

DREXEL UNIVERSITY

CS499I

ADVANCED NEURAL NETWORKS

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# Facial Recognition With Artificial Neural Networks

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May 1, 2017

# 1 Datasets

**Yale Faces Database** This dataset contains 165 grayscale images in GIF format of 15 individuals with 11 images per person. There is one image per each of the following configurations: center-light, w/glasses, happy, left-light, w/no glasses, normal, right-light, sad, sleepy, surprised, and wink.

# 2 Testing Parameters

The following variants are tested for accuracy:

1. With and without a bias node at the input layer
2. With and without a bias node at the hidden layer
3. With and without standardizing features
4. With and without applying PCA to reduce the number of features to 95%

Empirical data was generated to optimize the following parameters:

1. Termination criteria (Number of Training Iterations)
2. Hidden layer size
3. Image size
4. Learning Rate
5. PCA Field Retention

# 3 Baseline Accuracy

The baseline accuracy was created using the negative form of all variants with the exception of data standardization. The baseline parameters were as follows: 40 by 40 sized images, a hidden layer size of 20, 1000 training iterations, and a learning rate of 0.5.

Input layer bias node	N
Hidden layer bias node	N
Standardization of features	Y
PCA applied	N
Testing Accuracy	0.800000

Table 1: Baseline Testing Accuracy

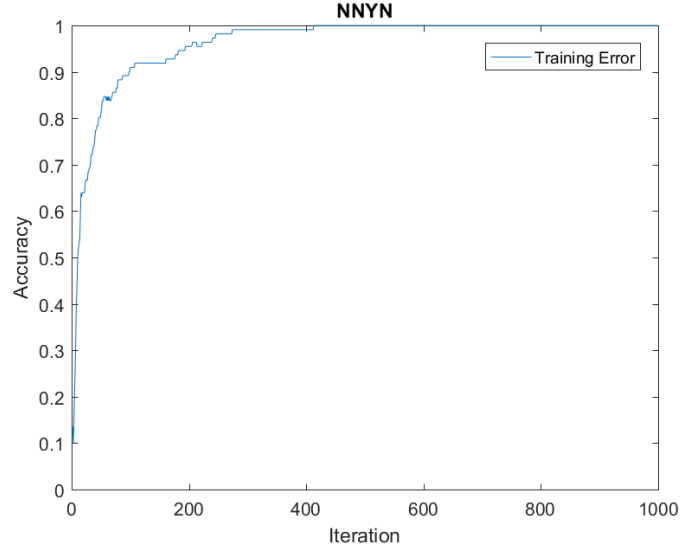


Figure 1: Baseline Training Accuracy

## 4 Variant Accuracy Testing

All variants were tested using 40 by 40 sized images, a hidden layer size of 20, 1000 training iterations, a learning rate of 0.5, and a PCA retention rate of 0.95.

Input layer bias node	N
Hidden layer bias node	N
Standardization of features	N
PCA applied	N
Testing Accuracy	0.163636

Table 2: NNNN Testing Accuracy

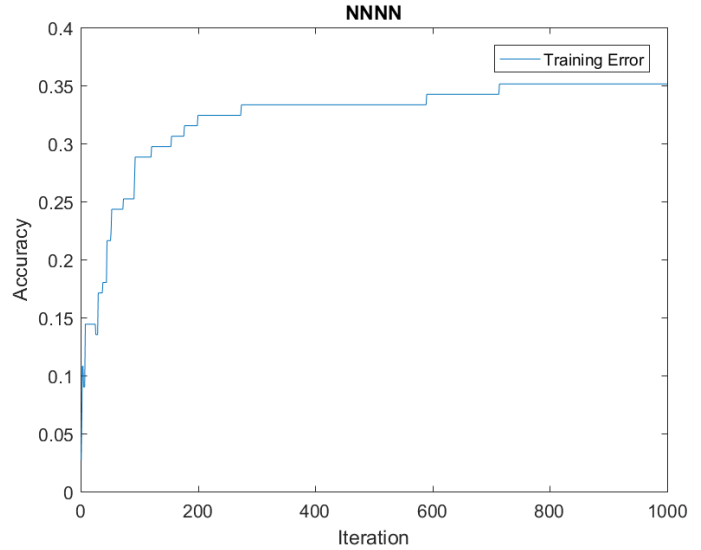


Figure 2: NNNN Training Accuracy

Input layer bias node	Y
Hidden layer bias node	N
Standardization of features	N
PCA applied	N
Testing Accuracy	0.272727

