EEG-based Emotion Recognition with Manifold Regularized ELM

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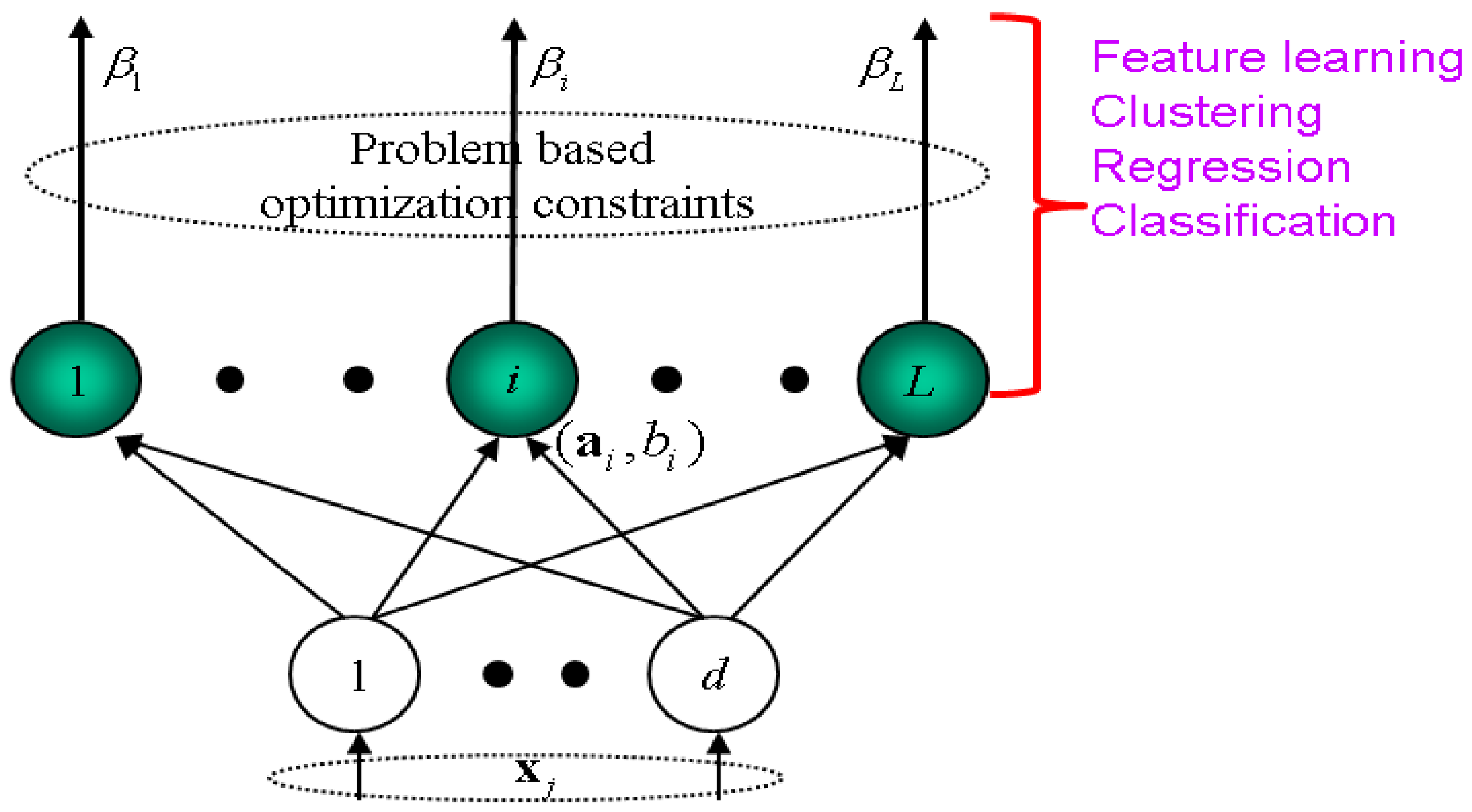
Introduction

EEG provides researchers an effective channel to investigate the transition of human's emotional states. The most widely used classifier is the support vector machine (SVM). This work introduces the Extreme Learning Machine (ELM) model and proposes to simultaneously take the discriminative and structure information in EEG data into consideration. The newly formulated model is the Manifold Regularized ELM (MRELM), and is proven to be an competitive model for EEG based emotion recognition.

