Load Data

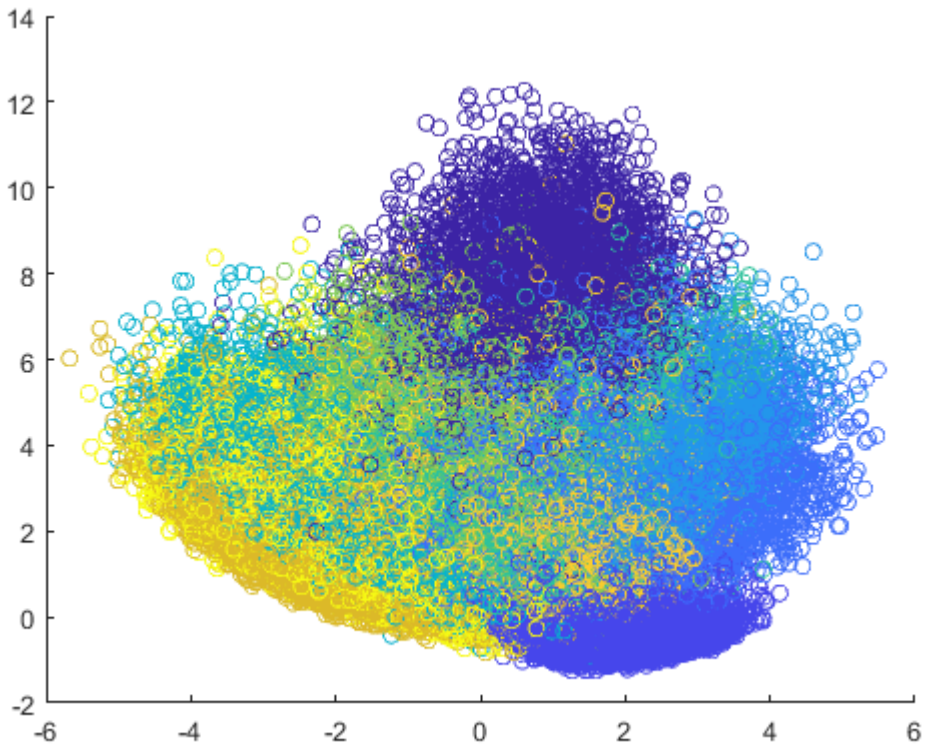
```
clear
clf
clc

[train_images,test_images,train_labels,test_labels] = load_MNIST();
```

PCA

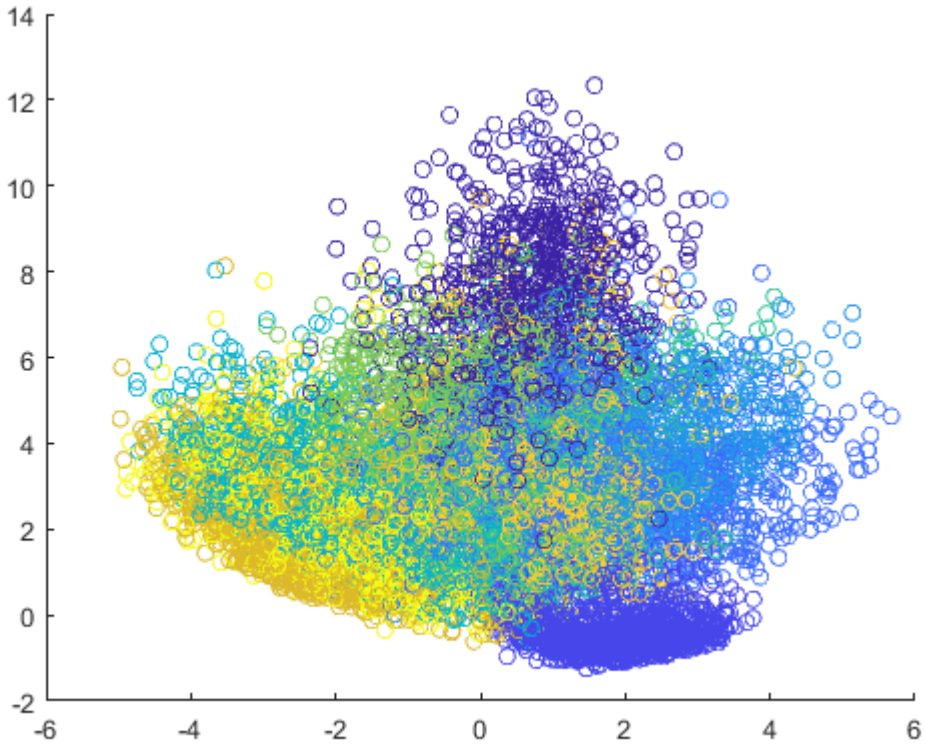
```
all_images = [train_images test_images];

[train_pca,test_pca] = pcaManual(all_images,train_images,test_images)
```

```
train_pca = 2×60000
    1.3085    1.2055   -1.4755    2.4504   -2.7936   -0.8095    0.7037    1.2791 ···
    3.4705    6.9538    2.7597   -0.1343    1.4565    3.7204    0.1264    4.9655
test_pca = 2×10000
   -2.8311    3.8353    1.7737   -0.3628   -2.7539    1.9940   -2.0968   -1.2786 ···
    1.6422    3.0915   -0.7185    7.8480    3.7038   -1.0153    1.9364    1.7228
```

```
% Plot the data
scatter(train_pca(1,:),train_pca(2,:),[],train_labels)
```



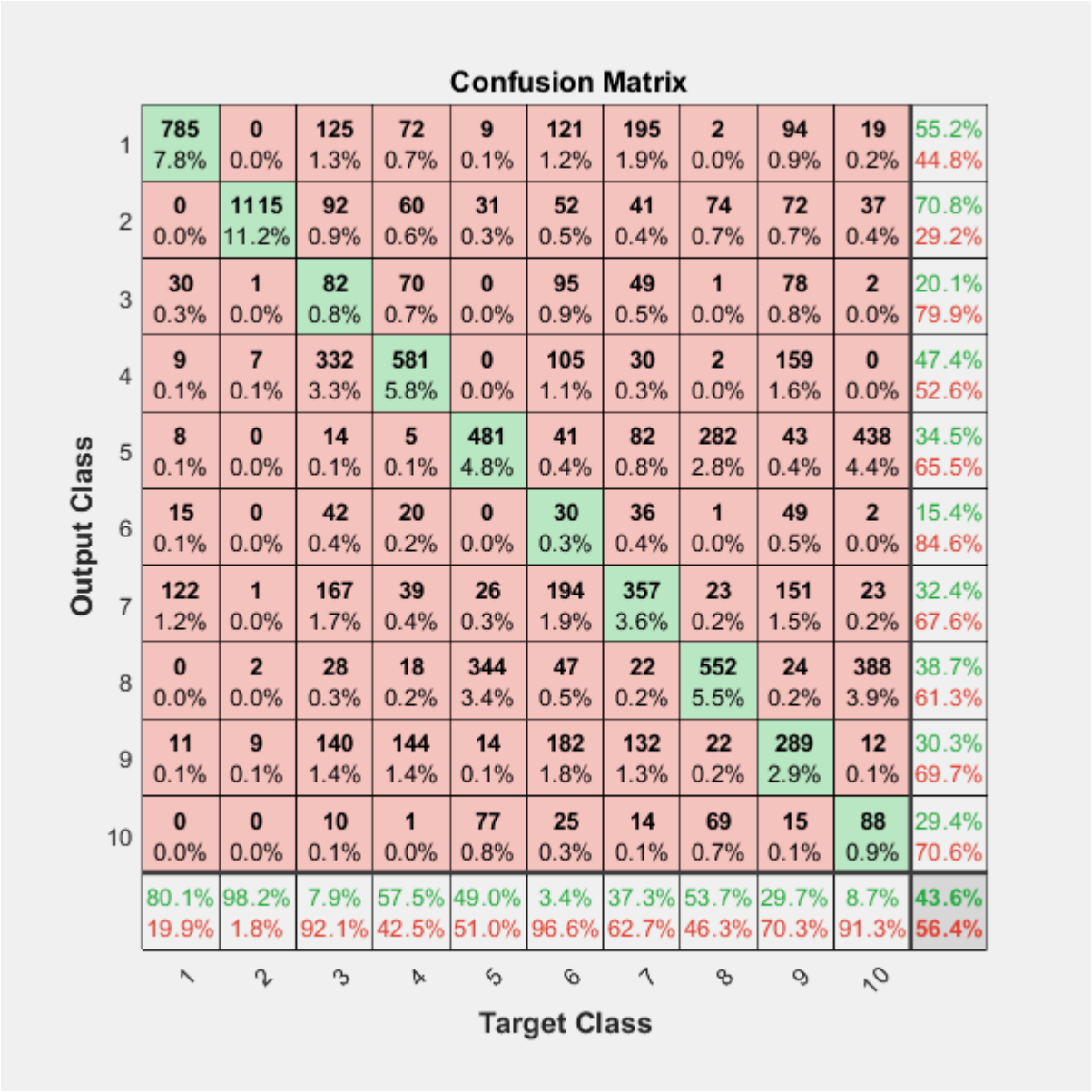

```
scatter(test_pca(1,:),test_pca(2,:)  ,[],test_labels)
```



