Machine Learning Lab 3: Bayesian Learning and Boosting

Tianxiao Zhao
Feiyang Liu

Mar. 1, 2017

Why Adaboost ?

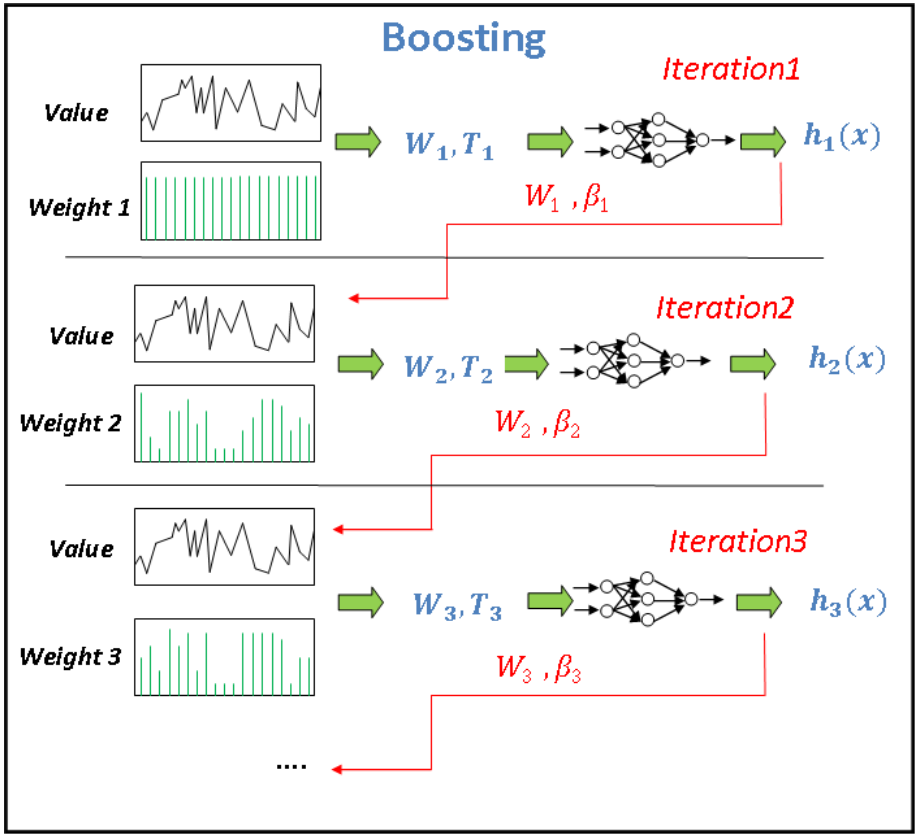
- Convert weak learners to strong ones
- Weak learners are usually easy to get
- Adaboost is a forward stage-wise additive algorithm using the exponential loss function, tending to reduce bias and variance

Pros & Cons of Adaboost

- **Pros**
  - Reduce bias and variance
  - Reduce dimensions of the model and the optimization problem (By using linear combination of weak learners)
  - Not easy to overfit in general
- **Cons**
  - Sensitive to Outliers (Because boosting gets base learner on previous errors. Outliers will get much higher attention than non-outliers)

How Adaboost works ?