Table 3: YNNN Testing Accuracy

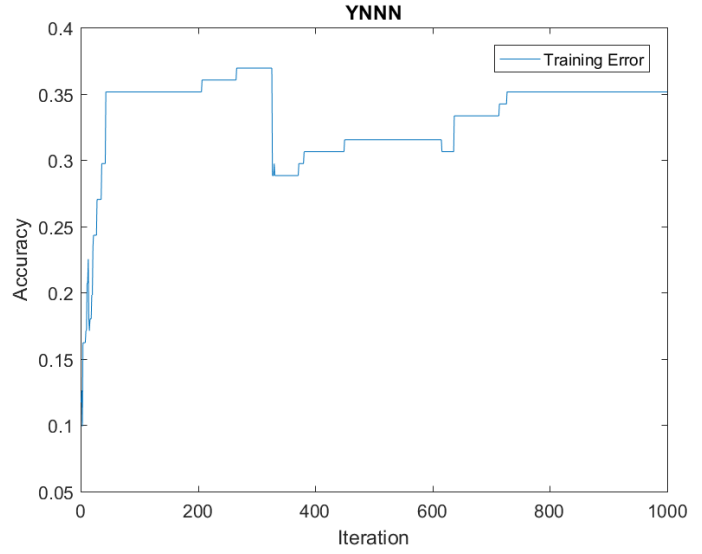


Figure 3: YNNN Training Accuracy

Input layer bias node	N
Hidden layer bias node	Y
Standardization of features	N
PCA applied	N
Testing Accuracy	0.218182

Table 4: NYNN Testing Accuracy

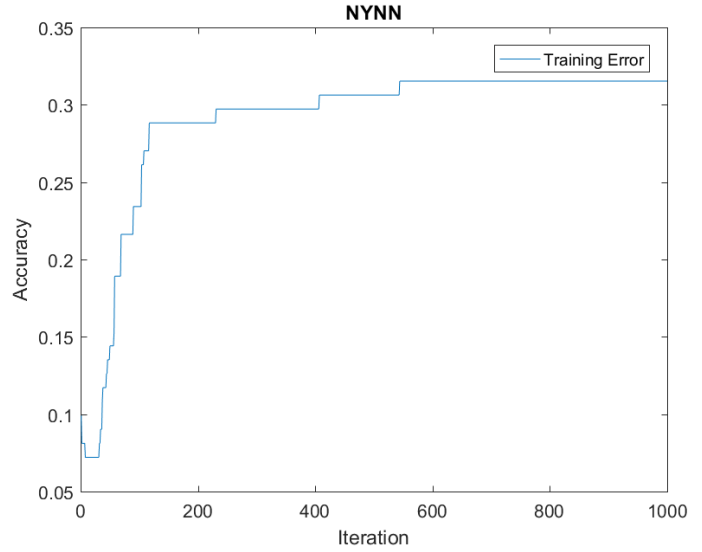


Figure 4: NYNN Training Accuracy

Input layer bias node	N
Hidden layer bias node	N
Standardization of features	N
PCA applied	Y
Testing Accuracy	0.254545

Table 5: NNNY Testing Accuracy

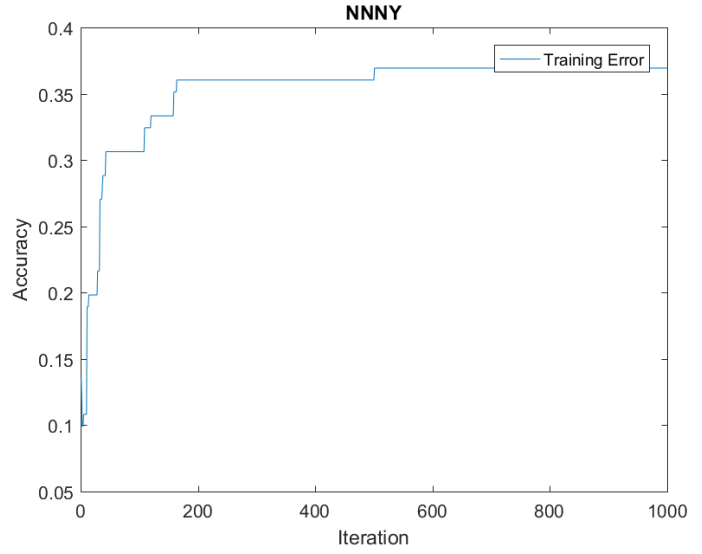


Figure 5: NNNY Training Accuracy

Input layer bias node	Y
Hidden layer bias node	Y
Standardization of features	N
PCA applied	N
Testing Accuracy	0.200000

