EEG Pattern Recognition (Machine Learning)

February 23, 2015

Experimental Design

- Experimental paradigm (what approach will we take)
- Establish an outcome (in our case we will consider only two discrete brain states)
- How many channels?
- Which brain locations to be monitored?
- How many subjects and trials do we need?

Steps in Machine Learning (1)

- Decide which brain tasks (states) you want to study
- Determine how many experiments you need to perform (for both initial analysis and testing)
- Randomize task performance
- Perform tasks and collect data (EEG) for each task performance

Steps in Machine Learning (2)

- Select possible EEG features to be used to differentiate between different tasks
- Analyze features to determine which could be suitable for machine learning
- Use these features and the training set of data with your machine learning approach (e.g. SVM) to create your algorithm
- Test algorithm with remaining data (test set)

Human (or Biological) Variability

- Experimental paradigm can be several trials for multiple subjects.
- Can be many trials for one subject
- More desirable to use one subject to avoid inter-subject variability – reduce total number of trials
- Less desirable to use one subject because results can’t be generalized

Number of Trials

- Depends on inter or intra subject variability when performing same task
- Depends on number of features measured from EEG to classify brain state
- Can be calculated statistically using a very complex multi-feature power analysis (usually based on only one outcome measure)
- No a priori knowledge of feature variance for each task
- Train subjects first to reduce variance?

Length of Each Data Record

- Time to perform a task
- Subject fatigue and ability to maintain a brain state for that task
- Variance of features considered over a given time window
- Mathematical constraints when determining feature value (e.g. can you reliably estimate delta power when data record 1 sec?

Determining Discriminatory Features

- Get ideas from published literature
- Select based on a priori knowledge or intuition
- Don’t select but consider all possible features in a given domain or multiple domains
- Requires feature optimization to limit number of features
- Remember fewer rather than more is more desirable
- Base features on physiology and anatomy where possible

Calculate Features

- Normalize features so all have same relative weight?
- If we consider frequency domain do we calculate powers, ratio of powers, coherence etc for each frequency or band of frequencies?
- Linearize features?

Select Model (Machine Learning)

- Linear or non-linear regression equation (dependent variable is brain state, features are independent variables)
- Can use step-wise regression to select features (form of optimization)
- Can use more modern techniques such as Support Vector Machine, Neural Network, Bayesian Estimator, etc.

Training and Testing Approach

- Leave one out (or n out) to use entire data set for both training and testing
- Accepted by engineers but not by clinicians since training and test sets are not independent
- Use first half of data to train classifier and second half to test

Suggested Paradigms (1)

- Motor Cortex tasks such as move left or move right (BCI for quadriplegia)
- Attractive because can train subject by actually doing task (only in normal subject)
- More difficult to visualize task without doing it in normal subjects (different brain area?)
- Paralyzed subject could be activating primary motor cortex but has no proprioceptive feedback

Suggested Paradigm (2)

- Cognitive Event Related Potentials (ERP)
- Recognition paradigm approach
- Present various visual or auditory stimuli and recognize the oddball, a specific number, etc
- ERPs could require averaging to get rid of background EEG (how many trials for each average)
- Objective to have single trial for ERP