An EEG Workload Classifier for Multiple Subjects

Ziheng Wang, Ryan M. Hope, Zuoguan Wang, Qiang Ji, Wayne Gray

Overview

1. Challenge
2. Approach
3. Experiment
4. Discussion
5. Future Direction

Challenge

* Large amount of noise

* Large between-subject/day/trial variations

	Individual subject	**8 subjects**
NB	80%	45%
NN	80%	58%

Goal

A Classifier for

Multiple Subjects!

Stimulation

* A subject-specific classifier

Trained and tested on individual subjects

* A cross-subject classifier

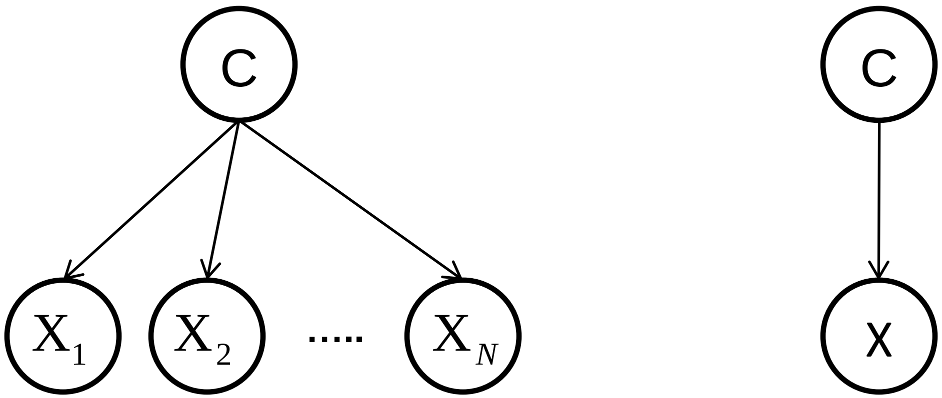
Trained on a group of subjects and tested on the same group of subjects

* A subject-independent classifier

Trained on a group of subjects but tested on a novel subject that has not been trained on

Approach

Naïve Bayes Classifier

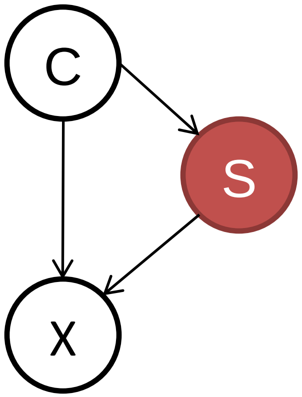


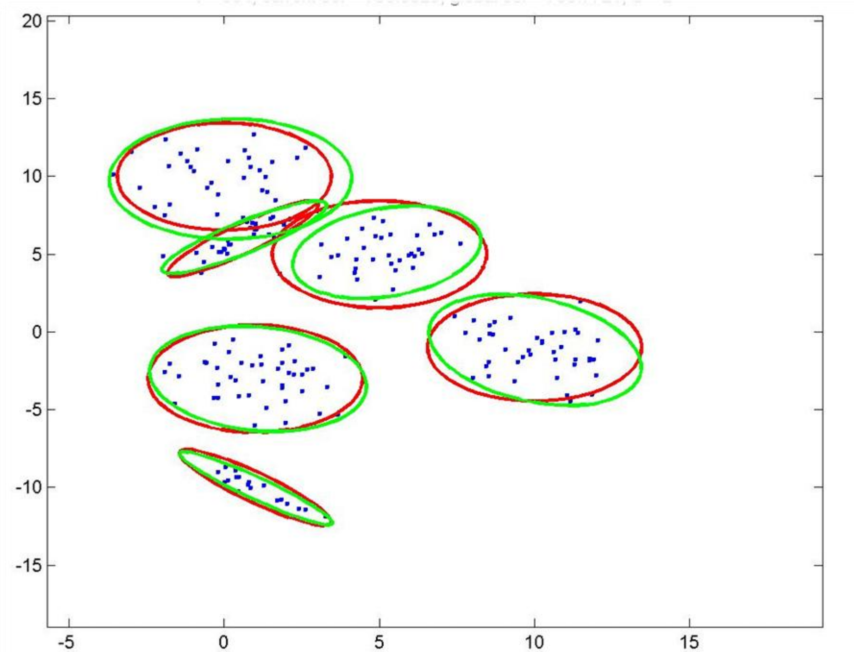
Likelihood $$P(X_1, X_2, \cdots, X_n \mid C) = \prod_{i=1}^{n} P(X_i \mid C)$$

Posterior Probability $$P(C \mid X_1, X_2, \cdots, X_n) \propto \prod_{i=1}^{n} P(X_i \mid C) P(C)$$