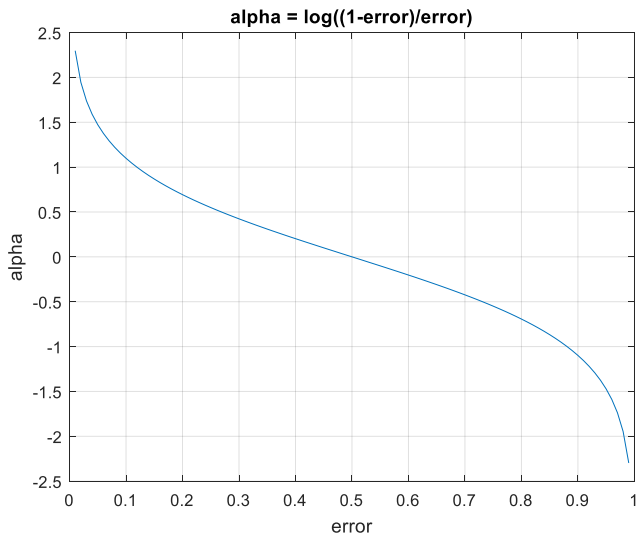
- Training
  - Step 1: Assign equal weight to each data
  - Step 2: Train weak learner with weights
  - Step 3: Get weak learner and its error with respect to weights
  - Step 4: Compute alpha based on error
  - Step 5: Update weights (pay higher focus on misclassified examples)
- Testing
  - Step 1: Classify using each weak learner
  - Step 2: Linear combination of outputs of all weak learners
- Summary of the Idea
  - Use weighted average
  - Consider prediction of higher vote

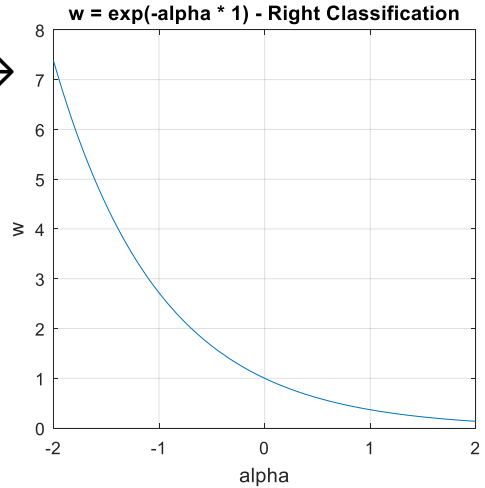


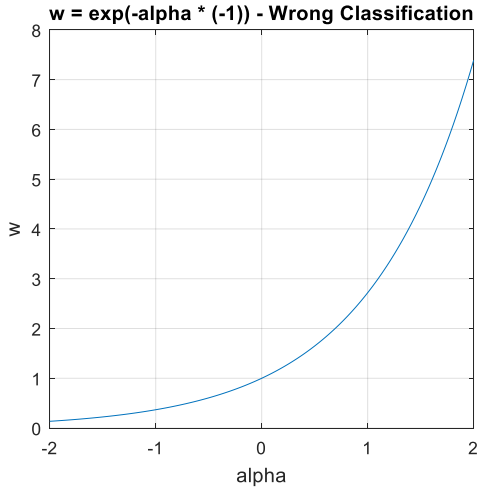
How Adaboost works ? (Cont')

- Alpha vs. Error
  - error > 0.5 → alpha < 0
  - error ↑ alpha ↓
  - Vice versa

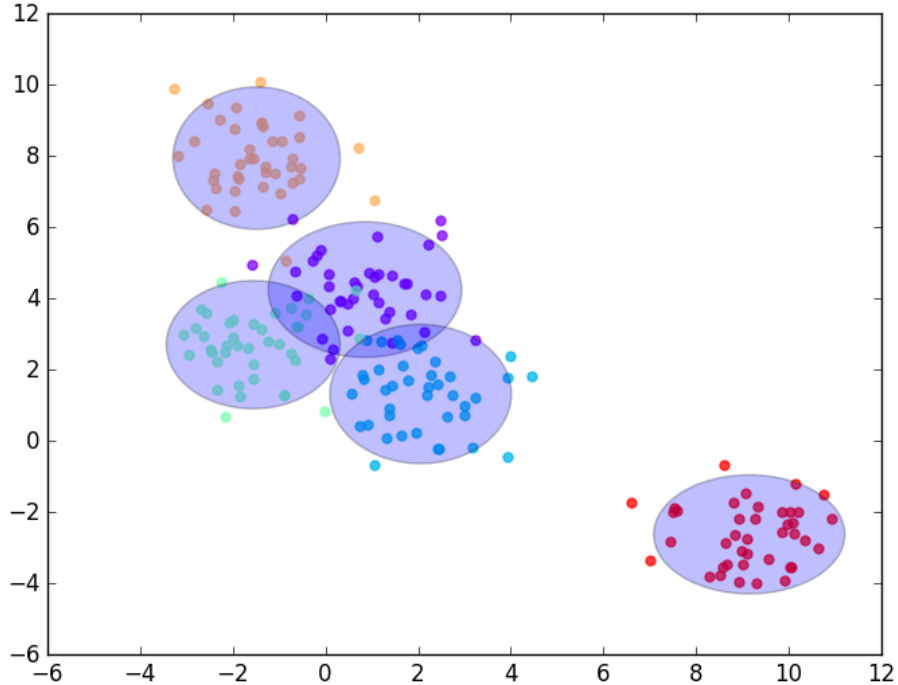
- Weights vs. Alpha
  - Right Classification & alpha > 0 → weights ↓
  - Wrong Classification & alpha > 0 → weights ↑
  - Vice versa