Method



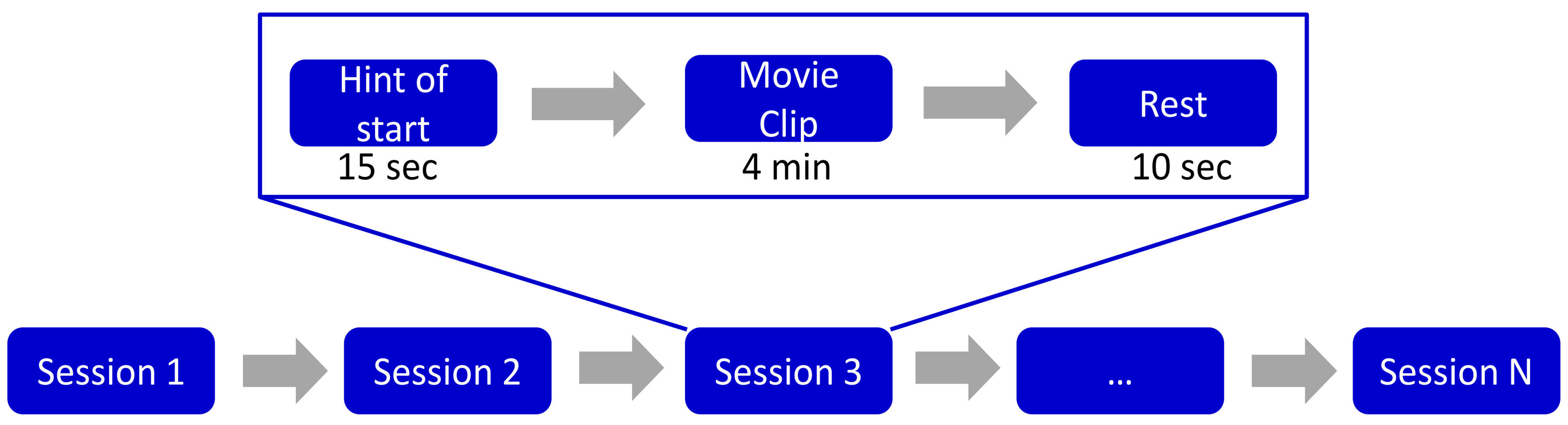
Overview of the Extreme Learning Machine

Generally, ELM can be viewed as a two-stage learning model
- Random Feature Mapping
- Output Weight Learning

