handwrittenDigit

October 25, 2015

```
In [12]: %pylab inline
         # https://www.terminal.com/snapshot/86889ee10f164c1bebcb47a37007e490d7a4c26fb20d6772c6eb232701
         # pandas and numpy
         # not so much of pandas but for read_csv which is more efficient than numpy.loadtxt
         import numpy as np
         import pandas as pd

         # scikit-learn classifiers and cross validation utils
         from sklearn.ensemble import RandomForestClassifier
         from sklearn.svm import SVC
         from sklearn.grid_search import GridSearchCV

         # scikit-learn dimension reduction
         from sklearn.decomposition import PCA

         # scikit-learn dataset processing utils
         from sklearn.preprocessing import MinMaxScaler
```

```
Populating the interactive namespace from numpy and matplotlib
```

```
In [6]: df = pd.read_csv('/root/machine-learning-classify-handwritten-digit/randomForest/Data/train.csv
        df = df.astype('float64')
        df.shape
```

```
Out[6]: (42000, 785)
```

```
In [9]: df.ix[1000:1010,200:215]
```

```
Out[9]:       pixel199  pixel200  pixel201  pixel202  pixel203  pixel204  pixel205  \
        1000         0         0         0         0         0         0         0
        1001         0         0         0         0         0         0         0
        1002         0         0         0         0         0         0         0
        1003         0         0         0         0         0         0         0
        1004         0         0         0         0         0         0         0
        1005         0         0         0        46       221       253       253
        1006         0         0         0         0         0         0         0
        1007         0         0         0         0         0         0         0
        1008         0         0         0         0         0         0         0
        1009         0         0         0         0         0         0       241
        1010         0         0         0         0         0         0         0

              pixel206  pixel207  pixel208  pixel209  pixel210  pixel211  pixel212  \
        1000         0         0         0       211       239        42         0
        1001         0         0         0         0         0         0         0
```

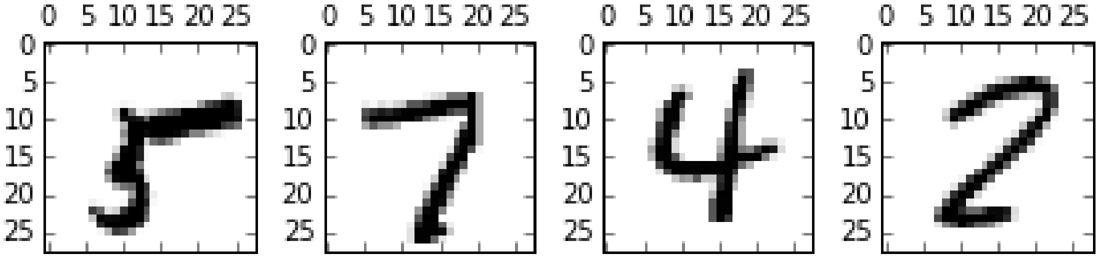
```
1002        0      0      0     51    254    254    139
1003      224    253    222     72      0      0      0
1004        0      2    132    254    215     55      0
1005      253    183    253    253    253    253    228
1006        0     12    171    252    253    252    252
1007        0      0      0      0      0      0     34
1008        0      0      0     10     29     41    141
1009      252    106      0      0      0      0      0
1010        0      0      0      0      0      0     57

      pixel213
1000         0
1001         0
1002         0
1003         0
1004         0
1005         0
1006       230
1007        82
1008       141
1009       253
1010       250
```

```
In [13]: f, (ax1, ax2, ax3, ax4) = subplots(ncols=4)

         imsize = (28, 28)
         ax1.matshow(np.reshape(df.ix[35023,1:], imsize), cmap='gray_r')
         ax2.matshow(np.reshape(df.ix[1008,1:], imsize), cmap='gray_r')
         ax3.matshow(np.reshape(df.ix[1009,1:], imsize), cmap='gray_r')
         ax4.matshow(np.reshape(df.ix[1012,1:], imsize), cmap='gray_r')

         f.tight_layout();
```



```
In [14]: #SVM
         #Create scaler and PCA objects

         min_max_scaler = MinMaxScaler()
         pca = PCA(n_components=80)
```

```
In [16]: X = min_max_scaler.fit_transform(df.ix[:9999,1:])
         X = pca.fit_transform(X)

         y = df.ix[:9999,0]
```

```
In [17]: tuned_parameters = [{'kernel' : ['rbf'], 'gamma': [0.1, 1e-2, 1e-3], 'C': [10, 100, 1000]},
                             {'kernel' : ['poly'], 'degree' : [5, 9], 'C' : [1, 10]}]

         svm = GridSearchCV( SVC(), tuned_parameters, cv=3, verbose=2 ).fit(X, y)
```

```
Fitting 3 folds for each of 13 candidates, totalling 39 fits
[CV] kernel=rbf, gamma=0.1, C=10 ...