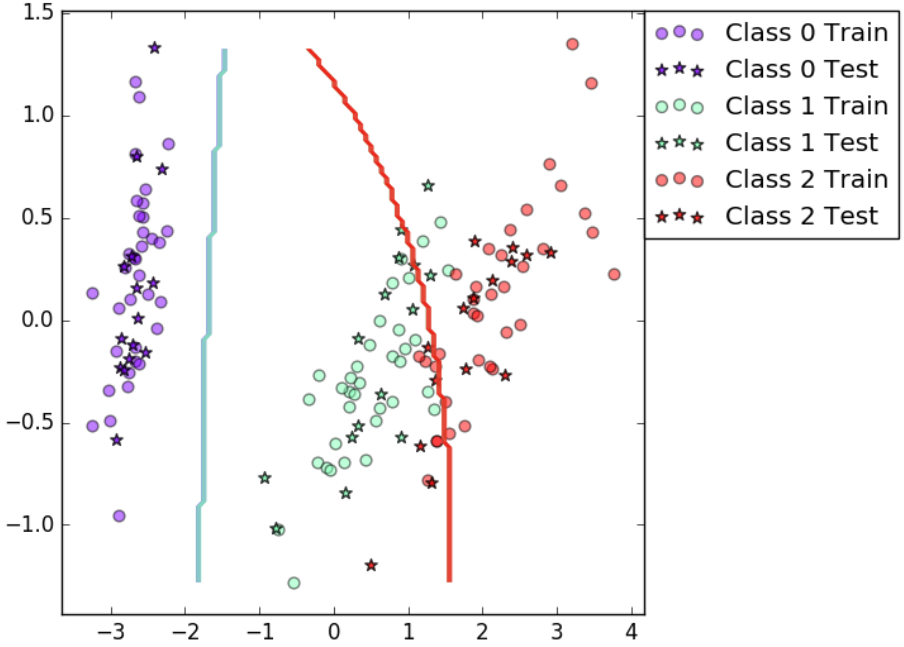
Experiment 1: Naïve Bayesian Maximum Likelihood Estimates



- Assumption: All of the feature dimensions are uncorrelated
- Covariance matrix is diagonal