Nearest Class Centroid Classifier

$$\|\mathbf{x}_i^{(k)} - \boldsymbol{\mu}_k\|_2^2,$$

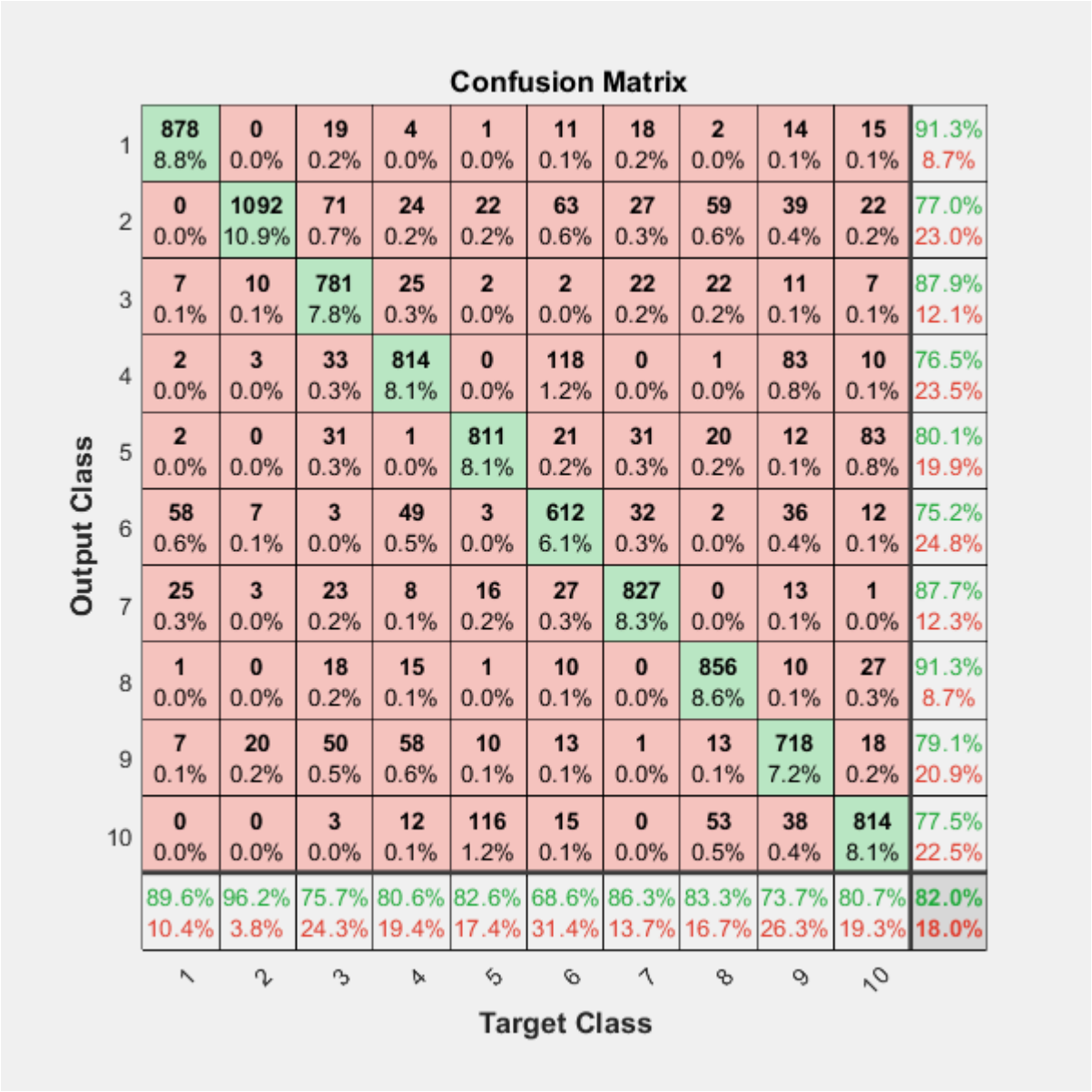
```
%PCA
class_labels = nearestClassCentroidClassifier(train_labels, train_pca, test_pca);
plotconfusionMatrixManualMNIST(test_pca, test_labels, class_labels)
```




```
Overall precision: 43.6%
```

```
Elapsed time is 2.232273 seconds.
```

```
%Real Data
class_labels = nearestClassCentroidClassifier(train_labels, train_images, test_images);
plotconfusionMatrixManualMNIST(test_images, test_labels, class_labels)
```




```
Overall precision: 82.03%
Elapsed time is 1.473488 seconds.
```

Nearest Sub-Class Centroid Classifier 2 PCA

```
%Pca
tic
class_labels = NearestSubClassCentroidClassifier(train_labels, train_pca, test_pca, 2);
plotconfusionMatrixManualMNIST(test_pca, test_labels, class_labels')
```

