A Study on an Application of Extreme Learning Machine to Brain Decoding of Human Emotion induced by Visual Stimuli

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1 Introduction

Emotions combine people's feelings, thoughts, and behaviors. With the psychological reaction of the outside world's stimuli, our cerebral cortex will have physiological reactions. Artificial intelligence has been widely used in the field of emotion recognition.

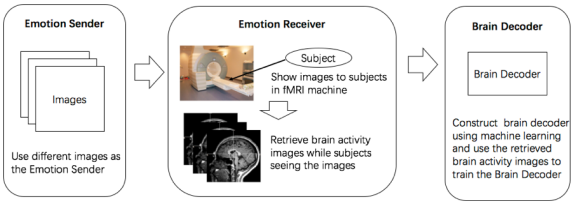
Brain decoding has been studied and focused in neuroscience field. Brain decoding of human emotion has also been studied since 2014. In the course of our experiments, we try to use classifier to classify human emotion induced by visual stimuli using brain activity measured by functional Magnetic Resonance Imaging(fMRI). For brain decoding traditional classifiers such as support vector machine(SVM)and feature extraction methods have been employed. The recent development of neural network classifiers is remarkable. Hybrid neural network classifier of extreme learning machine(ELM) and deep convolutional neural networks(CNN) machine has been proposed and achieve high accuracy[1].

2 Related work

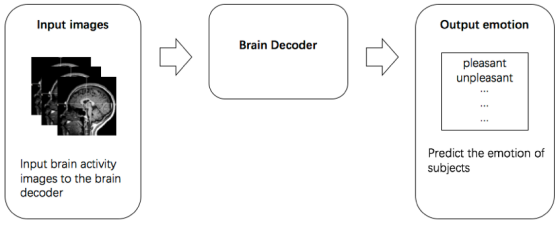
Brain decoding is developed since 2005. Brain decoding system including two phase. Learning phase and predicting phase. Figure1 shown process of brain decoding. Using different images or videos as the emotion sender. During the experiment, show the images or videos to the subjects while they are in the fMRI machine. Use fMRI machine to retrieved their brain activity images while they seeing the images. Then construct a brain decoder using machine learning method and use the retrieved brain activity images to train the Brain Decoder.

After the training of brain decoder, input brain activity images to the brain decoder. Use the trained brain decoder to predict the emotion of subjects is positive or negative. The traditional method in brain decoding is Support Vector Machine. In this thesis, we propose to use ELM to take the place of SVM to construct the brain decoder.

Extreme learning machine proposed by Huang[2] is a single-hidden-layer feedforward neural networks (SLFNs), which randomly chooses the input weights and analytically determines the output weights of SLFNs. The ELM algorithm provides a unified model for all



(a) Learning Phase of Brain Decoding



(b) Predicting Phase of Brain Decoding

Figure 1 Process of Brain Decoding

classification problems, inheriting the structural advantages of single-hidden-layer feedforward networks, and the computing speed is faster than the SVM algorithm. We choose the ELM algorithm to construct the brain decoder instead of SVM because ELM has simple structure and good learning efficiency.

3 ELM Brain Decoder

Haxby has proposed multi-voxel pattern analysis of fMRI data in 2001. Before the advent of MVPA, researchers used a generalized linear model to analyze the data. Norman K A and his team also did a lot of work on MVPA. Their paper introduced pattern classification algorithms to multi-voxel patterns of functional MRI data. Multi-voxel pattern analysis usually considers multi-voxel activation in the brain as a pattern in high-dimensional space, and uses pattern classification to decode the information contained in the activation pattern. In our experiment, analysis of fMRI data in the brain using multi-voxel pattern analysis typically involves the following steps: Feature selection, Pattern assembly, ELM Classifier training, cross-validation. The ELM-MVPA Brain Decoder Model is shown in Figure 2.