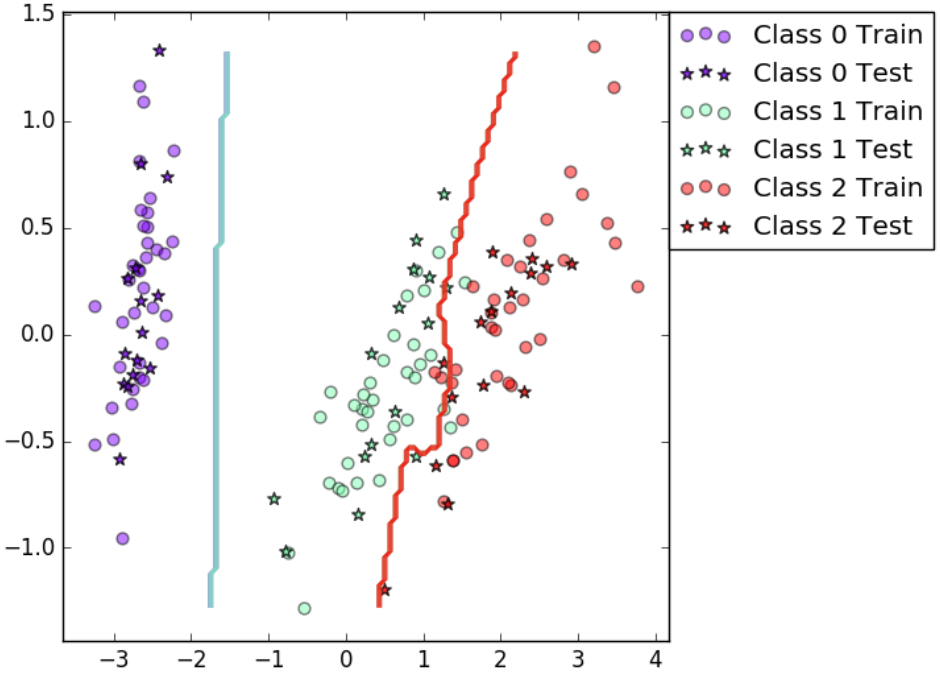
Experiment 2: Naïve Bayes Classifier on the Iris Dataset