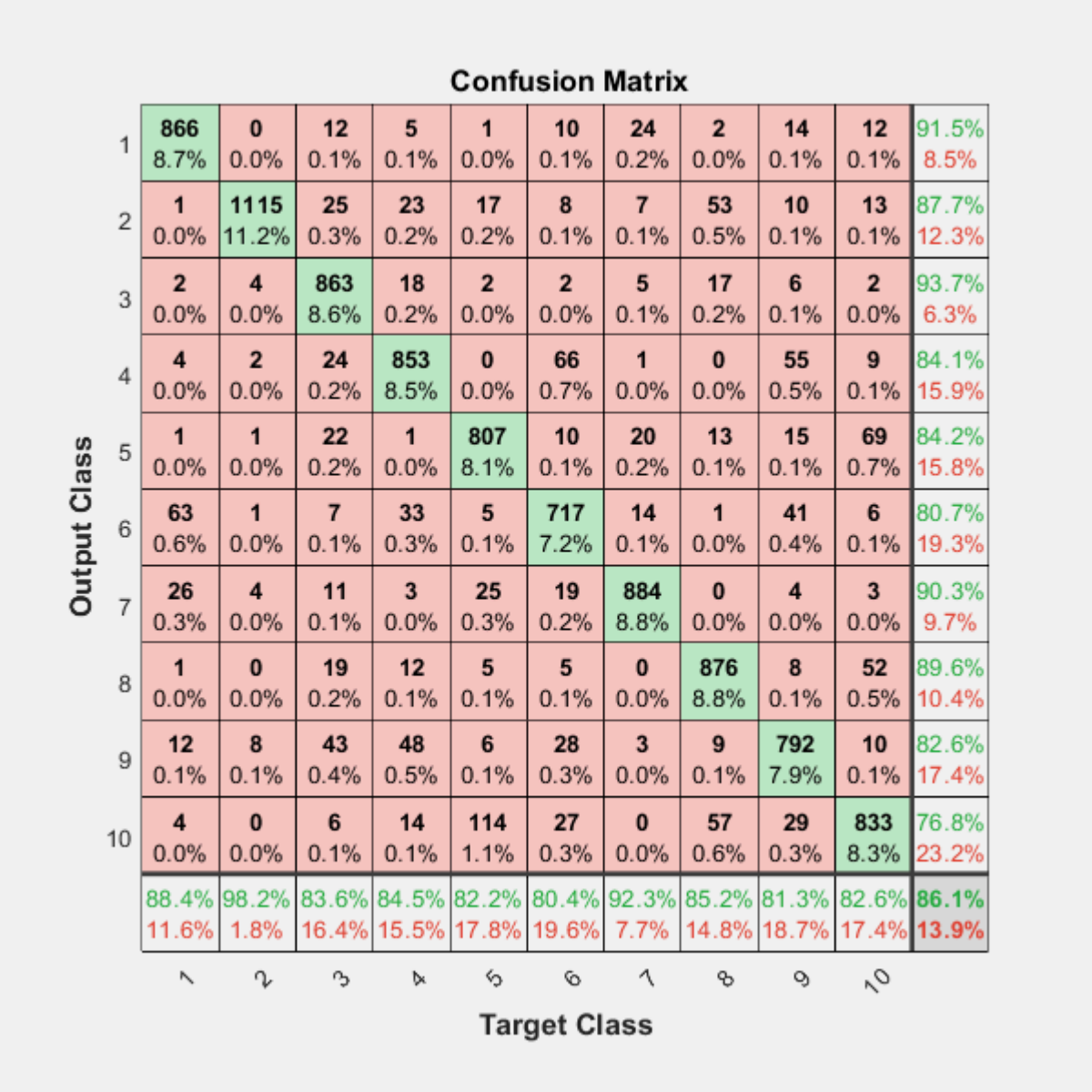
```
Overall precision: 42.86%
```

```
toc
```

```
Elapsed time is 2.737199 seconds.
```

Nearest Sub-Class Centroid Classifier 2

```
%Real Data
tic
class_labels = NearestSubClassCentroidClassifier(train_labels, train_images, test_images, 2);
plotconfusionMatrixManualMNIST(test_images, test_labels, class_labels')
```




```
Overall precision: 86.06%
```

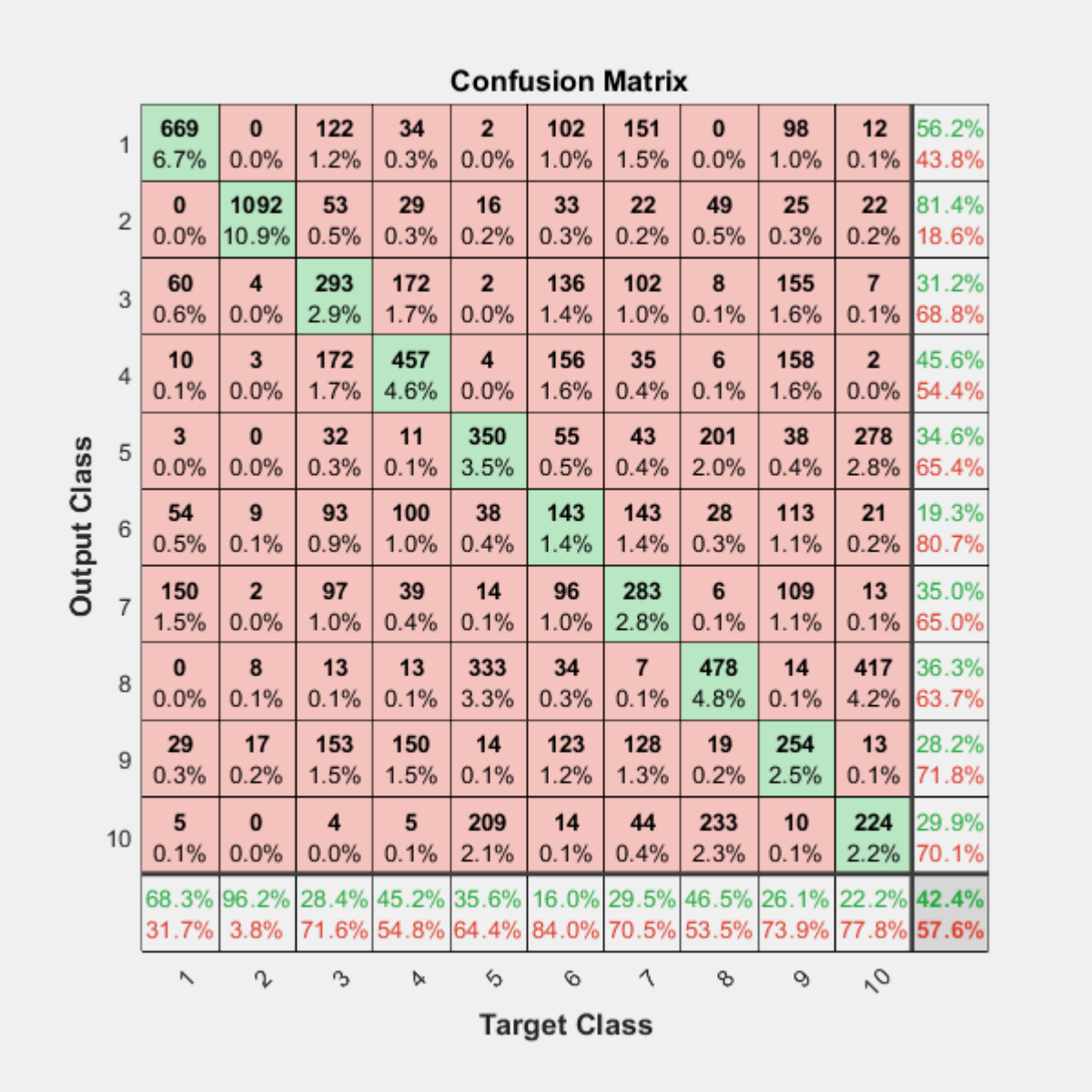
```
toc
```

```
Elapsed time is 105.196861 seconds.
```

