses to visual stimuli of different types of figures (Faces and Houses).

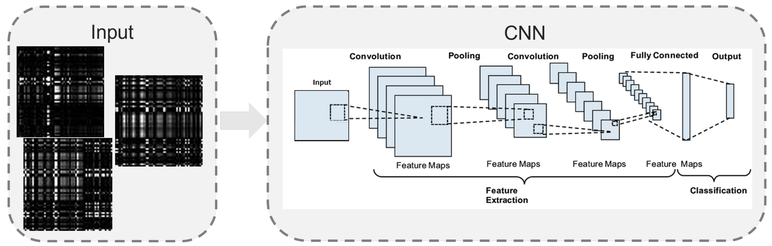
Dataset

- EEG Data from 7 epilepsy patients (double, dim = of channels x time stamps) along with the stimulus time course (categorical, dim = 1 x time stamps).
- While scanning, electrocorticographic (ECoG) arrays were placed on the subtemporal cortical surface of seven epilepsy patients.
- Number of channels varies among members.
- Data available at: http://purl.stanford.edu/xd109qh3109.



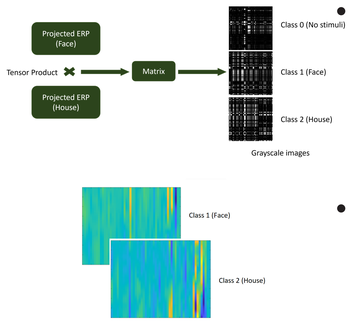
Proposed Framework

- Propose to use CNN to classify EEG signals into two classes, faces and houses stimuli.
- Use the Template Projections in [1]: Convolution of the ERP data with the stimulus triggered averages (STA) for "face" stimuli and "house" stimuli, respectively.
- Create images using these projection on the known time intervals where an stimulus occurs.
- Uses images as input of a CNN to classify them into classes.



Creating Input Images

- Propose two methods of creating images for inout of the CNN.

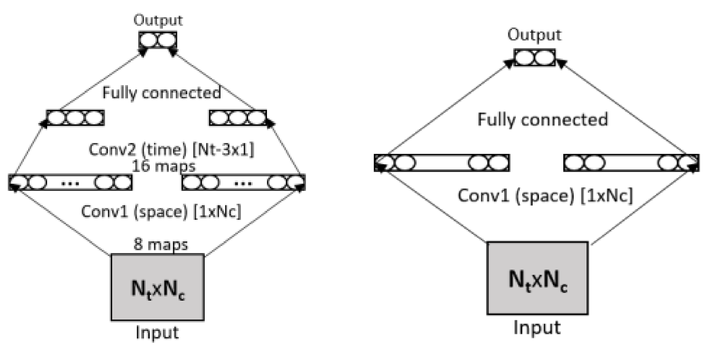


- Method 1 does a tensor matrix product between the projected ERP of the houses and projected ERP of the faces ate each known time interval where a stimulus occurs, and where non-stimulus occurs (class 0).

- $N_t x N_c$ matrices where N_t is the number of samples of the template signal on intervals where a stimulus occurs and N_c is the number of channels.

Proposed CNNs

- CNN1 (left): Convolution layer 1 has dimension N_c and 8 filters. Convolution layer 2 has dimension of Conv1 transpose and 16 filters. Fully connected layers have dimension 25 and 3 (or 2 for stimulation-only classification), respectively. ReLu as activation function.
- CNN2 (rigth): similar to CNN1 with just the first convolution layer.



Training Process

- Use deepNetworkDesigner toolbox in MatLab.
- CNNs were trained for each subject individually and used 30% of the original data for validation.
- Select parameters such that the validation accuracy is higher than 90%.

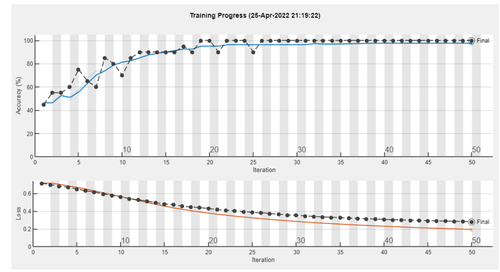


Figure 1: Example of a the training iterations for one of the CNNs and one of the subjects

Results

Patient	CNN1 (3)	CNN1 (2)	CNN2 (2)	Original
ja	82.5%	**92.22%**	89.00%	90.00%
ca	82.14%	90.00%	**94.00%**	91.00%
de	93.64%	95.56%	81.00%	**97.00%**
fp	82.14%	92.78%	**93.00%**	89.00%
mv	80.92%	**88.89%**	59.00%	77.00%
wc	94.64%	**96.67%**	91.00%	96.00%
zt	87.50%	**99.44%**	91.00%	95.00%

Table 1: Accuracy of our CNN1 classifying 3 classes, CNN1 and CNN2 classifying stimuli only, and the accuracy reported in [] section ....

Conclusions & Future Work

- Results show that for all subjects except "de" one of our two CNNs archieves higher accuracy than the method in [1].
- Our method seems to be more stable for different subjects.
- In the classification provided in this project, discriminating only stimulus type is more accurate.
- Detailed information of electrode placements were not found, making it hard to improve the method using tools that involves spatial properties.

References

[1] K. J. Miller, G. Schalk, D. Hermes, J. G. Ojemann, and R. P. Rao, "Spontaneous decoding of the timing and content of human object perception from cortical surface recordings reveals complementary information in the event-related potential and broadband spectral change," *PLoS computational biology*, vol. 12, no. 1, p. e1004660, 2016.

[2] H. Cecotti, "Convolutional neural networks for event-related potential detection: impact of the architecture," in *2017 39th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC)*, pp. 2031–2034, IEEE, 2017.

GitHub

- The codes of this method can be found here https://github.com/ortizbou/facevshouseCNN/