Non-boosting



- Final mean classification accuracy 89 with standard deviation 4.16

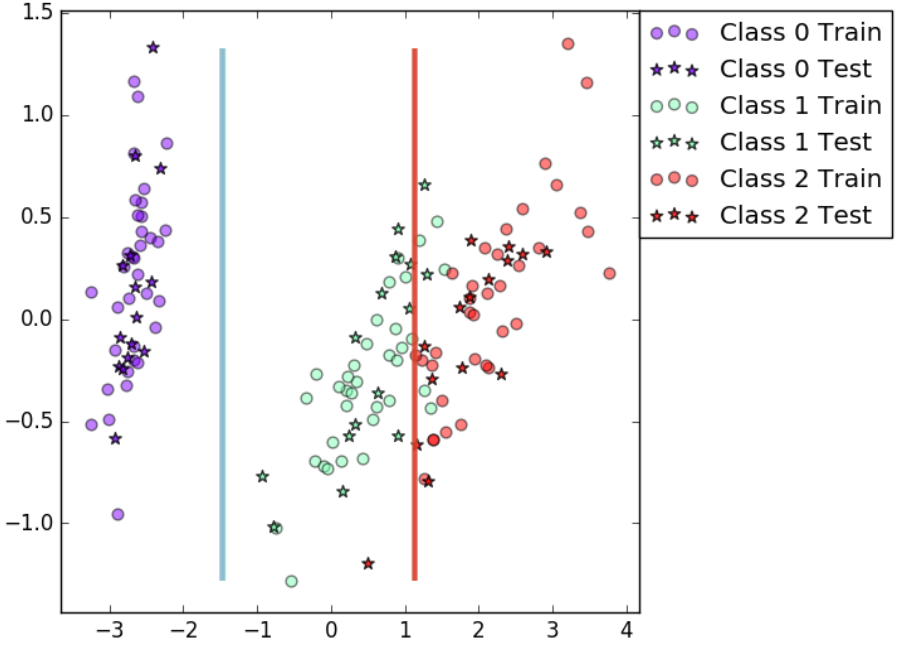
Boosting



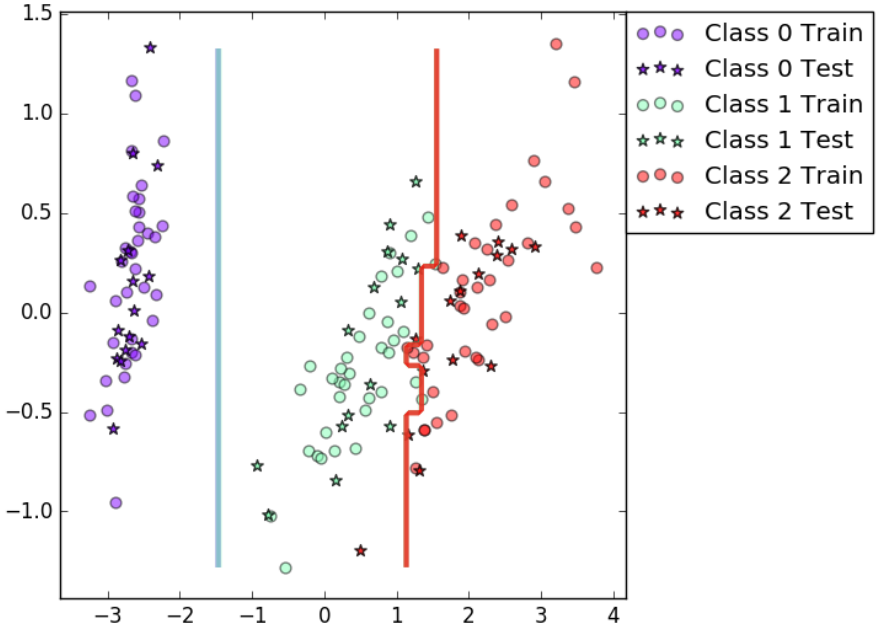
- Final mean classification accuracy 94.1 ↑ with standard deviation 6.72 ↑

Experiment 3: Decision Tree Classifier on the Iris Dataset

Non-boosting



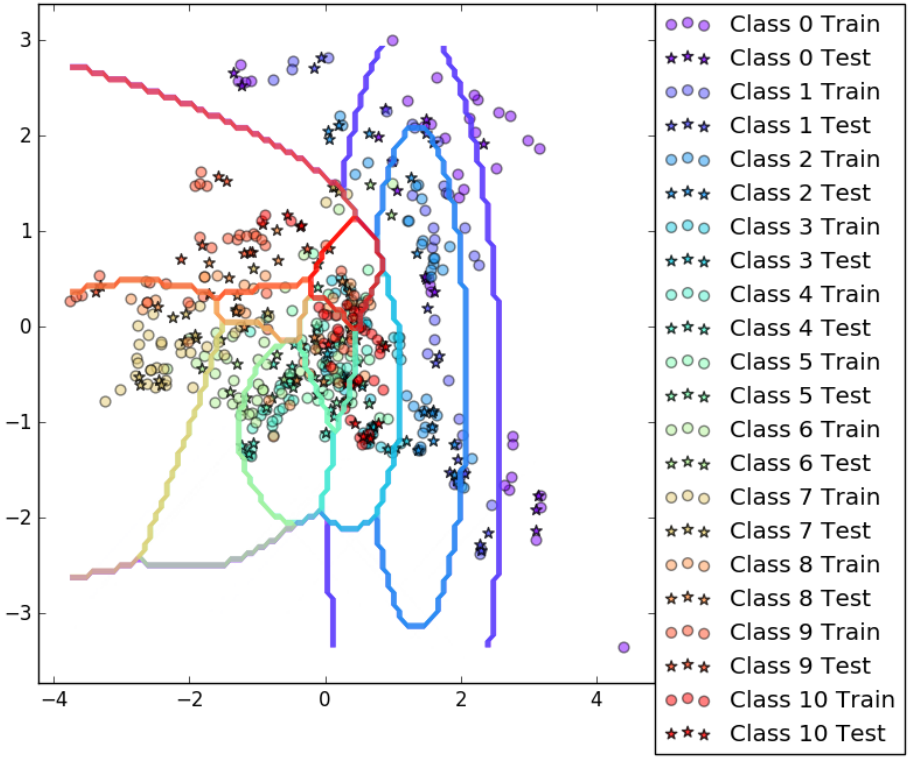
Boosting



- Final mean classification accuracy 92.4 with standard deviation 3.71
- Final mean classification accuracy 94.6 ↑ with standard deviation 3.65 ↓

