Übung 2: Gauss-Klassifikator - Rainier Robles & Valentin Wolf

In [1]:
```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns
%matplotlib inline
```

Import & visualise the data

In [2]:
```
train = pd.read_table('zip.train', delim_whitespace=True,header=None)
test = pd.read_table('zip.test', delim_whitespace=True,header=None)
```

In [3]:
```
train.head(3)
```

Out[3]:

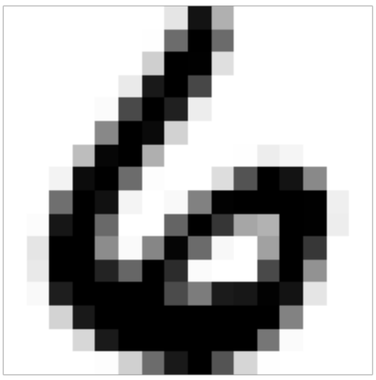
	0	1	2	3	4	5	6	7	8	9	...	247	248	249	250
0	6.0	-1.0	-1.0	-1.0	-1.000	-1.000	-1.000	-1.000	-0.631	0.862	...	0.304	0.823	1.000	0.482
1	5.0	-1.0	-1.0	-1.0	-0.813	-0.671	-0.809	-0.887	-0.671	-0.853	...	-0.671	-0.671	-0.033	0.761
2	4.0	-1.0	-1.0	-1.0	-1.000	-1.000	-1.000	-1.000	-1.000	-1.000	...	-1.000	-1.000	-1.000	-0.109

3 rows × 257 columns

In [4]:
```
#train = train[(train[0]==7)|(train[0]==8)]
#test = test[(test[0]==7)|(test[0]==8)]
#split labels y from data X
y_train = train[0].as_matrix()
y_test = test[0].as_matrix()
X_train = train.drop(0, axis=1).as_matrix()
X_test = test.drop(0, axis=1).as_matrix()
```

In [5]:
```
img = X_train[0,:].reshape(16,16)
im = plt.imshow(img, cmap='Greys')
plt.axis('off')
```

Out[5]: (-0.5, 15.5, 15.5, -0.5)



In [6]:
```
def is_invertible(X):
    return np.linalg.cond(X) < 1 / np.spacing(1)
```

Define the Classifier

In [7]:

```
class Classifier(object):
    def error_rate(self,truth, pred):
        """gets two vectors, returns (correct classified / total classified)"""
        amount = truth.shape[0]
        wrong = np.count_nonzero(truth - pred)
        return wrong/amount

    def accuracy(self,truth,pred):
        return np.mean(truth == pred)

def confused_matrix(x,y,percentage=False):
    assert(x.shape == y.shape)
    num_entries = x.shape[0]
    matrix = np.zeros((10,10))
    for i in range(num_entries):
        matrix[int(x[i]),int(y[i])] += 1
    if percentage==True:
        matrix /= np.sum(matrix,axis=1)
    return matrix
```

In [8]:

```
class GaussClassifier(Classifier):
    def fit(self,X,y):
        self.classes = np.unique(y)
        classes_count = len(self.classes)
        features = X.shape[1]
        self.centers = np.zeros((classes_count,features))
        self.pinv_covs = np.zeros((classes_count,features,features))
        self.dets = np.zeros(classes_count)


        for i in range(classes_count):
            cls = self.classes[i]
            X_class = X[y == cls]
            N = X_class.shape[0]
            self.centers[i] = np.mean(X_class,axis=0)
            X_class -= self.centers[i]
            cov = 1/N * np.sum((X_class[...,None] * X_class[:,None]),axis=0)
            #https://stackoverflow.com/questions/40413000/column-by-row-multipl
ication-in-numpy
            self.pinv_covs[i] = np.linalg.pinv(cov)

            self.dets[i] = 1/np.sqrt(np.linalg.norm((2*np.pi)*cov))


    def predict(self,X):
        classes_count = len(self.classes)
        scores = np.zeros((X.shape[0],classes_count))

        for i in range(X.shape[0]):
            for j in range(classes_count):
                Xi_centered = X[i] - self.centers[j]
                expo = (-0.5)*np.dot(np.dot(Xi_centered.T,self.pinv_covs[j]),Xi
_centered)
                scores[i,j] = self.dets[j] * np.exp(expo)

        best_scores = np.argmax(scores,axis=1)
        # np.argmax gives us the index of our predicted label in classes
        # so the actual label is in self.classes[index]
        f = lambda x: self.classes[x]
        labels = np.fromiter((f(xi) for xi in best_scores), best_scores.dtype)

        return labels
```

In [9]:
```
class_center = np.mean(X_test[y_test == 0],axis=0)
X_class = X_test[y_test == 0] - class_center
(X_class - class_center).T.dot((X_class - class_center)).shape
```

Out[9]:
```
(256, 256)
```

In [10]:
```
#cov = (X_class[...,None] * X_class[:,None])
#cov2 = np.sum((X_class[...,None] * X_class[:,None]),axis=0) / 359
#np.cov(X_train[y_train==8].T,bias=1).mean()
```

Fit & Predict

In [20]:
```
classifier = GaussClassifier()

classifier.fit(X_train, y_train)
```