Table 6: YYNN Testing Accuracy

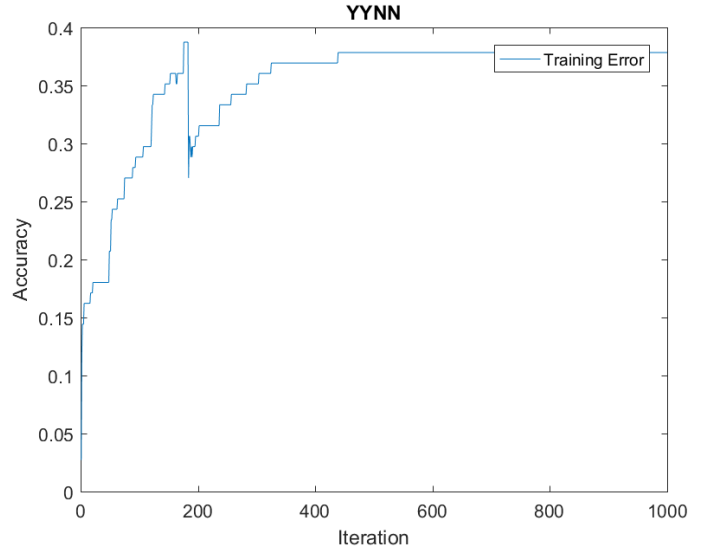


Figure 6: YYNN Training Accuracy

Input layer bias node	Y
Hidden layer bias node	N
Standardization of features	Y
PCA applied	N
Testing Accuracy	0.818182

Table 7: YNNY Testing Accuracy

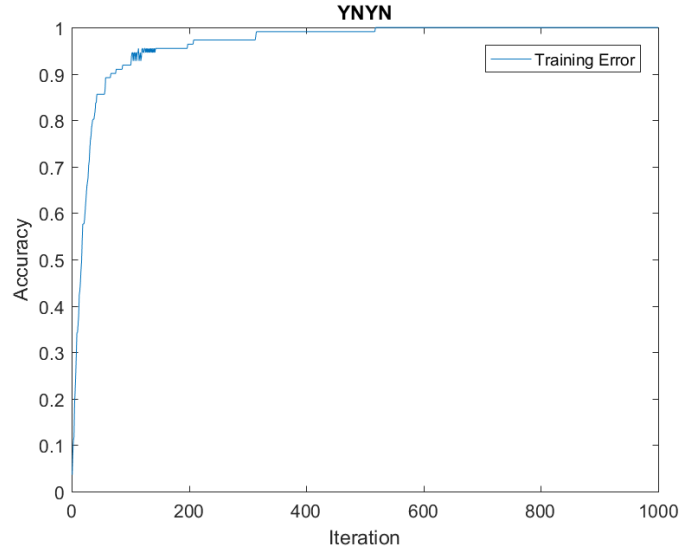


Figure 7: YNNY Training Accuracy

Input layer bias node	Y
Hidden layer bias node	N
Standardization of features	N
PCA applied	Y
Testing Accuracy	0.163636

Table 8: YNNY Testing Accuracy

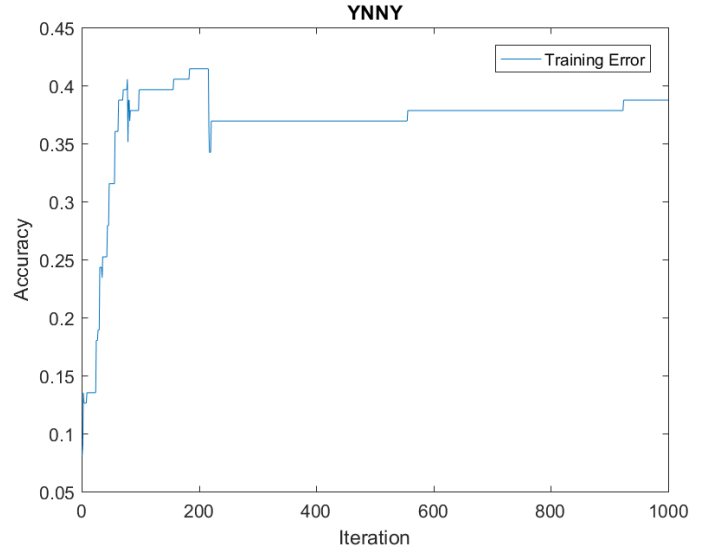


Figure 8: YNNY Training Accuracy

Input layer bias node	N
Hidden layer bias node	Y
Standardization of features	Y
PCA applied	N
Testing Accuracy	0.836364

Table 9: NYYN Testing Accuracy

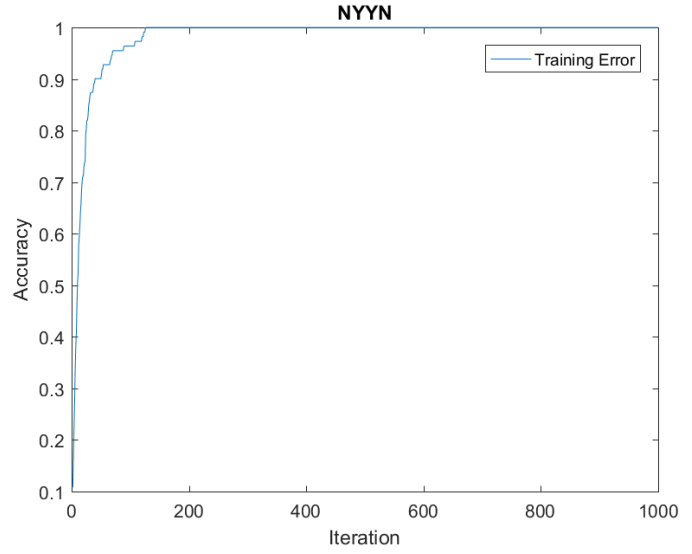


Figure 9: NYYN Training Accuracy

Input layer bias node	N
Hidden layer bias node	Y
Standardization of features	N
PCA applied	Y
Testing Accuracy	0.309091

