HW1

January 30, 2019

```
In [1]: import sys

        if sys.version_info[0] < 3:
            raise Exception("Python 3 not detected.")

        import numpy as np
        import matplotlib.pyplot as plt
        import operator

        from sklearn import svm
        from scipy import io
        from skimage import color

        from sklearn.metrics import accuracy_score

        from sklearn.model_selection import train_test_split
        from sklearn.model_selection import GridSearchCV
        from sklearn.model_selection import cross_validate
        from sklearn.linear_model import SGDClassifier
        from skimage.feature import hog

        import pandas as pd
```

0.1 1 (a)

```
In [2]: !python --version
```

```
Python 3.6.6
```

0.2 1 (b)

```
In [3]: !pip install scikit-learn scipy numpy matplotlib
```

```
Requirement already satisfied: scikit-learn in /home/hsong1101/miniconda3/envs/gluon/lib/pytho
Requirement already satisfied: scipy in /home/hsong1101/miniconda3/envs/gluon/lib/python3.6/si
Requirement already satisfied: numpy in /home/hsong1101/miniconda3/envs/gluon/lib/python3.6/si
Requirement already satisfied: matplotlib in /home/hsong1101/miniconda3/envs/gluon/lib/python3
Requirement already satisfied: cycler>=0.10 in /home/hsong1101/miniconda3/envs/gluon/lib/pytho
Requirement already satisfied: pyparsing!=2.0.4,!=2.1.2,!=2.1.6,>=2.0.1 in /home/hsong1101/min
Requirement already satisfied: python-dateutil>=2.1 in /home/hsong1101/miniconda3/envs/gluon/l
Requirement already satisfied: pytz in /home/hsong1101/miniconda3/envs/gluon/lib/python3.6/sit
Requirement already satisfied: six>=1.10 in /home/hsong1101/miniconda3/envs/gluon/lib/python3.
Requirement already satisfied: kiwisolver>=1.0.1 in /home/hsong1101/miniconda3/envs/gluon/lib/
Requirement already satisfied: setuptools in /home/hsong1101/miniconda3/envs/gluon/lib/python3
```

0.3 1 (c)

```
In [2]: data = []
        data_name = ["mnist", "spam", "cifar10"]
        for name in data_name:
            data.append(io.loadmat("data/%s_data.mat" % name))
            print("\nloaded %s data!" % name)
            fields = "test_data", "training_data", "training_labels"

        print()

        for i in range(3):
            print(data_name[i])
            for field in fields:
                print(field, data[i][field].shape)
            print()
```

```
loaded mnist data!

loaded spam data!

loaded cifar10 data!

mnist
test_data (10000, 784)
training_data (60000, 784)
training_labels (60000, 1)

spam
test_data (5857, 32)
training_data (5172, 32)
training_labels (5172, 1)

cifar10
test_data (10000, 3072)
training_data (50000, 3072)
training_labels (50000, 1)
```

```
In [3]: mnist = data[0]
        spam = data[1]
        cifar10 = data[2]
```

```
In [4]: mnist_train = mnist['training_data']/255
        mnist_label = mnist['training_labels']
        mnist_test = mnist['test_data']/255

        spam_train = spam['training_data']
        spam_label = spam['training_labels']
        spam_test = spam['test_data']

        cifar10_train = cifar10['training_data']
        cifar10_label = cifar10['training_labels']
        cifar10_test = cifar10['test_data']
```

```
In [5]: mnist_data = np.append(mnist_train, mnist_label, axis=1)
        spam_data = np.append(spam_train, spam_label, axis=1)
        cifar10_data = np.append(cifar10_train, cifar10_label, axis=1)
```

```
In [9]: def split(data, size):
            from math import floor

            dat = data.copy()

            # for reproducibility
            np.random.seed(24)

            # shuffle copied data
            np.random.shuffle(dat)

            if type(size) == float:
                size = floor(len(dat) * size)

            # training_data, validation_data, training_label, validation_label
            return dat[size:, :-1], dat[:size, :-1], dat[size:, -1], dat[:size, -1]
```

0.4 2 (a)

```
In [10]: X_mnist_train, X_mnist_valid, y_mnist_train, y_mnist_valid = split(mnist_data, 10000)
```