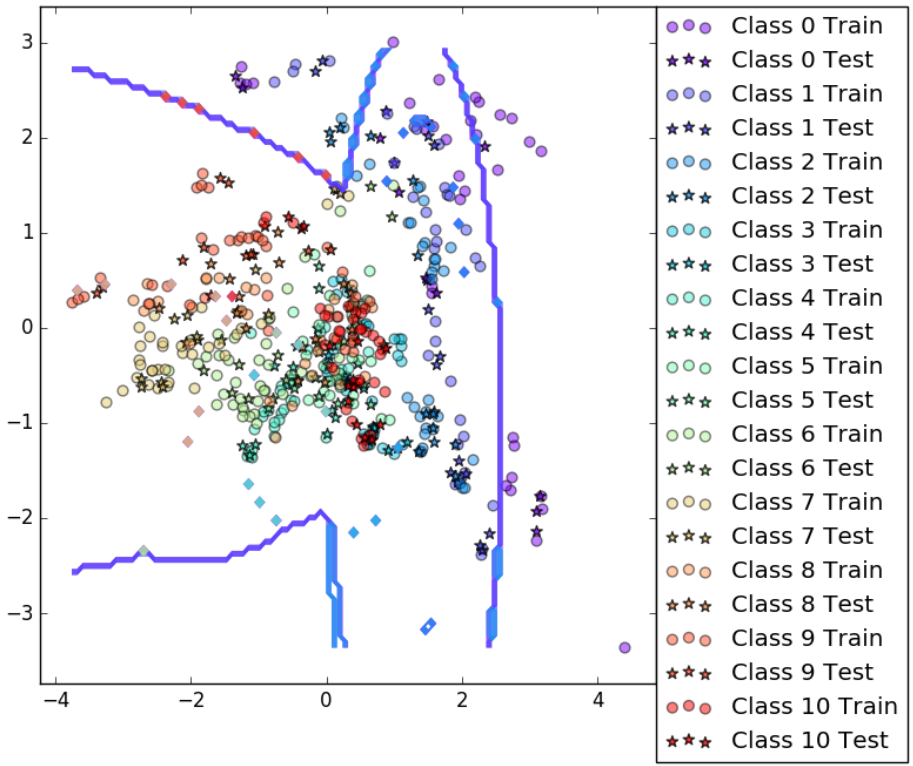
Experiment 4: Naïve Bayes Classifier on the Vowel Dataset