Approach

1st Attempt to Deal with Between-Subject Variations



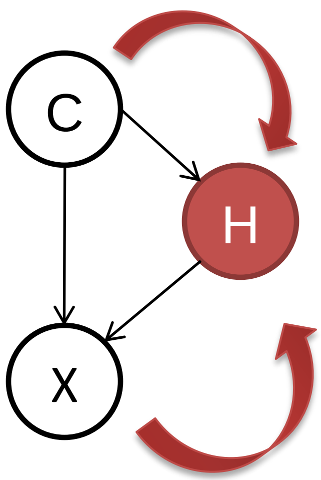


S is known during training but not testing

$$P(C \mid X) \propto \sum_S P(X \mid C, S) P(S \mid C) P(C)$$

Approach

2^{nd} Attempt to Deal with Between-Subject Variations

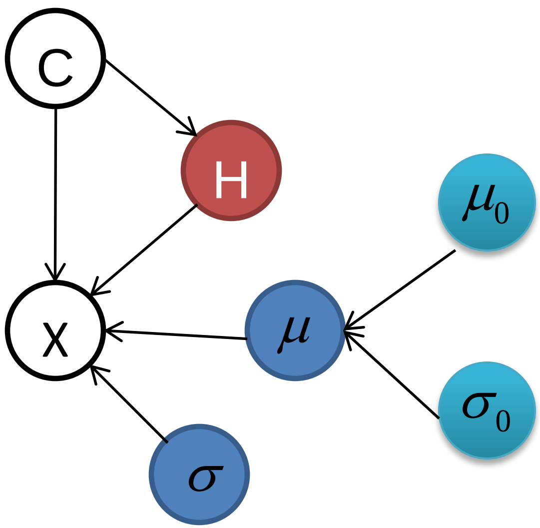


* Factors including subject that could cause variations
* Hidden Component

- H is unknown during both training and testing
- EM algorithm is used to uncover H node for training

Approach

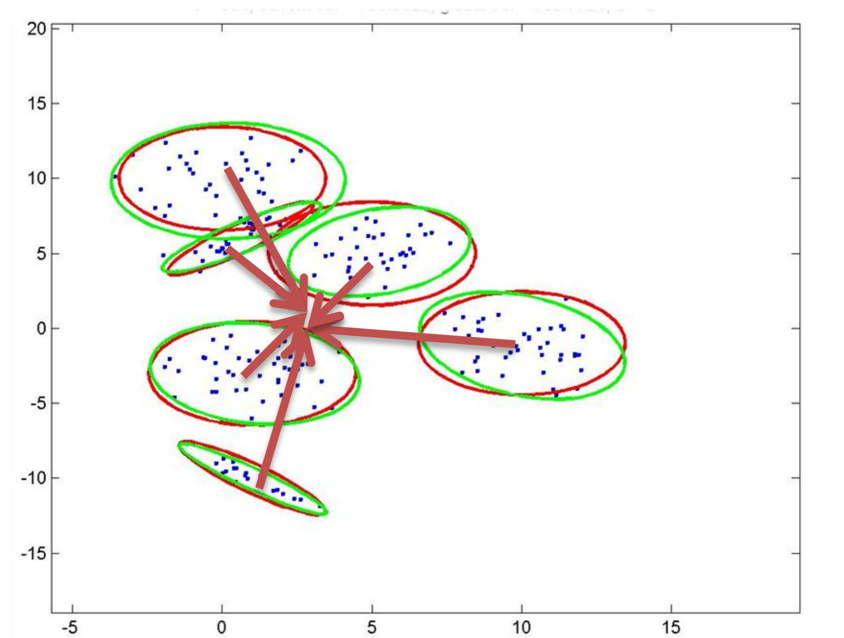
3rd Attempt to Deal with Between-Subject Variations