0.5 2 (b)

```
In [11]: X_spam_train, X_spam_valid, y_spam_train, y_spam_valid = split(spam_data, 0.2)
```

0.6 2 (c)

```
In [12]: X_cifar10_train, X_cifar10_valid, y_cifar10_train, y_cifar10_valid = split(cifar10_da
```

```
In [13]: X_mnist_train.shape, X_spam_train.shape, X_cifar10_train.shape
```

```
Out[13]: ((50000, 784), (4138, 32), (45000, 3072))
```

```
In [14]: X_mnist_valid.shape, X_spam_valid.shape, X_cifar10_valid.shape
```

```
Out[14]: ((10000, 784), (1034, 32), (5000, 3072))
```

```
In [15]: len(mnist_data), len(spam_data), len(cifar10_data)
```

```
Out[15]: (60000, 5172, 50000)
```

0.7 3 (a)

```
In [15]: mnist_size = [100, 200, 500, 1000, 2000, 5000, 10000]
         valid_accuracy = []
         train_accuracy = []

         for size in mnist_size:

             train = X_mnist_train[:size]
             label = y_mnist_train[:size]

             model = svm.SVC(kernel='linear')

             model.fit(train, label)

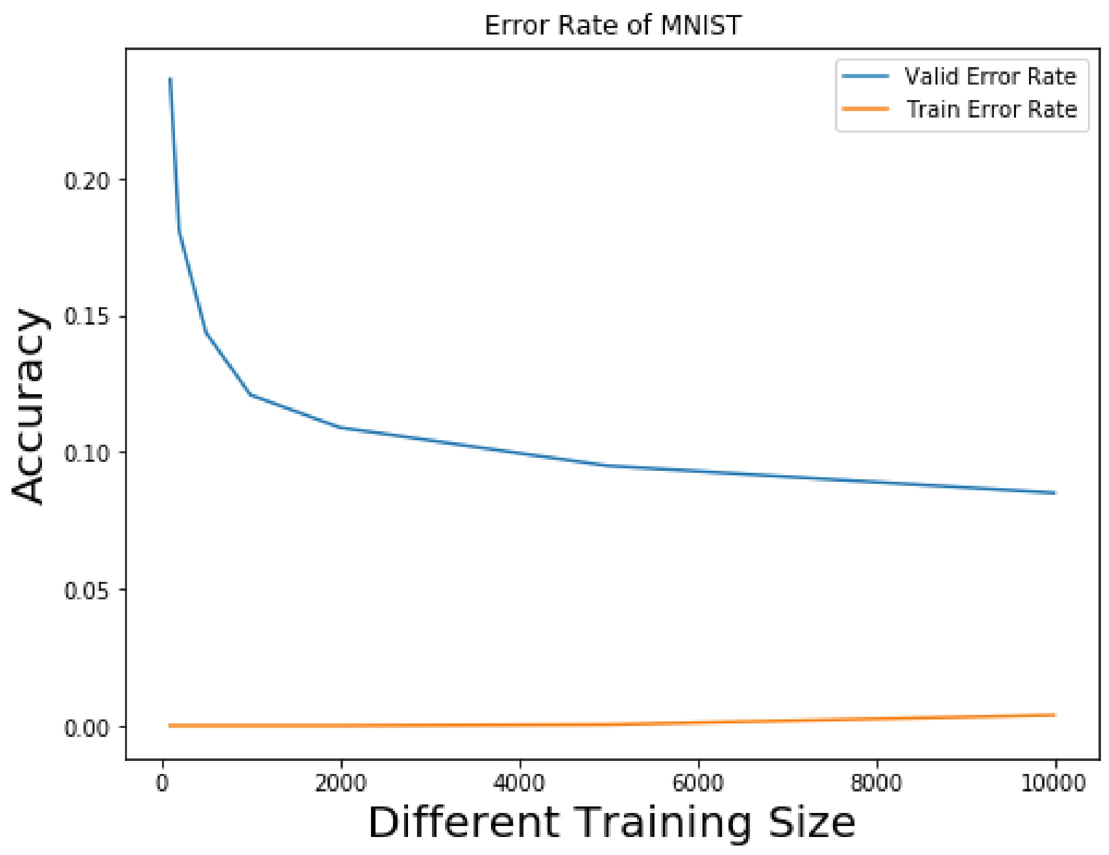
             pred = model.predict(X_mnist_valid)

             valid_accuracy.append(1-accuracy_score(y_mnist_valid, pred))
             train_accuracy.append(1-accuracy_score(label, model.predict(train)))
```

```
In [16]: plt.figure(figsize=(8,6))

         plt.plot(mnist_size, valid_accuracy, label='Valid Error Rate')
         plt.plot(mnist_size, train_accuracy, label='Train Error Rate')

         plt.xlabel('Different Training Size',size=20)
         plt.ylabel('Accuracy',size=20)
         plt.legend()
         plt.title("Error Rate of MNIST")
         plt.show();
```