In [21]:
```
pred = classifier.predict(X_test)
```

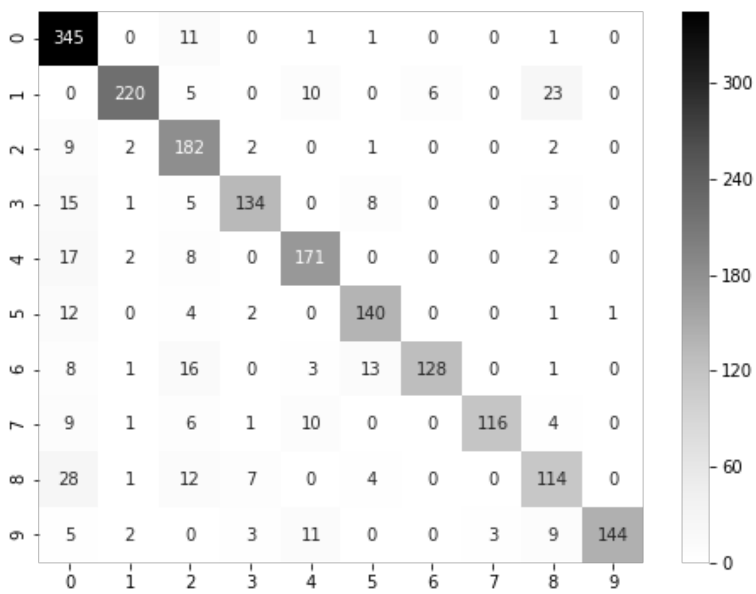
```
/Library/Frameworks/Python.framework/Versions/3.5/lib/python3.5/site-packages/
ipykernel_launcher.py:33: RuntimeWarning: overflow encountered in exp
```

In [22]:
```
print('Accuracy:', round(classifier.accuracy(y_test,pred),5),
      '\nError rate:', round(classifier.error_rate(y_test,pred),5))
```

```
Accuracy: 0.84405
Error rate: 0.15595
```

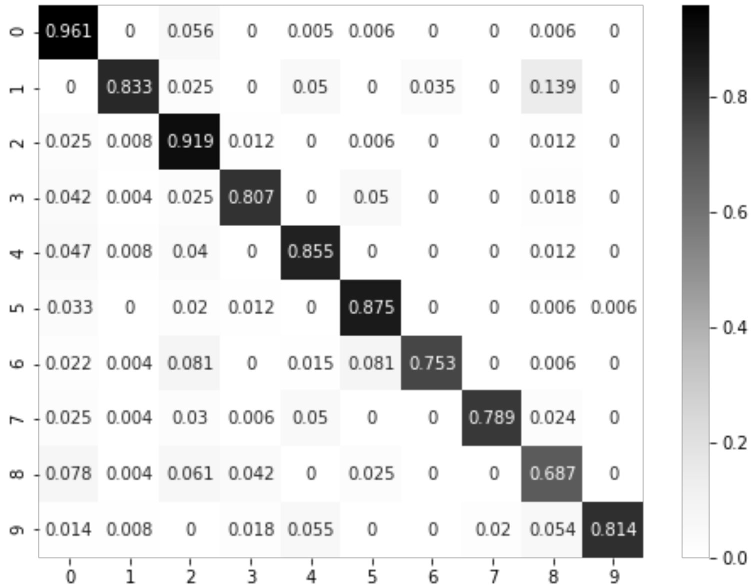
In [23]:
```
x = confused_matrix(y_test,pred)
dims = (8, 6)
fig, ax = plt.subplots(figsize=dims)
sns.heatmap(ax=ax,data=x, annot=True, fmt="g", cmap='Greys')
```

Out[23]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x10c4606a0>
```



In [15]:
```
x = confused_matrix(y_test,pred,percentage=True)
dims = (8, 6)
fig, ax = plt.subplots(figsize=dims)
sns.heatmap(ax=ax,data=np.round(x,3), annot=True, fmt="g", cmap='Greys')
```

Out[15]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x10bf0c1d0>
```



1 vs. 1 Prediction

In [16]:
```
array = [3,5,7,8] #range(10)

for i in array:
    for j in array:
        if i >= j:
            continue
        X_tr = X_train[(y_train==i)|(y_train==j)]
        y_tr = y_train[(y_train==i)|(y_train==j)]
        X_te = X_test[(y_test==i)|(y_test==j)]
        y_te = y_test[(y_test==i)|(y_test==j)]

        classifier = GaussClassifier()

        classifier.fit(X_tr, y_tr)

        pred = classifier.predict(X_te)

        print(i, 'vs.', j,
              'Accuracy:', round(classifier.accuracy(y_te,pred),4),
              'Error rate:', round(classifier.error_rate(y_te,pred),4))
```

```
3 vs. 5 Accuracy: 0.9233 Error rate: 0.0767
3 vs. 7 Accuracy: 0.9297 Error rate: 0.0703
3 vs. 8 Accuracy: 0.8434 Error rate: 0.1566
5 vs. 7 Accuracy: 0.9316 Error rate: 0.0684
5 vs. 8 Accuracy: 0.8742 Error rate: 0.1258
7 vs. 8 Accuracy: 0.8371 Error rate: 0.1629
```