In the ELM-CNN method, we use the VGG16 CNN Model to extract features of fMRI dataset. Use

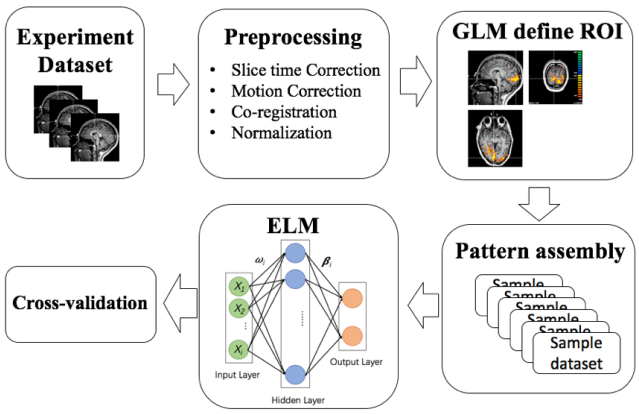


Figure 2 ELM-MVPA Brain Decoder Model

fMRI dataset as the input to the CNN after preprocessing the experimental data to extract features. Then train the ELM using these features and finally use cross-validation to evaluate the accuracy of the ELM-CNN brain decoder model.

4 Experiments Design

There are 6 subjects (4 male and 2 female). The fMRI machine was used to collect the stimuli of the subject's brain. The safety of the fMRI experimental device was informed before the experiment. The experiments were started after obtaining the consent of the subjects.The selected images form Open Access Series of Imaging Studies(OASIS) which could make subjects feel pleasant including healing images such as lovely animals, beautiful views and smiling faces and so on. The selected images which could make subjects feel unpleasant including injured animals, crying faces blooding knife and so on.

SIEMENS MAGNETOM Verio 3T is used as fMRI device located in Kochi University of Technology, Japan. Each session lasted 132 seconds (44 scans). Each experiment started playing the picture 15 seconds after the start of imaging. Put the pleasant/unpleasant image on a black background and the time gap between each image is 9 seconds (3 scans). Each subject do the experiment for 8 times.

5 Results and Conclusion

After Cross-Validation we got the average accuracy of ELM-MVPA model. We use tanh and sigmoid as activation function and the results is shown in Figure 3. From the results we could find when the number of hidden nodes of ELM is 2000-4000, the average accuracy rate remains at stable state around 65%.

The result is shown in Table 1. the average accuracy of ELM-MVPA Model with tanh activation function has the best performance compare to other methods.

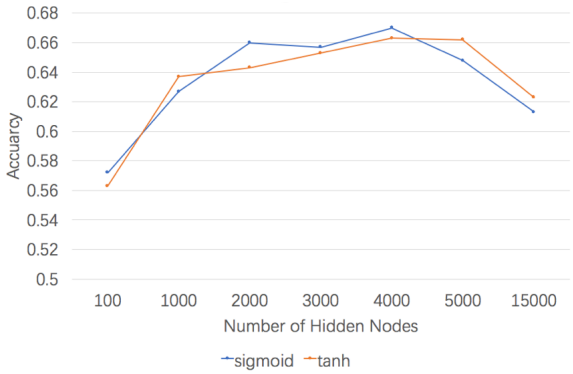


Figure 3 Average accuracy of ELM-MVPA with different Number of hidden nodes

The ELM-CNN Model could get best performance when the number of hidden nodes is between 1000-2000. We also use SVM Linear Kernel and RBF Kernel as the classifier of our brain decoder.

Table 1 Accuracy of ELM (elm), CNN-ELM (cnn-elm), and SVM (svm), t:tanh, s:sigmoid, l:linear, r:RBF

	elm-t	elm-s	cnn-elm	svm-l	svm-r
A	0.73	0.71	0.60	0.65	0.69
B	0.69	0.71	0.57	0.54	0.66
C	0.67	0.65	0.62	0.51	0.70
D	0.65	0.63	0.59	0.58	0.68
E	0.69	0.67	0.58	0.62	0.62
F	0.70	0.74	0.62	0.61	0.65
Avg.	0.688	0.685	0.597	0.585	0.667

The result is shown in Table 1. we could see the average accuracy of ELM Model with tanh activation function has the best performance compare to other methods. The average accuracy is around 0.688%.

References

[1] Matsuo T., Yoshida S., Improvement of Convolutional Neural Network using Extreme Learning Machine as Full-connected Layers, 4th InternationalWorkshop on Advanced Computational Intelligence 1 and Intelligent Informatics, 2015.

[2] Huang G. B., Zhu Q. Y., Siew C. K., Extreme learning machine: a new learning scheme of feedforward neural networks, Proc. 2004 IEEE Int. J. Conf. on NN, 985-990.