Table 10: NYNY Testing Accuracy

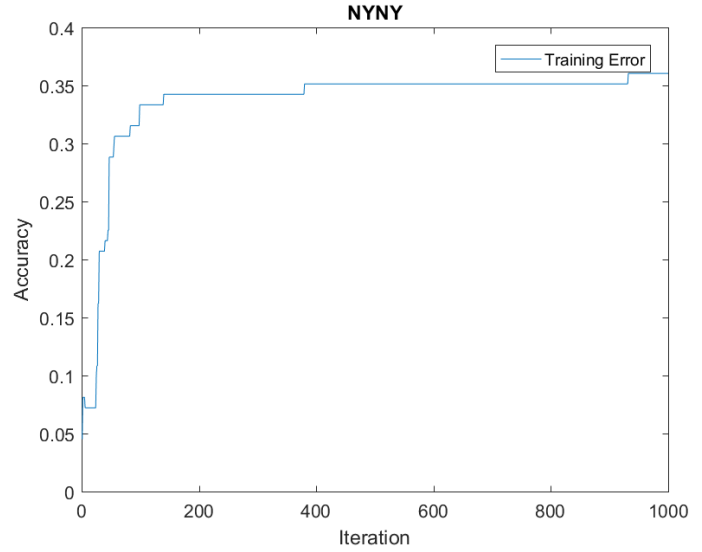


Figure 10: NYNY Training Accuracy

Input layer bias node	N
Hidden layer bias node	N
Standardization of features	Y
PCA applied	Y
Testing Accuracy	0.945455

Table 11: NNYY Testing Accuracy

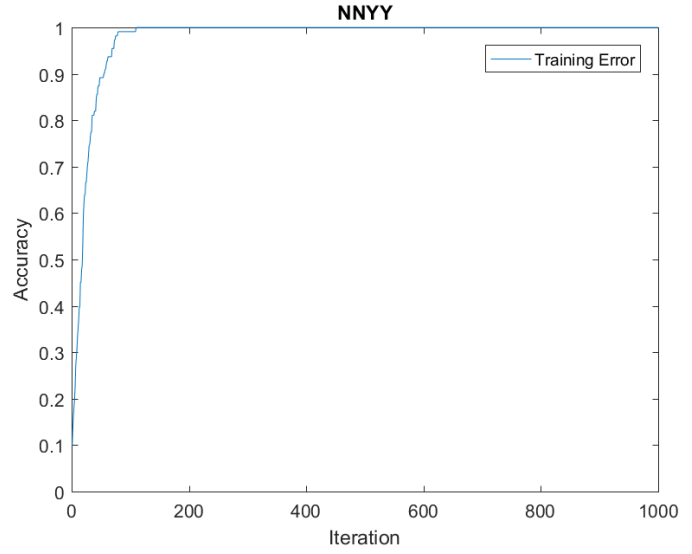


Figure 11: NNYY Training Accuracy

Input layer bias node	Y
Hidden layer bias node	Y
Standardization of features	Y
PCA applied	N
Testing Accuracy	0.781818

Table 12: YYYN Testing Accuracy

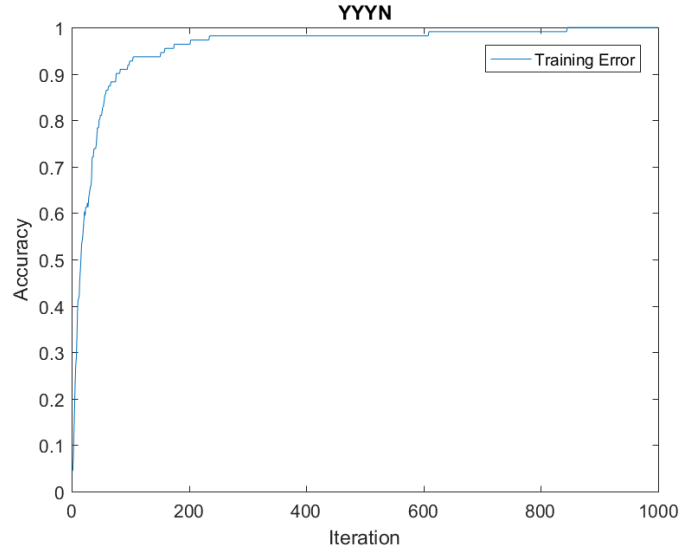


Figure 12: YYYN Training Accuracy



Input layer bias node	Y
Hidden layer bias node	Y
Standardization of features	N
PCA applied	Y
Testing Accuracy	0.327273