0.8 3 (b)

```
In [17]: spam_size = [100, 200, 500, 1000, 2000, len(spam_data)]
         valid_accuracy = []
         train_accuracy = []

         for size in spam_size:

             train = X_spam_train[:size]
             label = y_spam_train[:size]

             model = svm.SVC(kernel='linear')

             model.fit(train, label)

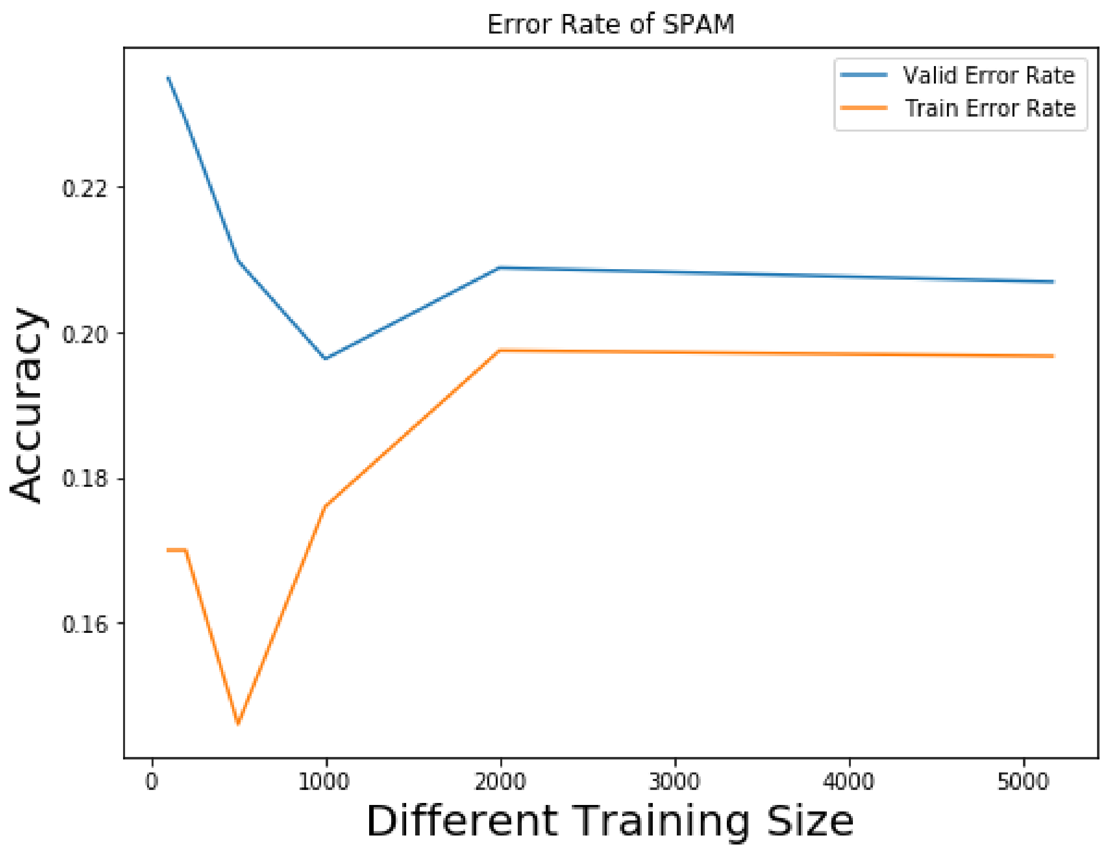
             pred = model.predict(X_spam_valid)

             valid_accuracy.append(1-accuracy_score(y_spam_valid, pred))
             train_accuracy.append(1-accuracy_score(label, model.predict(train)))
```

```
In [18]: plt.figure(figsize=(8,6))

         plt.plot(spam_size, valid_accuracy, label='Valid Error Rate')
         plt.plot(spam_size, train_accuracy, label='Train Error Rate')

         plt.xlabel('Different Training Size',size=20)
         plt.ylabel('Accuracy',size=20)
         plt.legend()
         plt.title("Error Rate of SPAM")
         plt.show();
```