Nearest Sub-Class Centroid Classifier 3 PCA

```
%Pca
```

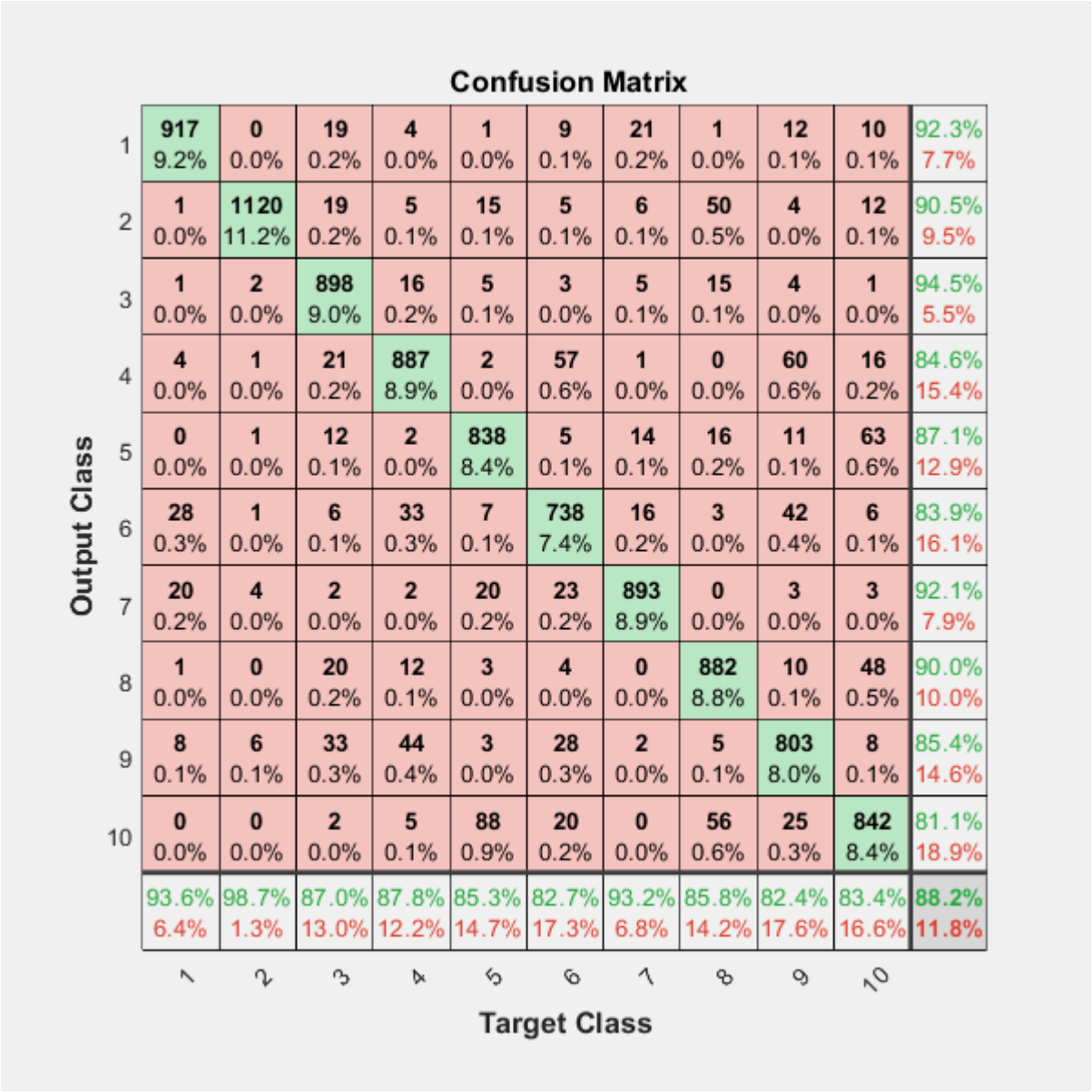
```
class_labels = NearestSubClassCentroidClassifier(train_labels, train_pca, test_pca, 3);
plotconfusionMatrixManualMNIST(test_pca, test_labels, class_labels')
```




```
Overall precision: 42.43%
```

Nearest Sub-Class Centroid Classifier 3

```
%Real Data
class_labels = NearestSubClassCentroidClassifier(train_labels, train_images, test_images, 3);
plotconfusionMatrixManualMNIST(test_images, test_labels, class_labels')
```



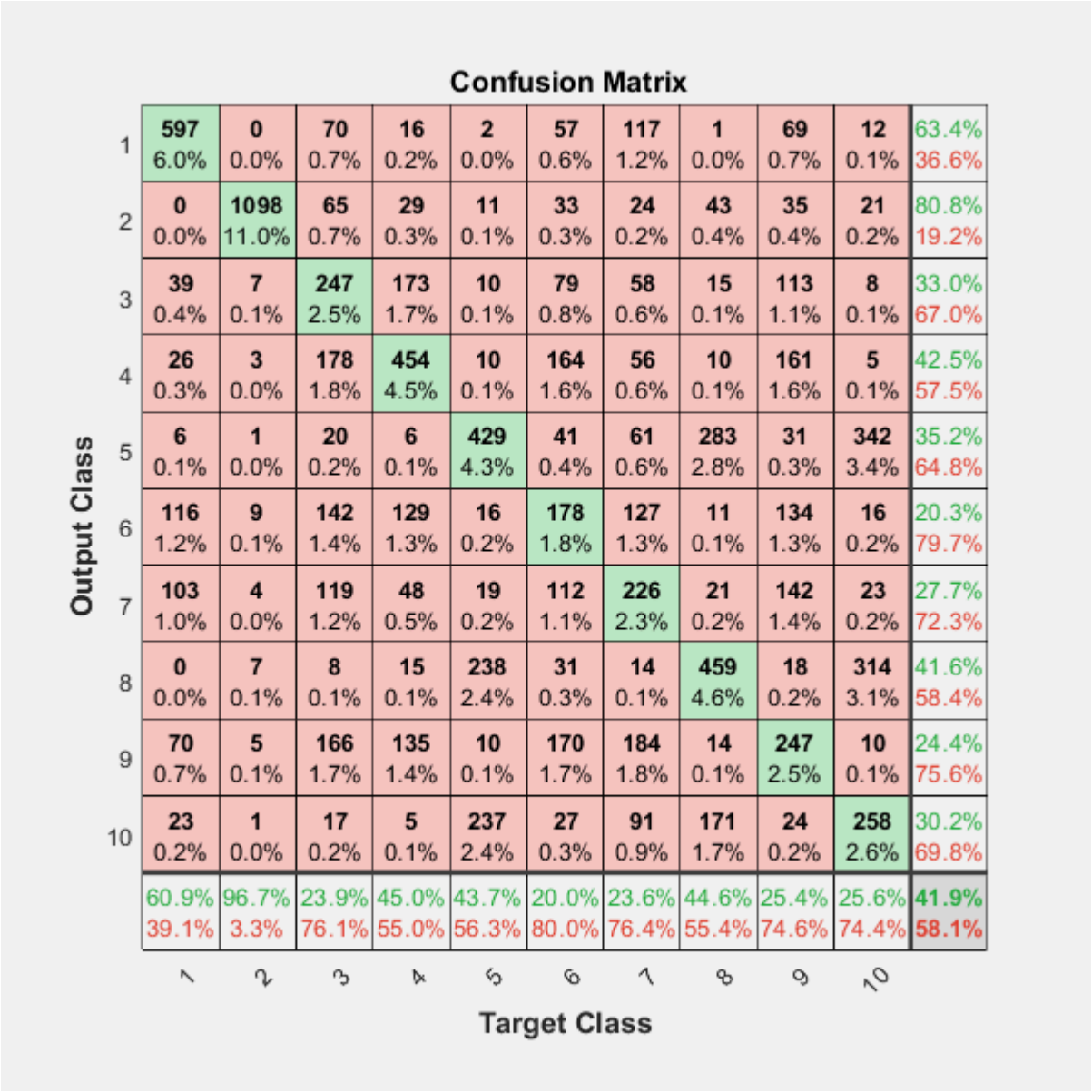

```
Overall precision: 88.18%
```

Nearest Sub-Class Centroid Classifier 5 PCA

```
%Pca
class_labels = NearestSubClassCentroidClassifier(train_labels, train_pca, test_pca, 5);
```

```
Warning: Failed to converge in 100 iterations during replicate 4.
```

```
plotconfusionMatrixManualMNIST(test_pca, test_labels, class_labels')
```