Table 13: YYNY Testing Accuracy

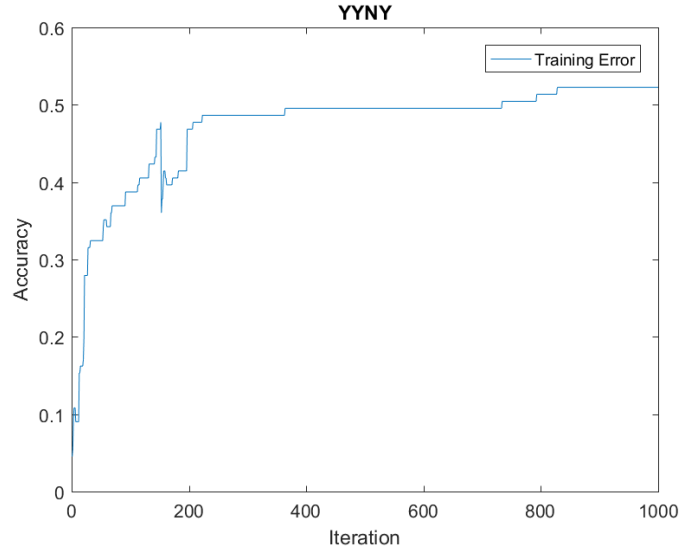


Figure 13: YYNY Training Accuracy

Input layer bias node	Y
Hidden layer bias node	N
Standardization of features	Y
PCA applied	Y
Testing Accuracy	0.963636

Table 14: YNYY Testing Accuracy

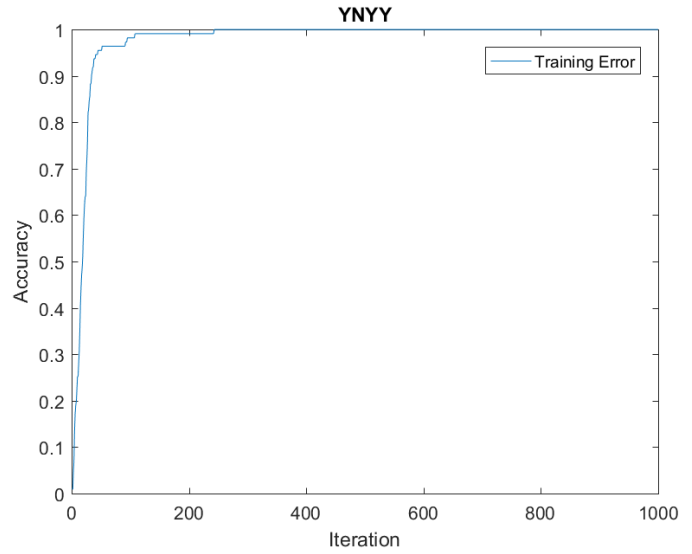


Figure 14: YNYY Training Accuracy

Input layer bias node	N
Hidden layer bias node	Y
Standardization of features	Y
PCA applied	Y
Testing Accuracy	0.945455

Table 15: NYYY Testing Accuracy

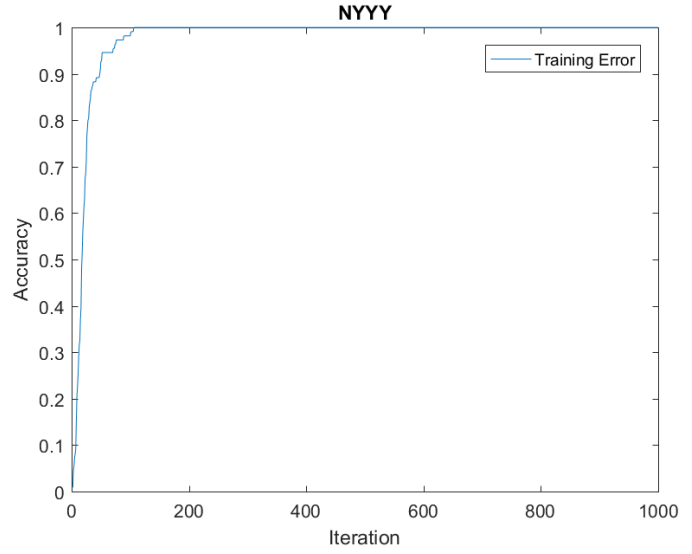


Figure 15: NYYY Training Accuracy

Input layer bias node	Y
Hidden layer bias node	Y
Standardization of features	Y
PCA applied	Y
Testing Accuracy	0.945455