0.9 3 (c)

```
In [17]: cifar10_size = [100, 200, 500, 1000, 2000, 5000]
         valid_accuracy = []
         train_accuracy = []

         for size in cifar10_size:

             train = X_cifar10_train[:size]
```

```
        label = y_cifar10_train[:size]

        model = svm.SVC(kernel='linear')

        model.fit(train, label)

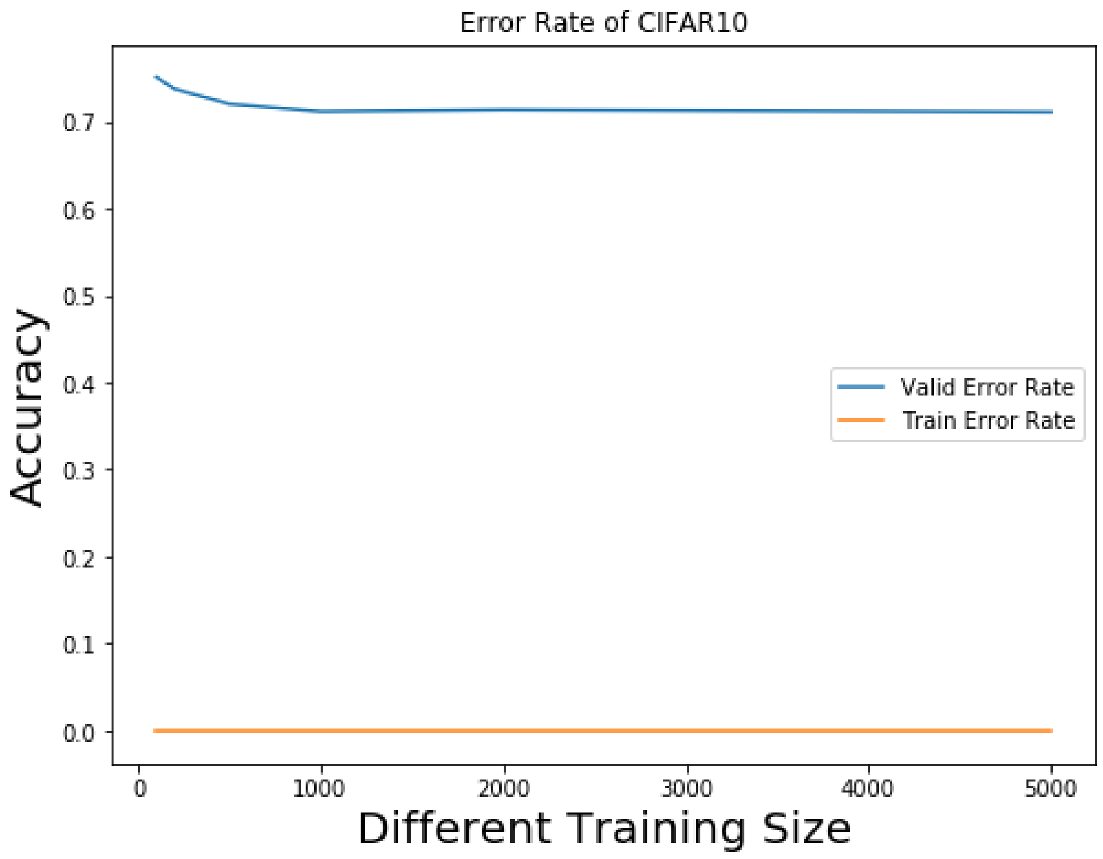
        pred = model.predict(X_cifar10_valid)

        valid_accuracy.append(1-accuracy_score(y_cifar10_valid, pred))
        train_accuracy.append(1-accuracy_score(label, model.predict(train)))
```

```
In [18]: plt.figure(figsize=(8,6))

         plt.plot(cifar10_size, valid_accuracy, label='Valid Error Rate')
         plt.plot(cifar10_size, train_accuracy, label='Train Error Rate')

         plt.xlabel('Different Training Size',size=20)
         plt.ylabel('Accuracy',size=20)
         plt.title("Error Rate of CIFAR10")
         plt.legend()
         plt.show();
```