Non-boosting



- Final mean classification accuracy 64.7 with standard deviation 4.03

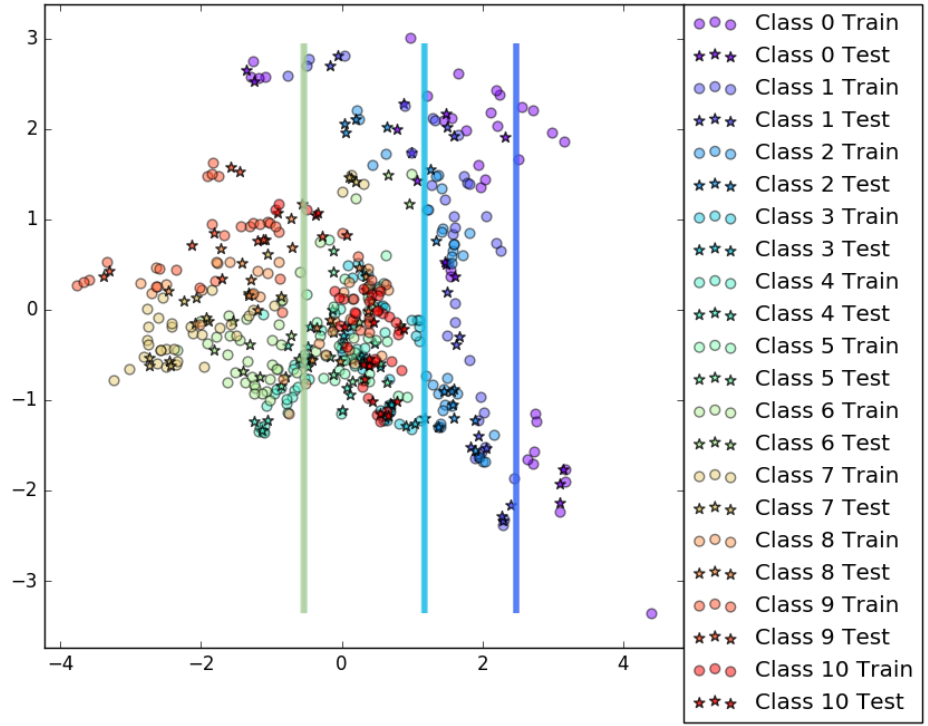
Boosting



- Final mean classification accuracy 80.2 ↑ with standard deviation 3.52 ↓

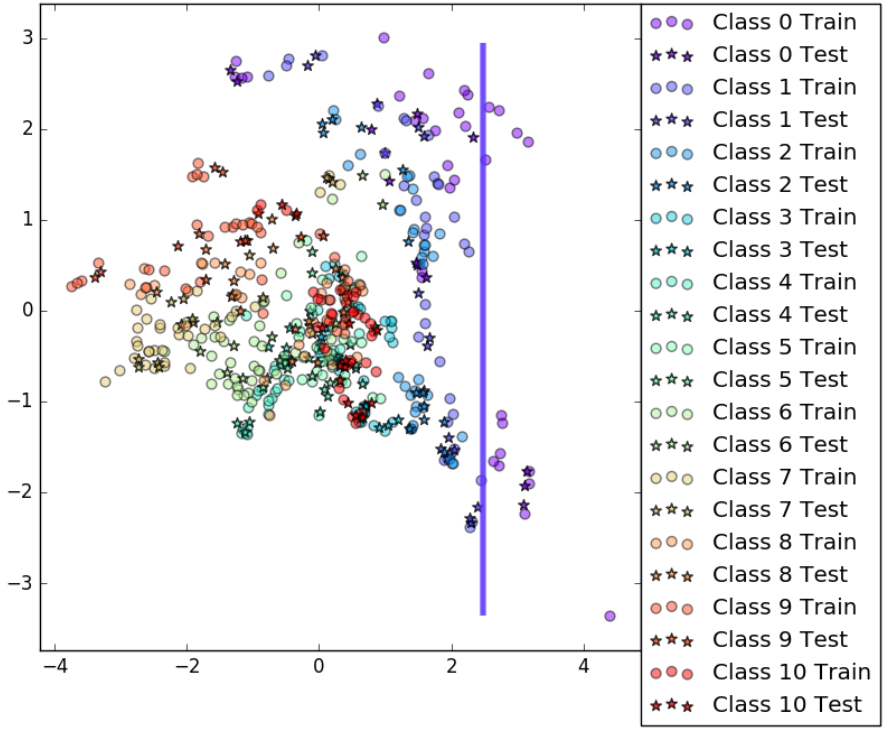
Experiment 5: Decision Tree Classifier on the Vowel Dataset

Non-boosting



- Final mean classification accuracy 64.1 with standard deviation 4

Boosting



- Final mean classification accuracy 86.9 ↑ with standard deviation 3.06 ↓

Experiment 6: Naïve Bayes Classifier on the Olivetti Dataset

- Final mean classification accuracy 87.7 with standard deviation 3.03

Experiment 7: Boosting Naïve Bayes Classifier on the Olivetti Dataset (Failed)

- Final mean classification accuracy 2.5 with standard deviation 0

Experiment 8: Decision Tree Classifier on the Olivetti Dataset (Failed)

- Final mean classification accuracy 48.5 with standard deviation 6.27

Experiment 9: Boosting Decision Tree Classifier on the Olivetti Dataset

- Final mean classification accuracy 71 ↓ with standard deviation 6.07 ↑

Experiment 10: Classify faces Using Boosting Decision Tree on Olivetti

Experiment 10: Classify faces Using Boosting Decision Tree on Olivetti (cont')