Overall precision: 41.93%

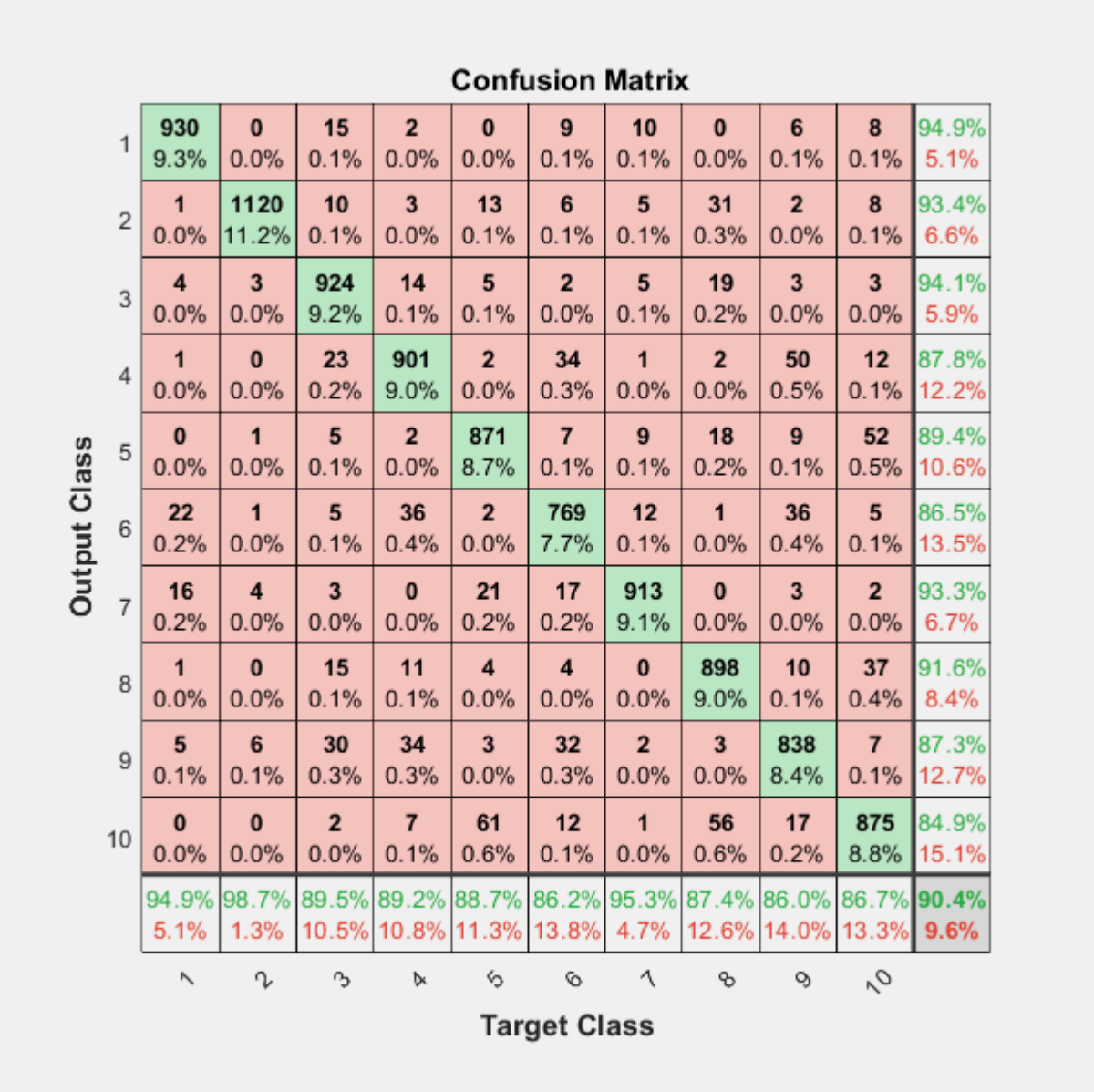
Nearest Sub-Class Centroid Classifier 5

```
%Real Data
class_labels = NearestSubClassCentroidClassifier(train_labels, train_images, test_images, 5);
```

```
Warning: Failed to converge in 100 iterations during replicate 4.
Warning: Failed to converge in 100 iterations during replicate 7.
Warning: Failed to converge in 100 iterations during replicate 14.
Warning: Failed to converge in 100 iterations during replicate 15.
Warning: Failed to converge in 100 iterations during replicate 1.
Warning: Failed to converge in 100 iterations during replicate 10.
Warning: Failed to converge in 100 iterations during replicate 12.
Warning: Failed to converge in 100 iterations during replicate 8.
Warning: Failed to converge in 100 iterations during replicate 12.
Warning: Failed to converge in 100 iterations during replicate 15.
```

```
Warning: Failed to converge in 100 iterations during replicate 7.
```

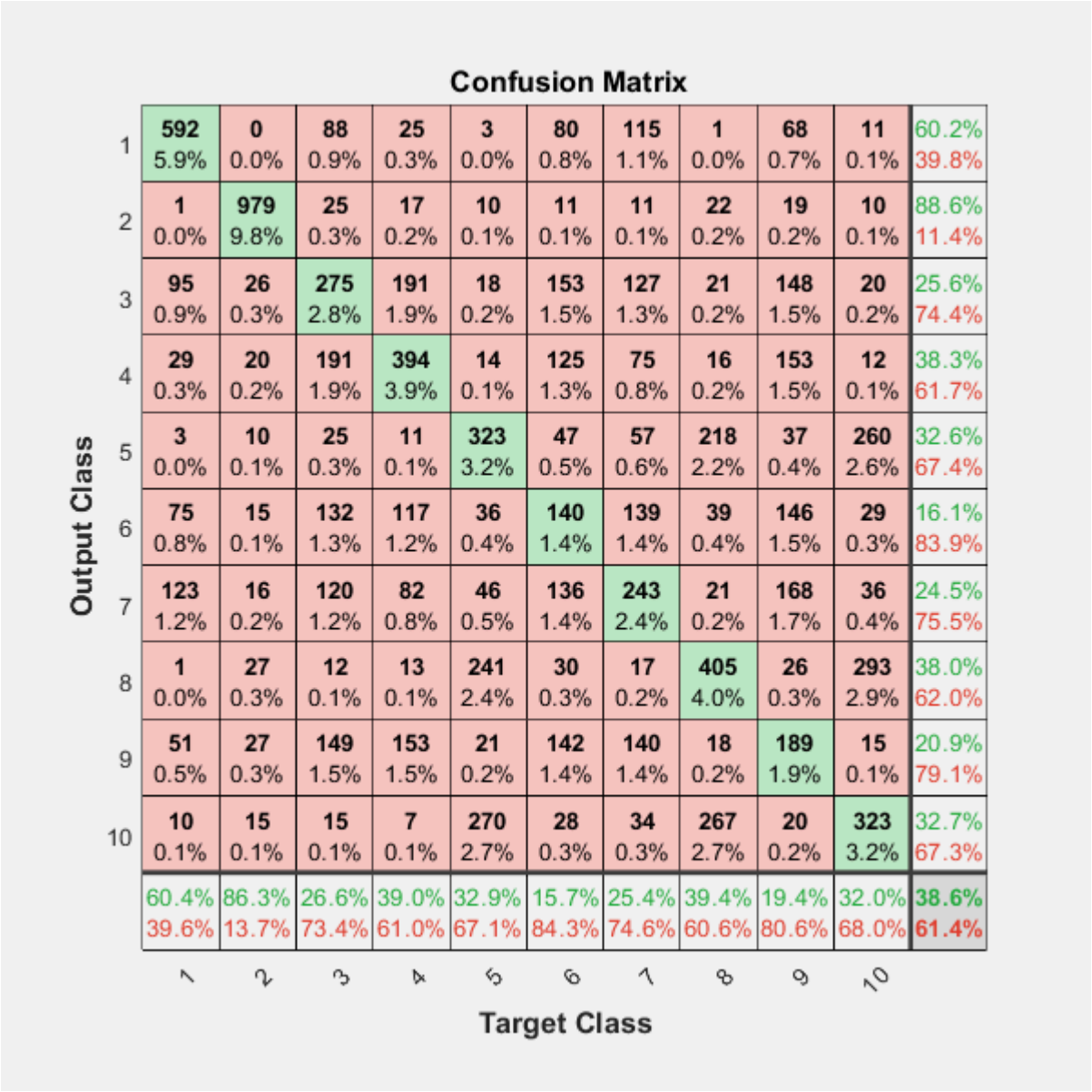
```
plotconfusionMatrixManualMNIST(test_images, test_labels, class_labels')
```




```
Overall precision: 90.39%
```