0.10 4

```
In [19]: C = np.arange(1, 60, 10)
         SIZE = [100, 500, 1000, 2000, 5000]
         accuracy = []
         max_c = [0,0,0]

         for c in C:
             for size in SIZE:
                 model = svm.SVC(c, kernel='linear')

                 train = X_mnist_train[:size]
                 label = y_mnist_train[:size]

                 model.fit(train, label)

                 accuracy.append([c, size, accuracy_score(y_mnist_valid, model.predict(X_mnist_

                 if accuracy[-1][2] > max_c[2]:
                     max_c = accuracy[-1]
```

```
In [20]: print('C value : {}\nTrain Size : {}\nAccuracy : {}'.format(max_c[0], max_c[1], max_c
```

```
C value : 1
Train Size : 5000
Accuracy : 0.905
```

```
In [21]: print('C value tested from 1 to 50')
```

```
C value tested from 1 to 50
```

```
In [22]: # C value, Training Size, Accuracy
         accuracy
```

```
Out[22]: [[1, 100, 0.7637],
          [1, 500, 0.8563],
          [1, 1000, 0.8791],
          [1, 2000, 0.891],
          [1, 5000, 0.905],
          [11, 100, 0.7637],
          [11, 500, 0.8563],
          [11, 1000, 0.8791],
          [11, 2000, 0.891],
          [11, 5000, 0.9042],
          [21, 100, 0.7637],
          [21, 500, 0.8563],
          [21, 1000, 0.8791],
          [21, 2000, 0.891],
          [21, 5000, 0.9042],
          [31, 100, 0.7637],
          [31, 500, 0.8563],
          [31, 1000, 0.8791],
          [31, 2000, 0.891],
          [31, 5000, 0.9042],
          [41, 100, 0.7637],
          [41, 500, 0.8563],
          [41, 1000, 0.8791],
          [41, 2000, 0.891],
          [41, 5000, 0.9042],
          [51, 100, 0.7637],
          [51, 500, 0.8563],
          [51, 1000, 0.8791],
          [51, 2000, 0.891],
          [51, 5000, 0.9042]]
```

0.11 5

```
In [23]: def K_fold(data, k, c):

             size = int(len(data) / k)
             dat = data.copy()
             np.random.shuffle(dat)

             accuracy = []


             for i in range(k):
                 index = np.arange(len(dat))

                 if i <= k-1:
                     valid_ind = index[i*size : (1+i)*size]
                 else:
                     valid_ind = index[(1+i)*size:]

                 train_ind = index[np.isin(index, valid_ind, invert=True)]

                 valid = dat[valid_ind]
                 train = dat[train_ind]

                 X_train, y_train = train[:, :-1], train[:, -1]
                 X_valid, y_valid = valid[:, :-1], valid[:, -1]

                 model = svm.LinearSVC(C=c)
                 model.fit(X_train, y_train)
```

```
                accuracy.append(accuracy_score(y_valid, model.predict(X_valid)))

            return np.mean(accuracy)
```

```
In [24]: C = np.arange(1, 300, 1)
         accuracy = {}

         for c in C:
             accuracy[c] = K_fold(spam_data, 5, c)
```

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  "the number of iterations.", ConvergenceWarning)
```

```
In [25]: max_c = max(accuracy.items(), key=operator.itemgetter(1))
```

```
In [26]: print('C value : {}\nAccuracy : {}'.format(max_c[0], max_c[1]))
```

```
C value : 238
Accuracy : 0.8239845261121858
```

```
In [27]: print('C value tested from 1 to 299')
```

```
C value tested from 1 to 299
```

0.12 6 Kaggle Submission

0.12.1 Kaggle Name : Han Song

MNIST score : 0.98233

```
In [ ]: X_train, X_valid, y_train, y_valid = train_test_split(mnist_data[:,:-1], mnist_data[:,
```