Table 16: YYYY Testing Accuracy

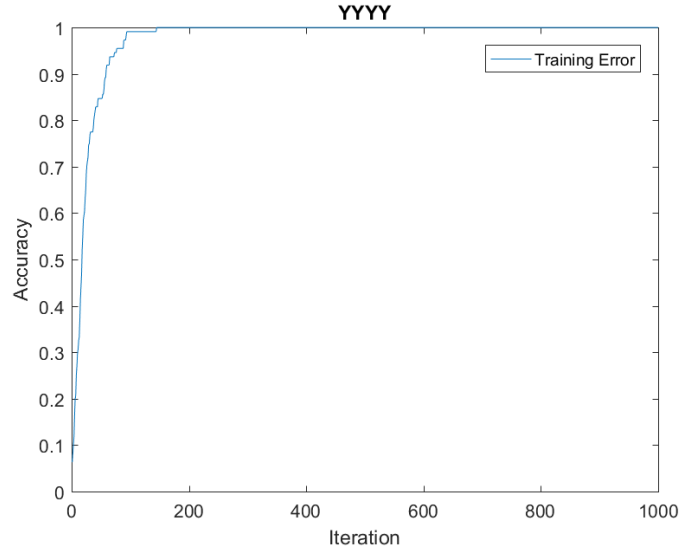


Figure 16: YYYY Training Accuracy

## 5 Empirical Parameter Accuracy Testing

All empirical data was gathered using the following variant which had the highest accuracy from the variant testing:

Input layer bias node	Y
Hidden layer bias node	N
Standardization of features	Y
PCA applied	Y
Testing Accuracy	0.963636

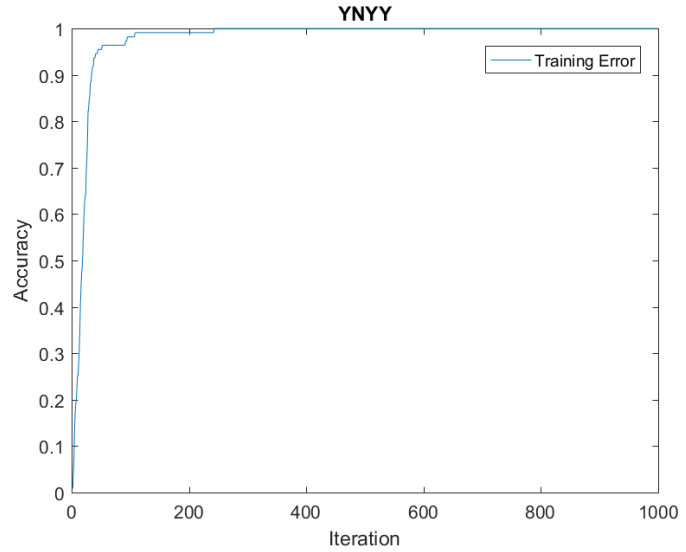


Table 17: YNYY Testing Accuracy

Figure 17: YNYY Training Accuracy

1. Number of Training Iterations The number of training iterations was varied from 0 to 10,000 by 100. The number of hidden nodes was 20, the image size was 40 by 40, and the learning rate was 0.5. The following is a plot of the accuracy as number of training iterations increases.

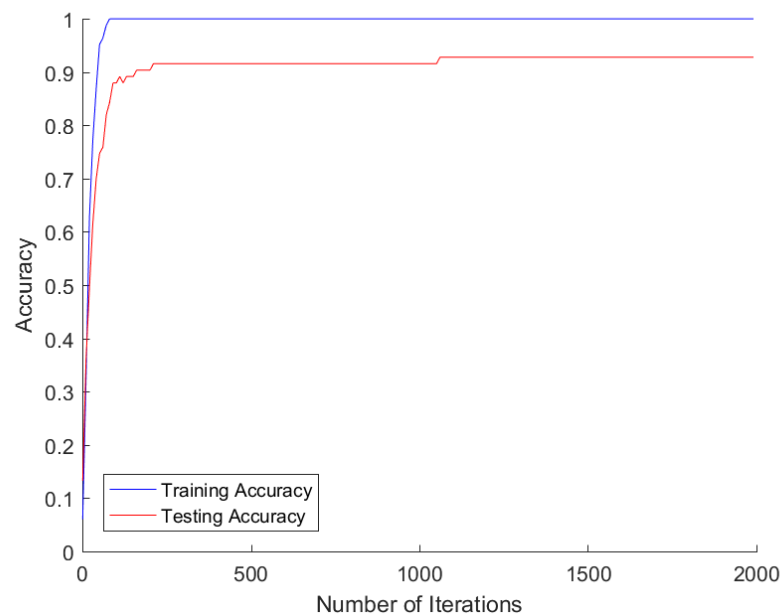


Figure 18: Plot of accuracy as number of training iterations increases

2. **Number of Hidden Nodes** The number of hidden nodes was varied from 0 to 1600 (the number of features) by 20. The number of training iterations was 10, the image size was 40 by 40, and the learning rate was 0.5. The following is a plot of the accuracy as number of hidden nodes increases. The number of training iterations was reduced to 10 in order to more clearly show the trend of increasing the number of hidden nodes.