[CV] ... kernel=rbf, gamma=0.1, C=10 -  19.2s
[CV] kernel=rbf, gamma=0.1, C=10 ...
[CV] ... kernel=rbf, gamma=0.1, C=10 -  19.3s
[CV] kernel=rbf, gamma=0.1, C=10 ...
[CV] ... kernel=rbf, gamma=0.1, C=10 -  19.7s
[CV] kernel=rbf, gamma=0.01, C=10 ...
[CV] ... kernel=rbf, gamma=0.01, C=10 -   3.4s
[CV] kernel=rbf, gamma=0.01, C=10 ...
[CV] ... kernel=rbf, gamma=0.01, C=10 -   3.4s
[CV] kernel=rbf, gamma=0.01, C=10 ...
[CV] ... kernel=rbf, gamma=0.01, C=10 -   3.5s
[CV] kernel=rbf, gamma=0.001, C=10 ...
[CV] ... kernel=rbf, gamma=0.001, C=10 -   3.5s
[CV] kernel=rbf, gamma=0.001, C=10 ...
[CV] ... kernel=rbf, gamma=0.001, C=10 -   3.6s
[CV] kernel=rbf, gamma=0.001, C=10 ...
[CV] ... kernel=rbf, gamma=0.001, C=10 -   3.6s
[CV] kernel=rbf, gamma=0.1, C=100 ...
[CV] ... kernel=rbf, gamma=0.1, C=100 -  19.2s
[CV] kernel=rbf, gamma=0.1, C=100 ...
[CV] ... kernel=rbf, gamma=0.1, C=100 -  19.3s
[CV] kernel=rbf, gamma=0.1, C=100 ...
[CV] ... kernel=rbf, gamma=0.1, C=100 -  19.5s
[CV] kernel=rbf, gamma=0.01, C=100 ...
[CV] ... kernel=rbf, gamma=0.01, C=100 -   3.4s
[CV] kernel=rbf, gamma=0.01, C=100 ...
[CV] ... kernel=rbf, gamma=0.01, C=100 -   3.4s
[CV] kernel=rbf, gamma=0.01, C=100 ...
[CV] ... kernel=rbf, gamma=0.01, C=100 -   3.5s
[CV] kernel=rbf, gamma=0.001, C=100 ...
[CV] ... kernel=rbf, gamma=0.001, C=100 -   2.9s
[CV] kernel=rbf, gamma=0.001, C=100 ...
[CV] ... kernel=rbf, gamma=0.001, C=100 -   2.9s
[CV] kernel=rbf, gamma=0.001, C=100 ...
[CV] ... kernel=rbf, gamma=0.001, C=100 -   2.9s
[CV] kernel=rbf, gamma=0.1, C=1000 ...
[CV] ... kernel=rbf, gamma=0.1, C=1000 -  19.2s
[CV] kernel=rbf, gamma=0.1, C=1000 ...
[CV] ... kernel=rbf, gamma=0.1, C=1000 -  19.2s
[CV] kernel=rbf, gamma=0.1, C=1000 ...
[CV] ... kernel=rbf, gamma=0.1, C=1000 -  19.2s
[CV] kernel=rbf, gamma=0.01, C=1000 ...
[CV] ... kernel=rbf, gamma=0.01, C=1000 -   3.4s
[CV] kernel=rbf, gamma=0.01, C=1000 ...
[CV] ... kernel=rbf, gamma=0.01, C=1000 -   3.4s
[CV] kernel=rbf, gamma=0.01, C=1000 ...