```
In [ ]: model = svm.SVC(C=5, gamma=0.05)
        model.fit(X_train, y_train)

        pred = model.predict(mnist_test)
```

```
In [ ]: accuracy_score(y_valid, model.predict(X_valid))

In [12]: dat = pd.DataFrame(pred,columns=['Category'], index=np.arange(1, 10001, 1), dtype=int
         dat.index.name = 'Id'

         dat.to_csv('mnist.csv')
```

SPAM score : 0.76949

```
In [13]: from sklearn.feature_extraction.text import TfidfTransformer

In [27]: transformer = TfidfTransformer()

In [28]: tfidf = transformer.fit_transform(spam_data[:, :-1])

In [29]: X_train, X_valid, y_train, y_valid = train_test_split(tfidf.toarray(), spam_data[:,-1

In [55]: test = transformer.fit_transform(spam_test)

In [56]: model = svm.SVC(C=117, gamma=.06)
         model.fit(X_train, y_train)

         pred = model.predict(test.toarray())
         acc = accuracy_score(y_valid, model.predict(X_valid))

In [59]: dat = pd.DataFrame(pred,columns=['Category'], index=np.arange(1, len(test.toarray())+
         dat.index.name = 'Id'

         dat.to_csv('spam.csv')
```

CIFAR10 score : .25533

Source from https://www.kaggle.com/manikg/training-svm-classifier-with-hog-features

```
In [28]: cifar_train = cifar10_data[:, :-1].reshape(-1, 3, 32, 32).transpose(0, 2, 3, 1)
         cifar_test = cifar10_test.reshape(-1, 3, 32, 32).transpose(0, 2, 3, 1)

         labels = cifar10_data[:,-1].reshape(-1, 1)

         data_gray = [ color.rgb2gray(i)/255 for i in cifar_train]
         test_gray = [ color.rgb2gray(i)/255 for i in cifar_test]

/home/hsong1101/miniconda3/envs/gluon/lib/python3.6/site-packages/skimage/util/dtype.py:141: U
  .format(dtypeobj_in, dtypeobj_out))


In [29]: ppc = 8
         hog_images_train = []
         hog_features_train = []
```

```
        for image in data_gray:

            fd,hog_image = hog(image, orientations=9, pixels_per_cell=(ppc,ppc),cells_per_bloc
            hog_images_train.append(hog_image)
            hog_features_train.append(fd)


        hog_images_test = []
        hog_features_test = []

        for image in test_gray:

            fd,hog_image = hog(image, orientations=9, pixels_per_cell=(ppc,ppc),cells_per_bloc
            hog_images_test.append(hog_image)
            hog_features_test.append(fd)
```

```
/home/hsong1101/miniconda3/envs/gluon/lib/python3.6/site-packages/skimage/feature/_hog.py:248:
  'be changed to `visualize` in v0.16', skimage_deprecation)
```

```
In [31]: hog_images_train = np.array(hog_images_train)
         hog_images_test = np.array(hog_images_test)

In [32]: data_frame_train = np.hstack((hog_images_train.reshape(-1, 32*32), hog_features_train
         dat_train = np.hstack((data_frame_train, cifar10_data[:, :-1]))

         data_frame_test = np.hstack((hog_images_test.reshape(-1, 32*32), hog_features_test))
         dat_test = np.hstack((data_frame_test, cifar10_test))

In [ ]: X_train, X_valid, y_train, y_valid = train_test_split(dat_train, labels)

In [41]: clf = svm.SVC()

         clf.fit(X_train[:5000], y_train[:5000])

         pred = clf.predict(X_valid)

         accuracy_score(y_valid, pred)
```

```
/home/hsong1101/miniconda3/envs/gluon/lib/python3.6/site-packages/sklearn/utils/validation.py:
  y = column_or_1d(y, warn=True)
/home/hsong1101/miniconda3/envs/gluon/lib/python3.6/site-packages/sklearn/svm/base.py:931: Con
  "the number of iterations.", ConvergenceWarning)
```

```
Out[41]: 0.23232

In [34]: pred = clf.predict(dat_test)
In [35]: dat = pd.DataFrame(pred,columns=['Category'], index=np.arange(1, len(dat_test)+1, 1),
         dat.index.name = 'Id'

         dat.to_csv('cifar.csv')
```