Nearest Neighbor classifier PCA

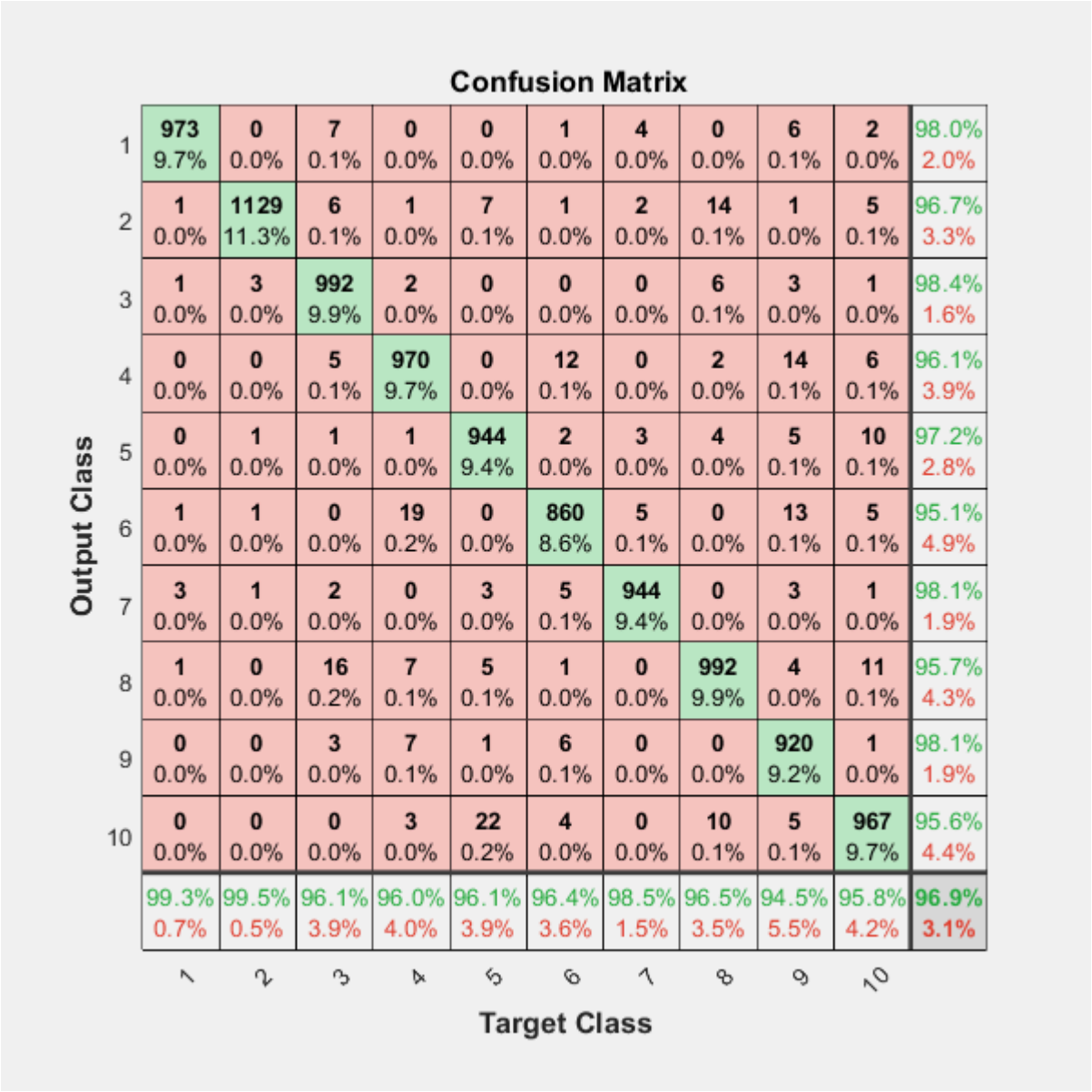
```
%Pca
class_labels = NearestNeighborClassifier(train_labels, train_pca, test_pca);
plotconfusionMatrixManualMNIST(test_pca, test_labels, class_labels)
```




```
Overall precision: 38.63%
```

Nearest Neighbor classifier

```
%Real data
class_labels = NearestNeighborClassifier(train_labels, train_images, test_images);
plotconfusionMatrixManualMNIST(test_images, test_labels, class_labels)
```