[CV] ... kernel=rbf, gamma=0.01, C=1000 -   3.4s
```

```
[CV] kernel=rbf, gamma=0.001, C=1000 ...
[CV] ... kernel=rbf, gamma=0.001, C=1000 -   3.0s
[CV] kernel=rbf, gamma=0.001, C=1000 ...
[CV] ... kernel=rbf, gamma=0.001, C=1000 -   3.0s
[CV] kernel=rbf, gamma=0.001, C=1000 ...
[CV] ... kernel=rbf, gamma=0.001, C=1000 -   3.0s
[CV] degree=5, kernel=poly, C=1 ...
[CV] ... degree=5, kernel=poly, C=1 -  14.1s
[CV] degree=5, kernel=poly, C=1 ...
[CV] ... degree=5, kernel=poly, C=1 -  14.3s
[CV] degree=5, kernel=poly, C=1 ...
[CV] ... degree=5, kernel=poly, C=1 -  14.0s
[CV] degree=9, kernel=poly, C=1 ...
[CV] ... degree=9, kernel=poly, C=1 -  16.2s
[CV] degree=9, kernel=poly, C=1 ...
[CV] ... degree=9, kernel=poly, C=1 -  16.6s
[CV] degree=9, kernel=poly, C=1 ...
[CV] ... degree=9, kernel=poly, C=1 -  16.6s
[CV] degree=5, kernel=poly, C=10 ...
[CV] ... degree=5, kernel=poly, C=10 -   9.9s
[CV] degree=5, kernel=poly, C=10 ...
[CV] ... degree=5, kernel=poly, C=10 -  10.0s
[CV] degree=5, kernel=poly, C=10 ...
[CV] ... degree=5, kernel=poly, C=10 -   9.9s
[CV] degree=9, kernel=poly, C=10 ...
[CV] ... degree=9, kernel=poly, C=10 -  16.1s
[CV] degree=9, kernel=poly, C=10 ...
[CV] ... degree=9, kernel=poly, C=10 -  16.0s
[CV] degree=9, kernel=poly, C=10 ...
[CV] ... degree=9, kernel=poly, C=10 -  15.9s

[Parallel(n_jobs=1)]: Done   1 jobs       | elapsed:   19.2s
[Parallel(n_jobs=1)]: Done  39 out of  39 | elapsed:  6.7min finished
```

```
In [18]: svm.best_estimator_
```

```
Out[18]: SVC(C=100, cache_size=200, class_weight=None, coef0=0.0, degree=3, gamma=0.01,
           kernel='rbf', max_iter=-1, probability=False, random_state=None,
           shrinking=True, tol=0.001, verbose=False)
```

```
In [21]: Xt = min_max_scaler.transform(df.ix[35000:,1:])
         yt = df.ix[35000:,0]

         yp = svm.predict(pca.transform(Xt))
```

```
In [31]: print ('prediction accuracy: %.4f' % (1./len(yt) * sum( yp == yt )))
```

```
prediction accuracy: 0.9681
```

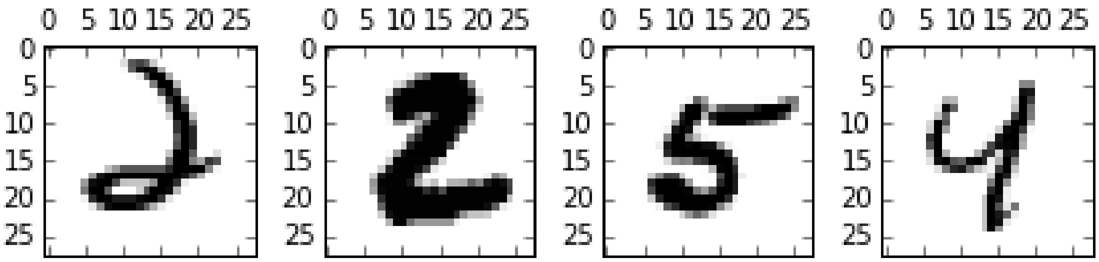
```
In [33]: print (yp[:30].astype(int))
```

```
[2 2 5 4 7 6 0 6 9 5 4 8 5 2 6 2 3 9 3 9 4 0 4 5 2 0 6 5 5 0]
```

```
In [35]: f, (ax1, ax2, ax3, ax4) = subplots(ncols=4)