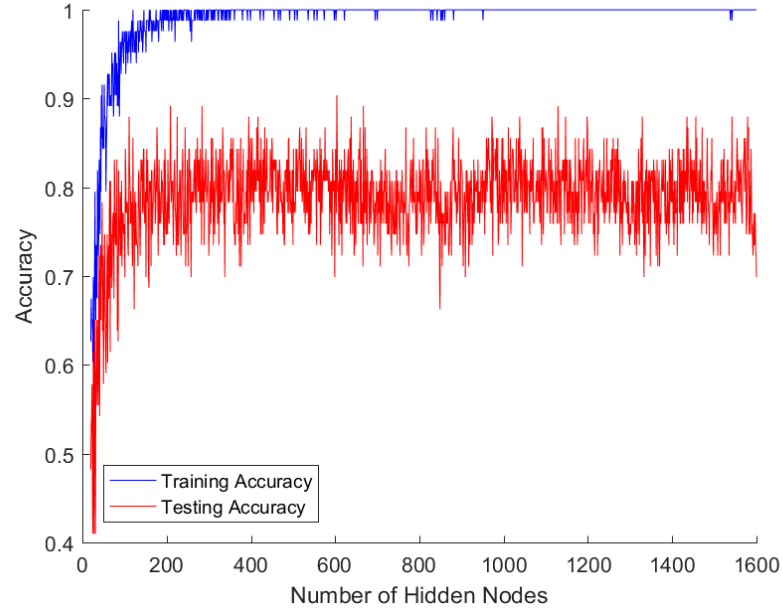


Figure 19: Plot of accuracy as number of hidden nodes increases

3. **Image Size** The image size was varied from 10 to 100 by 1, thus increasing the number of features quadratically. The number of training iterations was 500, the number of hidden nodes was 20, and the learning rate was 0.5. The number of training iterations was reduced to 500 in order to more clearly show the trend of increasing the number of hidden nodes.

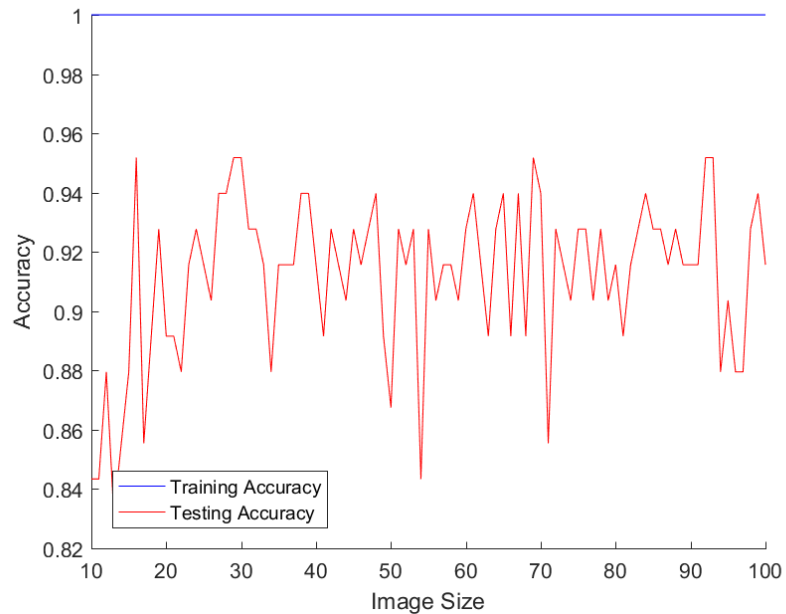


Figure 20: Plot of accuracy as the image size increases

4. Learning Rate The learning rate was varied from 0.05 to 20 by 0.05. The number of training iterations was 50, the number of hidden nodes was 20, and the image size was 40 by 40. The number of iterations was reduced to 50 in order to more clearly show the trend of increasing the learning rate.