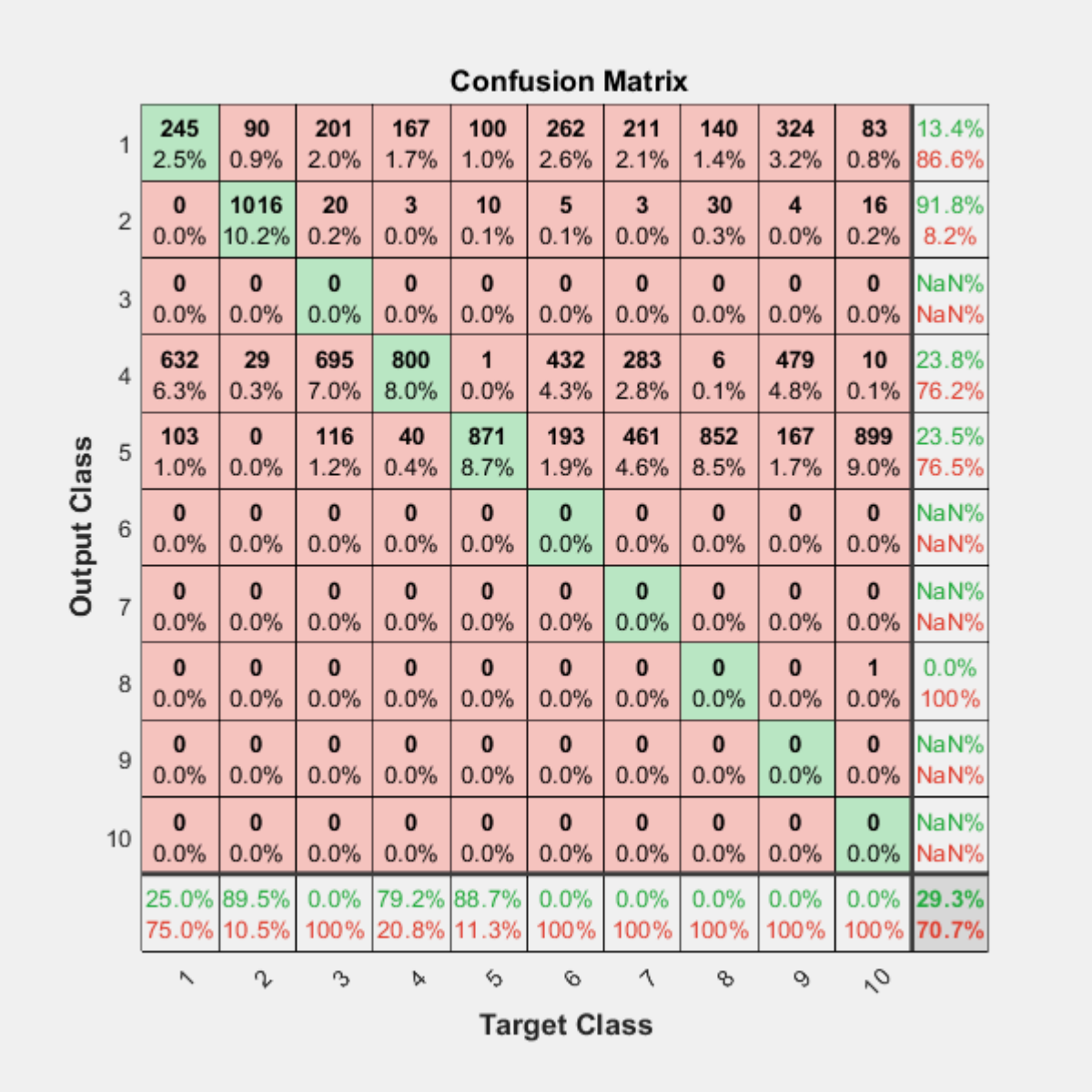

```
Overall precision: 96.91%
```

Perceptron with backpropagation PCA

```
nDOT      = 10^(-3);
max_runs = 600;

result = perceptron_with_back(train_pca,train_labels,nDOT,max_runs)
```

```
bincounts = 1×10
        5923        6742        5958        6131        5842        5421 ···
result = 3×10
 -359.2890    0.8940  -44.5520  -45.3670  -28.9250  -31.1820  -48.5990  -22.6510 ···
    1.1294   23.8632    4.0255   22.3541  -20.5899    3.0369   21.9451  -12.5246
   42.4111  -80.9825  -49.8554    9.3143    7.5514   -1.7157  -71.1062  -23.7302
```

```
plots_perceptronForMNISTPcaVersion(test_pca,test_labels,result);
```




```
Overall accuracy: 84.306%
```

Perceptron with backpropagation

```
%Real data
result = perceptron_with_back(train_pca,train_labels,nDOT,max_runs)

plots_perceptronForMNIST(test_images,test_labels,result)
```

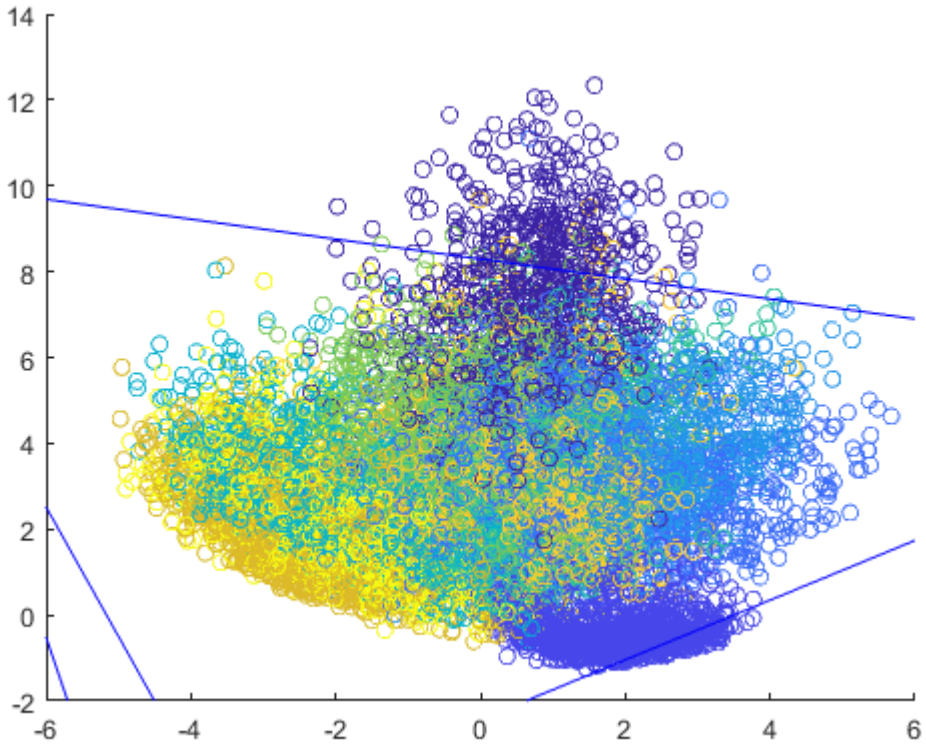
Perceptron LMS PCA

```
w = Perceptron_LMS(train_labels, train_pca)
```