         imsize = (28, 28)
         ax1.matshow(np.reshape(df.ix[35000,1:], imsize), cmap='gray_r')
         ax2.matshow(np.reshape(df.ix[35001,1:], imsize), cmap='gray_r')
         ax3.matshow(np.reshape(df.ix[35002,1:], imsize), cmap='gray_r')
         ax4.matshow(np.reshape(df.ix[35003,1:], imsize), cmap='gray_r')

         f.tight_layout();
```



```
In [37]: #RandomForest
         min_max_scaler = MinMaxScaler()
         pca = PCA(n_components=80)
         X = min_max_scaler.fit_transform(df.ix[:9999,1:])
         X = pca.fit_transform(X)

         y = df.ix[:9999,0]


         tuned_parameters = [{'max_features': ['sqrt', 'log2'], 'n_estimators': [1000, 1500]}]

         rf = GridSearchCV(RandomForestClassifier(min_samples_split=1,
                                                  n_jobs=-1),
                           tuned_parameters,
                           cv=3,
                           verbose=2).fit(X, y)
```

```
Fitting 3 folds for each of 4 candidates, totalling 12 fits
[CV] max_features=sqrt, n_estimators=1000 ...
[CV] ... max_features=sqrt, n_estimators=1000 -  18.7s
[CV] max_features=sqrt, n_estimators=1000 ...
[CV] ... max_features=sqrt, n_estimators=1000 -  19.3s
[CV] max_features=sqrt, n_estimators=1000 ...
[CV] ... max_features=sqrt, n_estimators=1000 -  18.8s
[CV] max_features=sqrt, n_estimators=1500 ...
[CV] ... max_features=sqrt, n_estimators=1500 -  28.2s
[CV] max_features=sqrt, n_estimators=1500 ...
[CV] ... max_features=sqrt, n_estimators=1500 -  28.0s
[CV] max_features=sqrt, n_estimators=1500 ...
[CV] ... max_features=sqrt, n_estimators=1500 -  29.4s
[CV] max_features=log2, n_estimators=1000 ...
[CV] ... max_features=log2, n_estimators=1000 -  15.7s
```

```
[CV] max_features=log2, n_estimators=1000 ...
[CV] ... max_features=log2, n_estimators=1000 -  16.1s
[CV] max_features=log2, n_estimators=1000 ...
[CV] ... max_features=log2, n_estimators=1000 -  16.1s
[CV] max_features=log2, n_estimators=1500 ...
[CV] ... max_features=log2, n_estimators=1500 -  24.7s
[CV] max_features=log2, n_estimators=1500 ...
[CV] ... max_features=log2, n_estimators=1500 -  24.7s
[CV] max_features=log2, n_estimators=1500 ...