$$P(X \mid C, H) \sim N(\mu, \sigma)$$

$$\mu \sim N(\mu_0, \sigma_0)$$

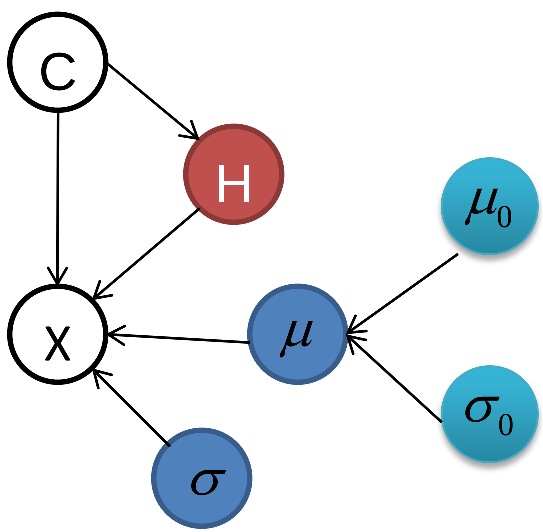
Constraints over parameters



Approach

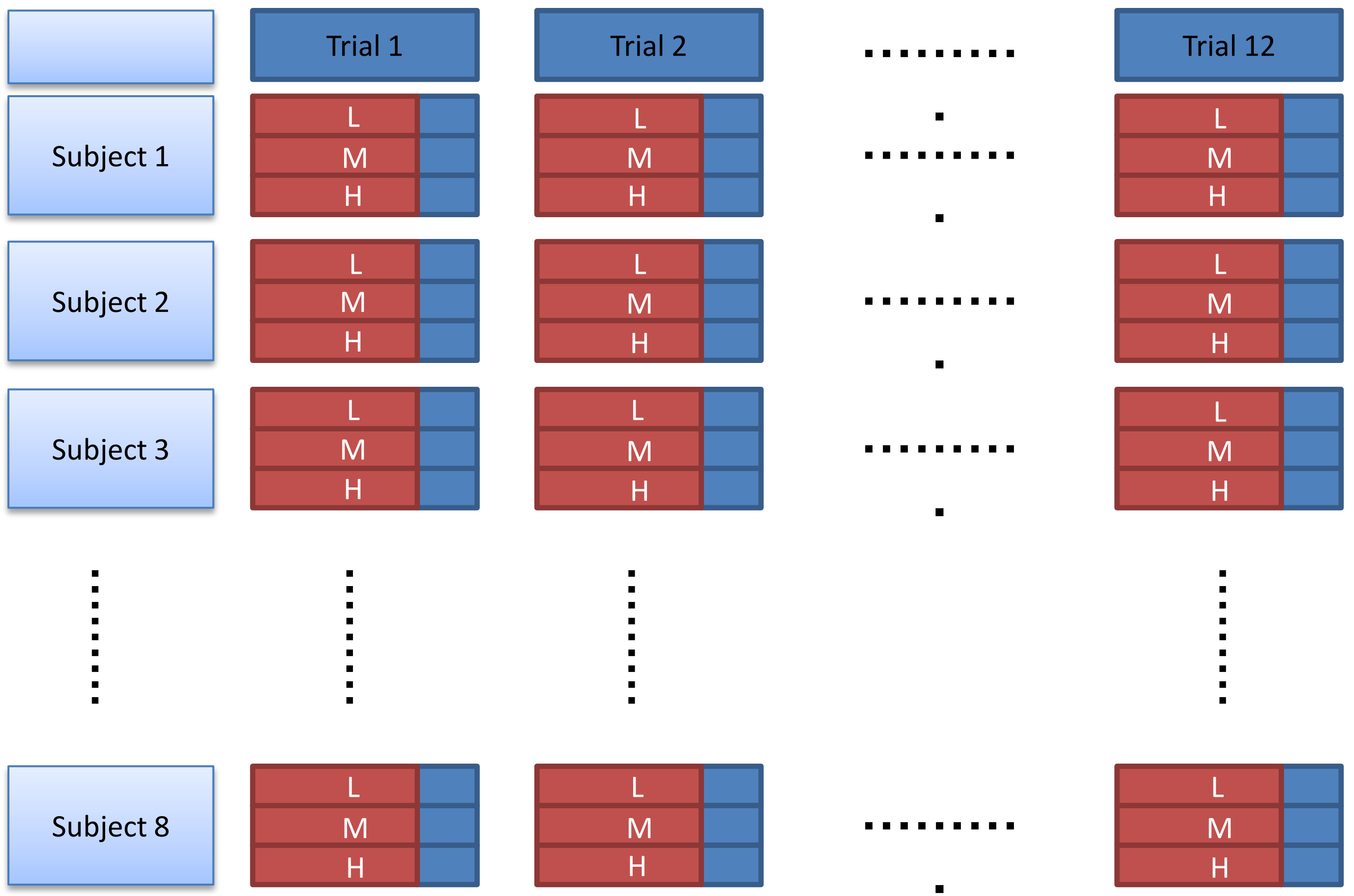
Properties:

* No a prior information is needed during both training and testing
* Able to capture the between-subject variations automatically
* Avoid overfitting by high level constraints