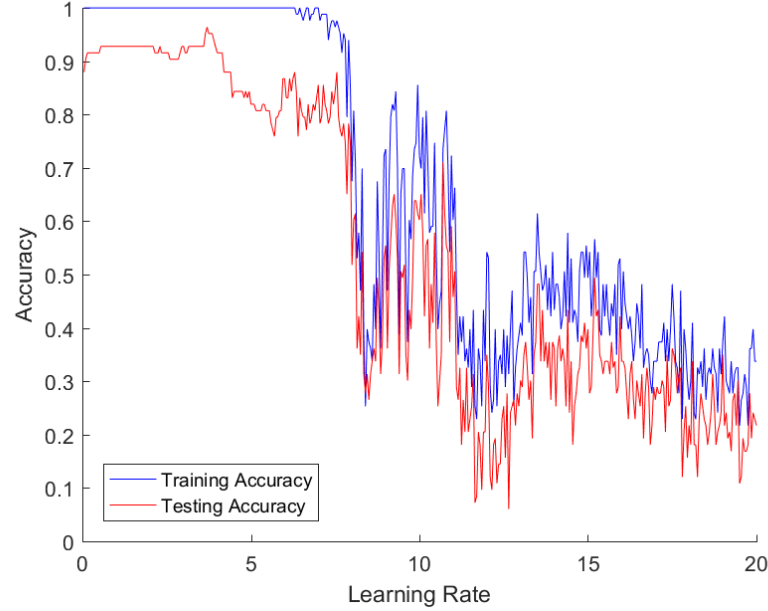


Figure 21: Plot of accuracy as the learning rate increases

5. PCA Field Retention The PCA field retention rate was varied from 0.01 to 1 by 0.01. The number of training iterations was 200, the number of hidden nodes was 20, and the image size was 40 by 40. The number of iterations was reduced to 200 in order to more clearly show the trend of increasing the PCA field retention.

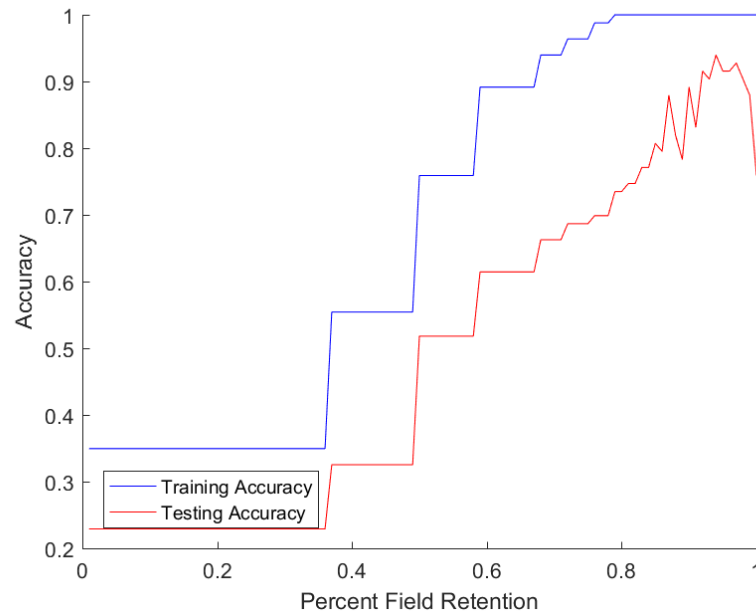


Figure 22: Plot of accuracy as the field retention increases

## 6 Optimally Trained Network

Using the empirically investigated parameter values from the previous section we trained a network using the optimal values shown below.

Input layer bias node	Y
Hidden layer bias node	N
Standardization of features	Y
PCA applied	Y
Training Iterations	1000
Hidden Nodes	1200
Image Size	30
Learning Rate	0.75
PCA Field Retention	0.97
Testing Accuracy	0.8364

Table 18: Optimal Training Values

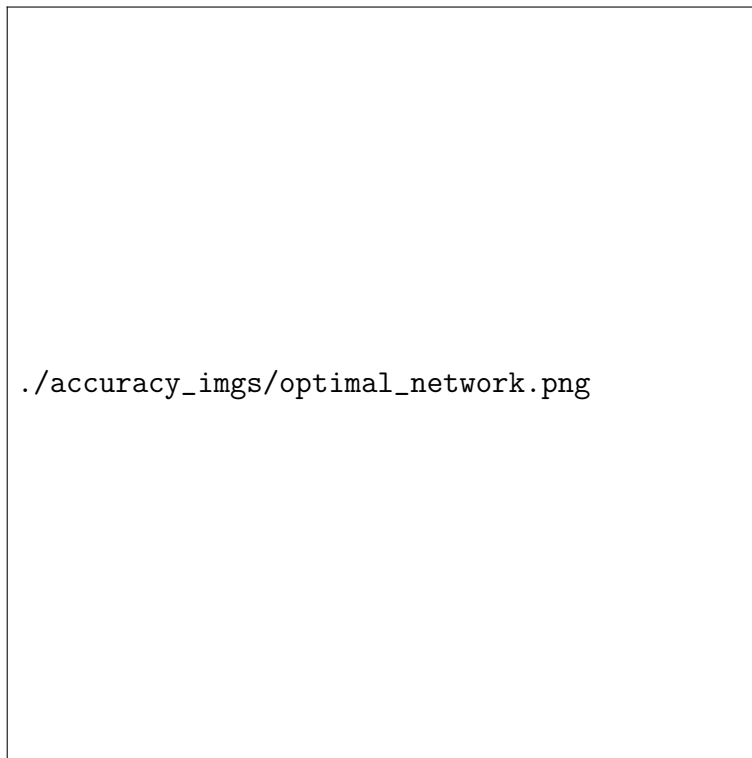


Figure 23: Training Accuracy

Although the testing accuracy only increased from 0.8182 to 0.8364 the number of training iterations taken to reach 100% training accuracy was decreased from 332 to 11.