[CV] ... max_features=log2, n_estimators=1500 -  24.6s

[Parallel(n_jobs=1)]: Done   1 jobs       | elapsed:   18.7s
[Parallel(n_jobs=1)]: Done  12 out of  12 | elapsed:  4.4min finished
```

```
In [39]: Xt = min_max_scaler.transform(df.ix[35000:,1:])
         yt = df.ix[35000:,0]

         yp = rf.predict(pca.transform(Xt))


         print ('prediction accuracy: %.4f' % (1./len(yt) * sum( yp == yt )))
```

```
prediction accuracy: 0.9420
```

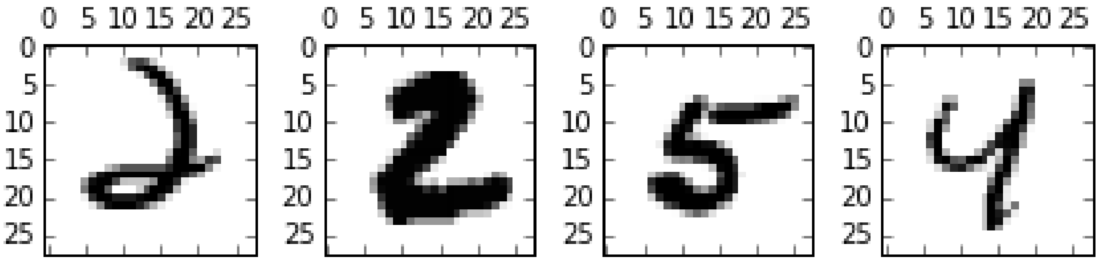
```
In [40]: print (yt[:30].values.astype(int))
```

```
[2 2 5 4 7 6 0 6 4 5 4 8 5 2 6 2 3 9 3 9 4 0 4 5 2 0 6 5 5 0]
```

```
In [41]: f, (ax1, ax2, ax3, ax4) = subplots(ncols=4)

         imsize = (28, 28)
         ax1.matshow(np.reshape(df.ix[35000,1:], imsize), cmap='gray_r')
         ax2.matshow(np.reshape(df.ix[35001,1:], imsize), cmap='gray_r')
         ax3.matshow(np.reshape(df.ix[35002,1:], imsize), cmap='gray_r')
         ax4.matshow(np.reshape(df.ix[35003,1:], imsize), cmap='gray_r')

         f.tight_layout();
```



```
In [42]: #Submission attempts
         #    First attempt: split data into three, build an SVM for each,
         #      majority voting for end prediction --> Kaggle score 0.97429
         scalers = []
         pca_xfrms = []
         clfs = []

         # compute indexes where to split the data
         ixs = np.arange(df.shape[0])
         splits = np.split(ixs, [14000, 28000])

         tuned_parameters = [{'gamma': [0.1, 1e-2, 1e-3], 'C': [10, 100, 1000]}]

         # use all data for training
         for s in splits:
             min_max_scaler = MinMaxScaler()
             pca = PCA(n_components=80)

             # get training subset
             X = df.ix[s,1:].copy()
             y = df.ix[s,0].copy()

             # all the transformations
             X = min_max_scaler.fit_transform(X)
             X = pca.fit_transform(X)

             # train the classifier
             svm = GridSearchCV( SVC(), tuned_parameters, cv=3, verbose=1 ).fit(X, y)

             # store scaler, PCA transformer, and SVM classifier for this subset
             scalers.append(min_max_scaler)
             pca_xfrms.append(pca)
             clfs.append(svm)
```

```
[Parallel(n_jobs=1)]: Done   1 jobs       | elapsed:   37.1s
[Parallel(n_jobs=1)]: Done  27 out of  27 | elapsed:  7.3min finished

Fitting 3 folds for each of 9 candidates, totalling 27 fits
Fitting 3 folds for each of 9 candidates, totalling 27 fits

[Parallel(n_jobs=1)]: Done   1 jobs       | elapsed:   37.1s
[Parallel(n_jobs=1)]: Done  27 out of  27 | elapsed:  7.3min finished

Fitting 3 folds for each of 9 candidates, totalling 27 fits

[Parallel(n_jobs=1)]: Done   1 jobs       | elapsed:   36.9s
[Parallel(n_jobs=1)]: Done  27 out of  27 | elapsed:  7.2min finished
```

```
In [46]: df2 = pd.read_csv('/root/machine-learning-classify-handwritten-digit/randomForest/Data/test.csv
         df2 = df2.astype('float64')
```

```
In [47]: preds = np.zeros((len(clfs), df2.shape[0]))

         i = 0
         for scaler, xfrm, clf in zip(scalers, pca_xfrms, clfs):
             Xt = df2.copy()
             Xt = scaler.transform(Xt)
             preds[i] = clf.predict(xfrm.transform(Xt))

             i += 1

         total_pred = [np.bincount(x).argmax() for x in preds.T.astype(int)]
```

```
In [49]: with open(’/root/machine-learning-classify-handwritten-digit/randomForest/submission.csv’, ’w’
             of.write("ImageId,label\n")
             for x in enumerate(total_pred, start=1):
                 of.write("%s,%s\n" % x)
```

```
In [ ]: # Delong
        #        0.97371         2         Sun, 25 Oct 2015 16:40:42
```