Our MRELM model can be derived as

Model Evolution of ELM Variants

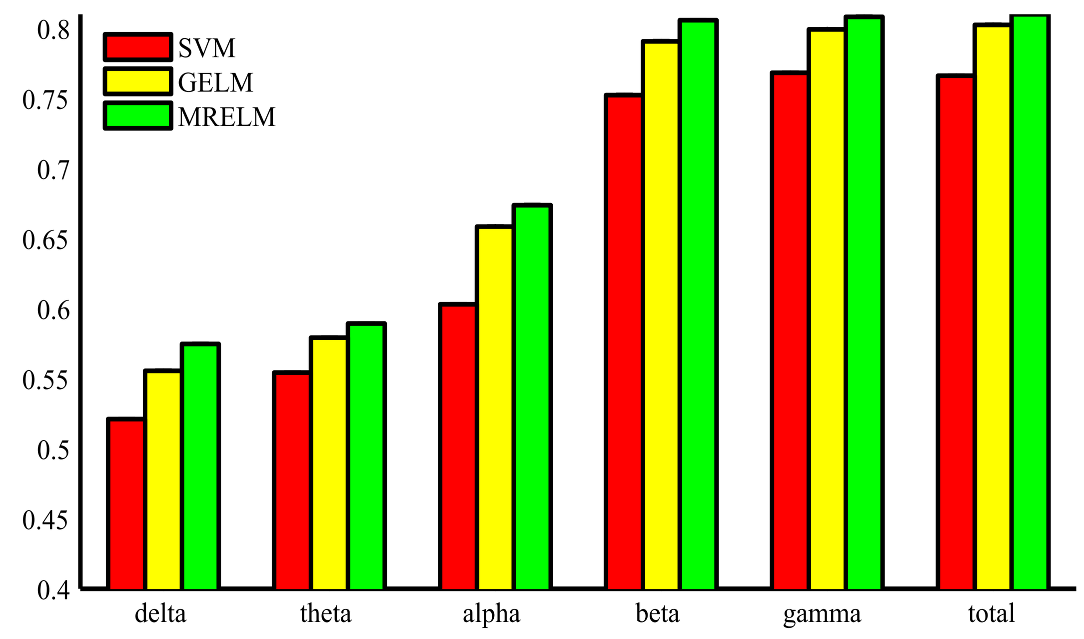
Data Acquistion



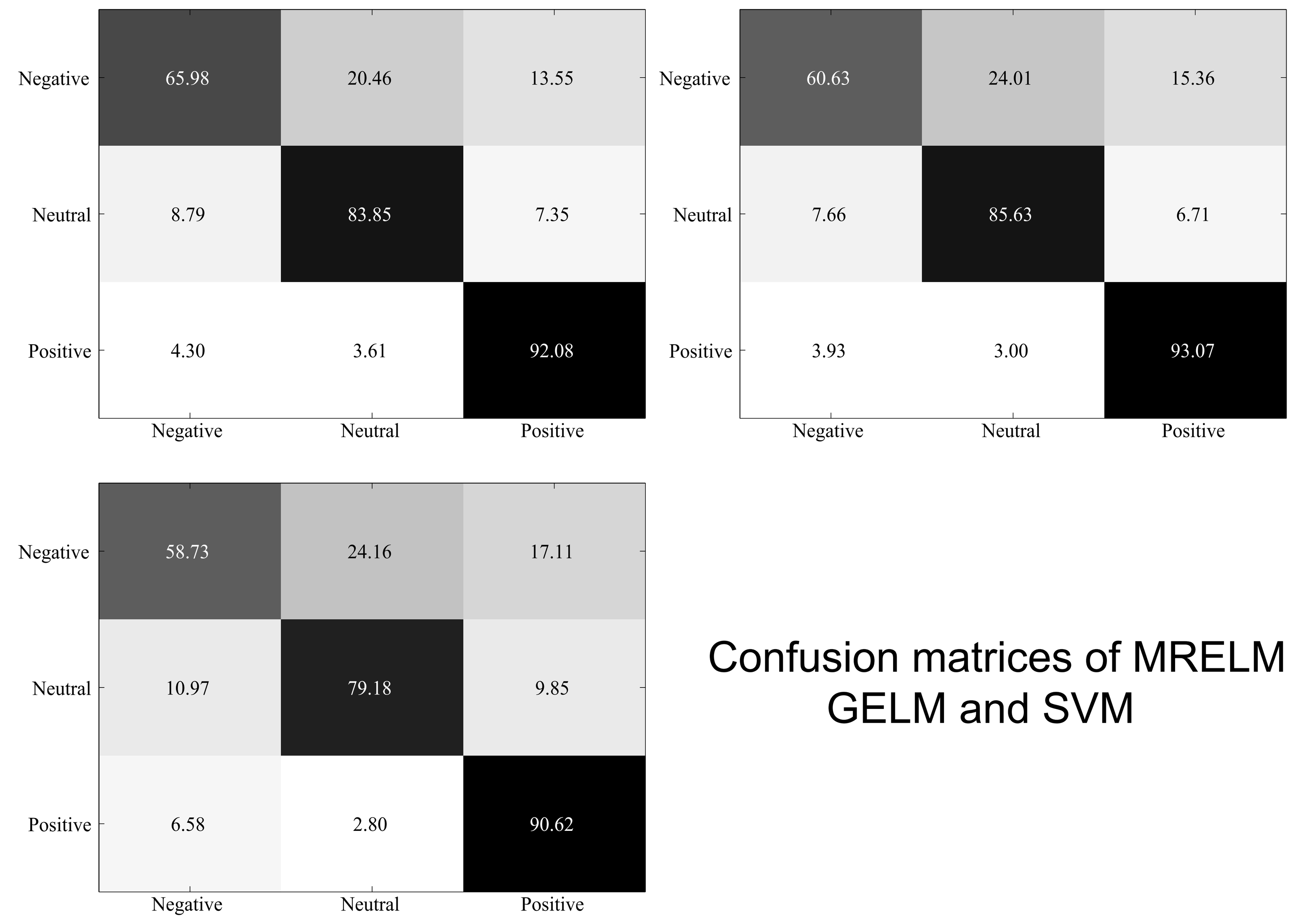
Protocol of the EEG Acquisition

- Model perspective:
  - 'discriminative information + geometrical structure' is more effective

Experimental Paradigm 1: For each subject, using former data training and later data for testing.

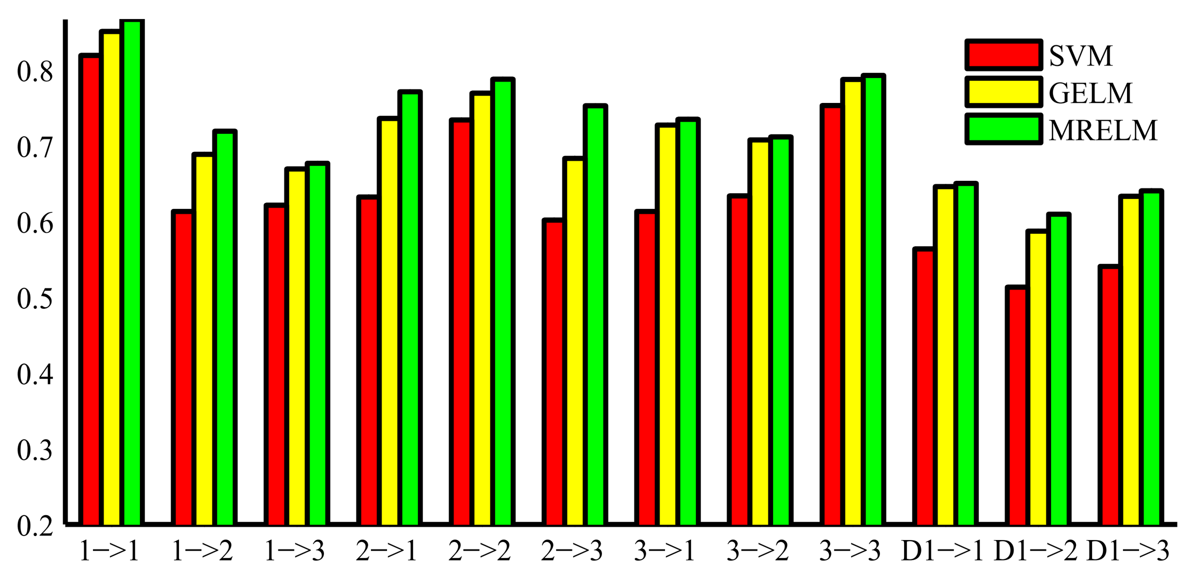


Recognition Accuracy in Experimental Paradigm 1



Confusion matrices of MRELM GELM and SVM

Experimental Paradigm 2: Training and testing data are from different subjects.



Accuracies for Subject Transfer

Conclusions

- Biomedical perspective:
  - 'beta' and 'gamma' features are more related to the transition of emotional states;
  - positive state are easiest to be estimated than the other two states;
  - the connection between emotional states and EEG is stable among different sessions and different subjects

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