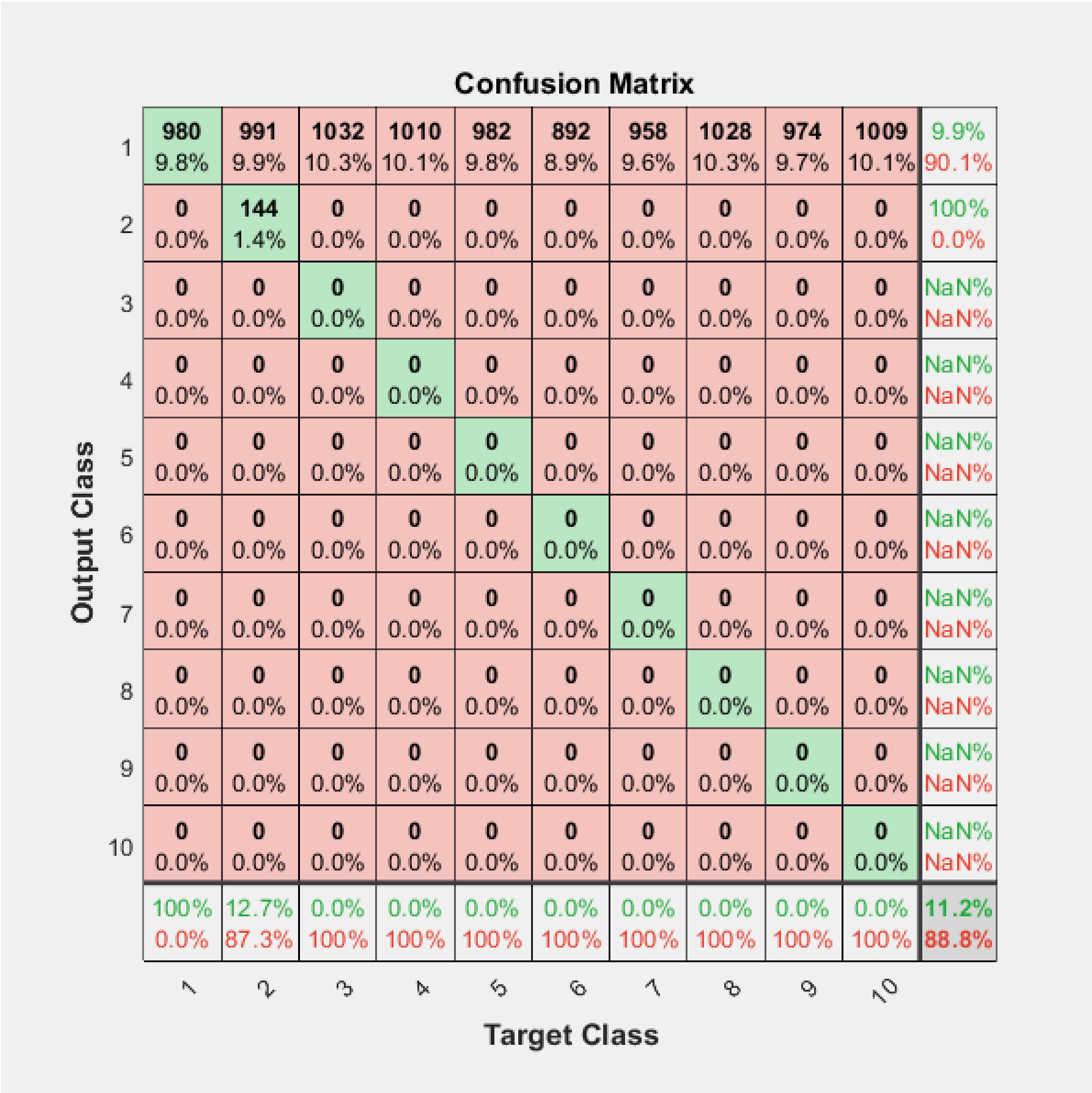
```
w = 3×10
```

```
   -1.2569   -0.3519   -0.8518   -0.8361   -0.7689   -0.8651   -0.8851   -0.6564 ···
    0.0352    0.1005    0.0640    0.0991   -0.1179    0.0261   -0.0003   -0.1271
    0.1516   -0.1445    0.0153    0.0112   -0.0093    0.0147    0.0276   -0.0421
```

```
figure
scatter(test_pca(1,:),test_pca(2,:),[],test_labels)
hold on
for i = 1:size(w,2)
    plotpc(w(2:end,i)',w(1,i));
end
hold off
```




```
plots_perceptronForMNISTPcaVersion(test_pca,test_labels,w);
```




```
Overall accuracy: 90.393%
```

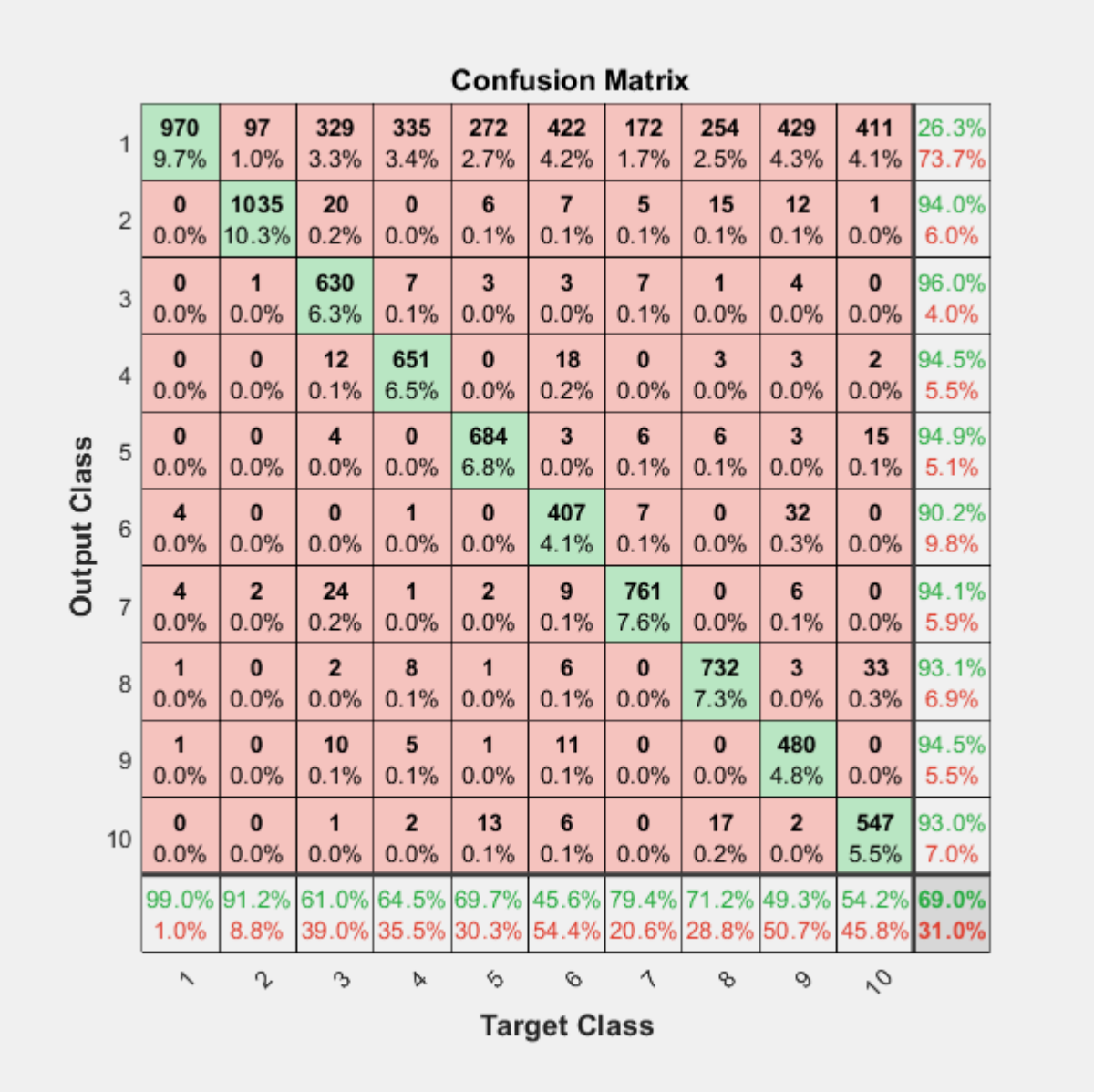
Perceptron LMS

```
w = Perceptron_LMS(train_labels, train_images)
```

```
w = 785×10
   -0.6844   -0.5173   -0.9003   -0.9598   -0.5824   -0.6228   -0.8610   -0.7169 ···
   -0.0000   -0.0000   -0.0000   -0.0000   -0.0000    0.0000    0.0000    0.0000
    0.0000   -0.0000    0.0000   -0.0000    0.0000   -0.0000    0.0000    0.0000
    0.0000   -0.0000   -0.0000    0.0000    0.0000   -0.0000    0.0000   -0.0000
    0.0000   -0.0000    0.0000    0.0000    0.0000    0.0000   -0.0000   -0.0000
    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000   -0.0000   -0.0000
   -0.0000   -0.0000    0.0000   -0.0000   -0.0000   -0.0000    0.0000    0.0000
    0.0000    0.0000   -0.0000    0.0000   -0.0000   -0.0000    0.0000   -0.0000
  -30.3232   10.1744    9.1996  -13.5964   12.4488    0.3666   -0.7510    4.1085
    7.7375   -2.0091   -2.3198    2.3146   -2.5973    0.2275    0.1750   -2.0915
```

⋮

```
plots_perceptronForMNIST(test_images,test_labels,w)
```




```
Overall accuracy: 96.348%
```