Experiment

Data



Experiment

Feature

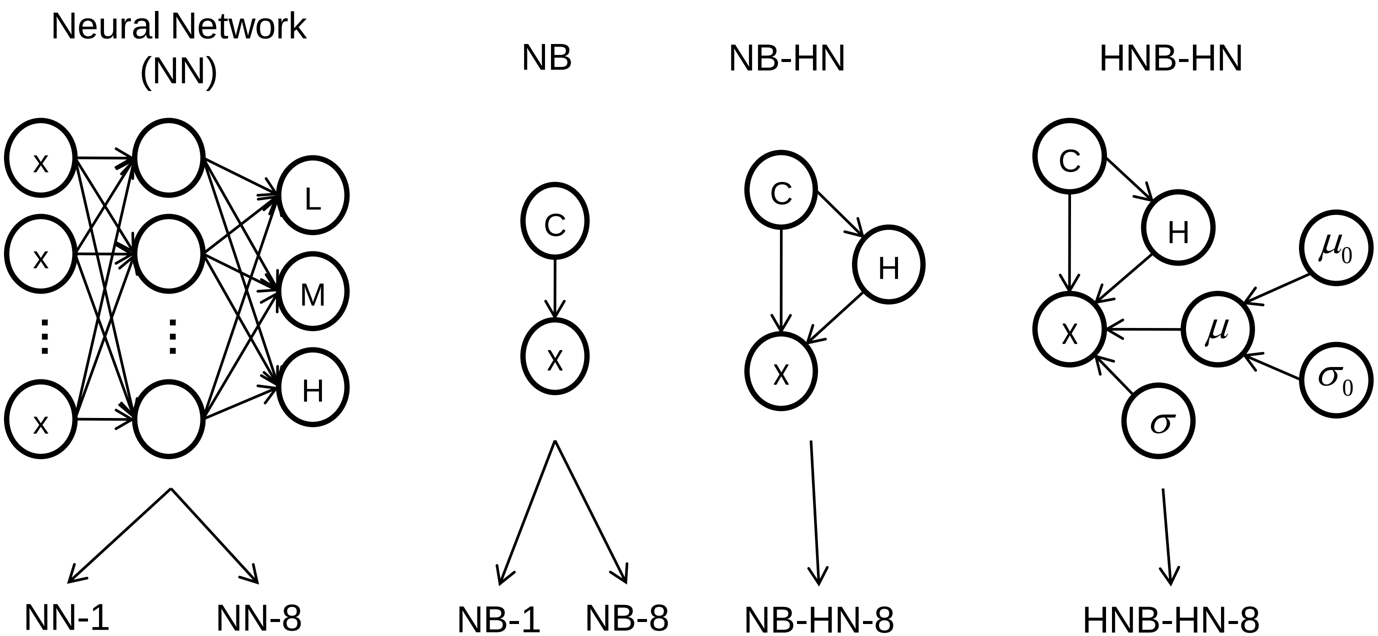
* **19 EEG channels**
* **Down sampled to 128 Hz**
* **No artifact correction or rejection**
* **Short-term Fourier transform**
* **40s windows with 35s of overlap**
* **No taper function was applied to the windows**
* **Magnitude of 5 standard clinical bands**
* **Delta [2-4Hz], theta [5-8Hz], alpha [9-13Hz], beta [14-32Hz], gamma [33-43Hz], expanded gamma [33-57Hz], [63-100Hz]**
* **A total of 133 input features**

Experiment

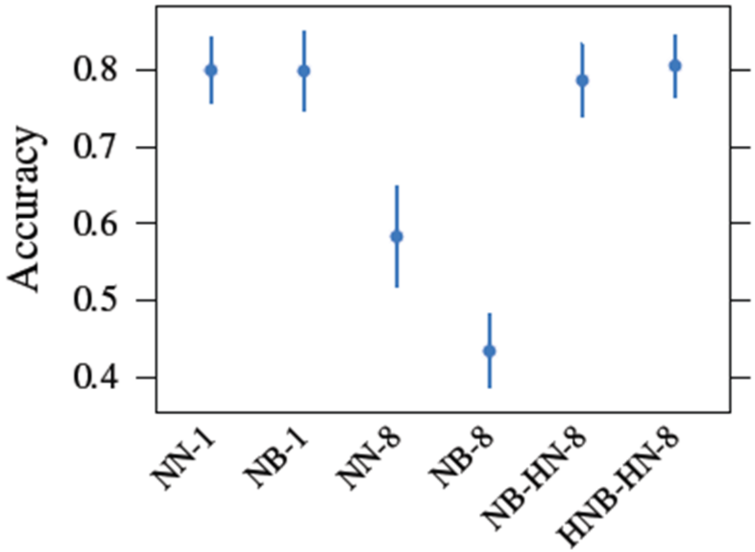
Classifiers

*** '-1': classifier that is trained and tested on individual subjects**

*** '-8': classifier that is trained on all 8 subjects but tested on individual subjects**



Discussion



*** As expected, NN-8 and NB-8 performs much worse than NN-1 and NB-1 when presented to a group of subjects**

*** NB with a hidden node performs as well as subject specific classifiers NN-1 and NB-1**

*** Constraints on the parameters led to further improvement**

Future Direction

* Cross-trial, cross-day workload classification
* A subject-independent classifier

For more details, you can also refer to our paper in the NeuroImage journal:

http://dx.doi.org/10.1016/j.neuroimage.2011.07.094

The work was supported in part by grant N0001410019 to Wayne D. Gray from the Office of Naval Research, Dr. Ray Perez, Project Officer.

Questions?