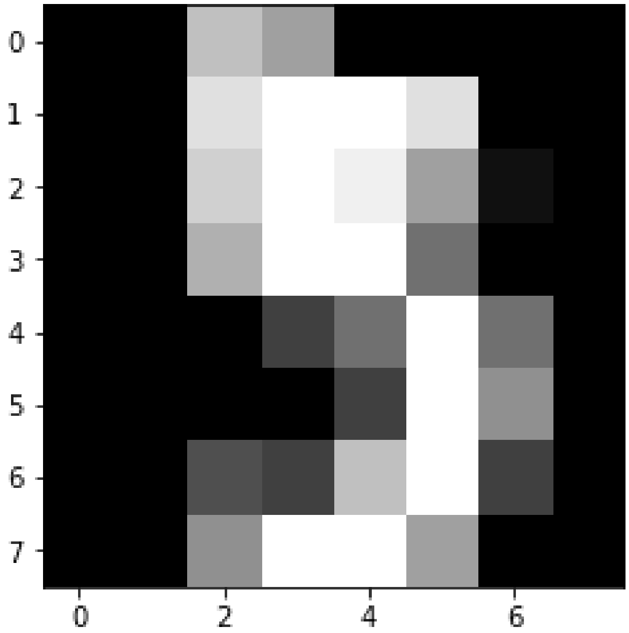
nearest-neighbor

November 7, 2017

```
In [33]: # import packages
         from sklearn.datasets import load_digits
         from sklearn.model_selection import train_test_split
         from sklearn.neighbors import KNeighborsClassifier
         from scipy.spatial import distance
         from scipy.stats import mode
         import numpy as np
         import time
         import itertools
         import matplotlib.pyplot as plt
```

```
In [5]: digits = load_digits()

        print(digits.keys())

        data = digits["data"]
        images = digits["images"]
        target = digits["target"]
        target_names = digits["target_names"]

        print('Data type is: ' + str(data.dtype))
        print('Shap is: ' + str(data.shape))

        img_number = 5
        print(target_names[img_number])
        img_shape = [8, 8]

        img = images[img_number]  # np.reshape(data[img_number],img_shape)

        # test dimensionality
        assert 2 == np.size(np.shape(img))

        plt.figure()
        plt.gray()
        plt.imshow(img, interpolation="nearest")
        plt.show()
        X_all = data
        y_all = target

        # this is deprecated
        # X_train, X_test, y_train, y_test = cross_validation.train_test_split(digits.data, di
        X_train, X_test, y_train, y_test = train_test_split(digits.data, digits.target, test_s
```

```
dict_keys(['data', 'target', 'target_names', 'images', 'DESCR'])
Data type is: float64
Shap is: (1797, 64)
5
```



1 2.2 Loopy Distance Function

```
In [6]: # that's an incredible loopy function
        def dist_loop(training_set, test_set):
            # train_shape = training
            dist = np.zeros((training_set.shape[0], test_set.shape[0]))
            for i in range(training_set.shape[0]):
                for j in range(test_set.shape[0]):
                    dist[i, j] = np.sqrt(np.sum(np.square(test_set[j,k]-training_set[i,k]) for
            return dist
```

2 2.3 Efficient Distance Function

```
In [10]: def dist_mat(training_set, test_set):
             dist = distance.cdist(training_set, test_set, metric="euclidean")
             return dist
```

```
In [12]: t = time.process_time()
         dist1 = dist_loop(X_train, X_test)
         elapsed_time = time.process_time() - t
         print("Elapsed time for loopy function was " + str(elapsed_time))

         t = time.process_time()
         dist2 = dist_mat(X_train, X_test)
         elapsed_time = time.process_time() - t
         print("Elapsed time for matrix function was " + str(elapsed_time))


         # check equality of both functions
         eps = 1e-5
         abs_diff = np.abs(dist1 - dist2)
         assert abs_diff.all() < eps
```

```
Elapsed time for loopy function was 115.453125
Elapsed time for matrix function was 0.046875
```

```
In [14]: # implementation of nearest neighbour classifier
         dist = dist2
```

3 2.4 NN

```
In [29]: # only use 3 and 9
         n1 = 3
         n2 = 9
         sub_ix = np.where((y_train == n1) | (y_train == n2))
         y_train_sub = y_train[sub_ix]
         X_train_sub = (X_train[sub_ix,:]).squeeze()

         sub_ix = np.where((y_test == n1) | (y_test == n2))
         y_test_sub = y_test[sub_ix]
         X_test_sub = (X_test[sub_ix,:]).squeeze()

         def nearest_neighbour(xt, x, yt): # x: new data, xt: trained data yt: trained target
             dist = dist_mat(xt, x) # rows are xt, columns x, so find argmin in one column
             argmin_dist = np.argmin(dist, 0)
             y = yt[argmin_dist]
             return y
         def calc_true_pred(y_p, y_t):
             is_true = np.zeros_like(y_t)
             is_true[(y_p == y_t)] = 1
             no_true = np.sum(is_true)
             perc_true = no_true / len(y_p)
             return no_true, perc_true

         y_pNN = nearest_neighbour(X_train_sub, X_test_sub, y_train_sub)
         _, percent_true_1NN = calc_true_pred(y_pNN, y_test_sub)
         print(percent_true_1NN)
```

```
0.986111111111
```

4 2.5 kNN

```
In [32]: def k_nearest_neighbour(xt, x, yt, k):
             dist = dist_mat(xt, x)  # rows are xt, columns x, so find argmin in one column
             argmin_dist = np.argsort(dist, 0)
             y_argmin_dist = yt[argmin_dist[:k,:]] #[argmin_dist,k]
             # find most common value and output that as majority vote /// tbd
             majority_information = mode(y_argmin_dist, axis=0)
             return np.squeeze(majority_information.mode)

         k_tests = [1, 3, 5, 9, 17, 33]
         for k in k_tests:
             y_pkNN = k_nearest_neighbour(X_train_sub, X_test_sub, y_train_sub, k)
             _, percent_true_kNN = calc_true_pred(y_pkNN, y_test_sub)
             print('k: ' + str(k) + ' success: ' + str(percent_true_kNN))
```

```
k: 1 success: 0.986111111111
k: 3 success: 0.993055555556
k: 5 success: 0.993055555556
k: 9 success: 0.993055555556
k: 17 success: 0.993055555556
k: 33 success: 0.979166666667
```

5 3 Cross Validation

```
In [45]: def cross_validation(x,y,k,folds):
             len_data = len(y)
             fold_size = np.floor(len_data / folds)

             percent_true_sk_kNN = np.zeros((folds,1))
             percent_true_own_kNN = np.zeros((folds,1))
             for i in range(folds):
```

```
        ix_test = list(range(int(i * fold_size), int((i + 1) * fold_size)))
        ix_train = list(range(len_data))
        del ix_train[int(i * fold_size):int((i + 1) * fold_size)]

        xs_train = x[ix_train]
        xs_test = x[ix_test]

        ys_train = y[ix_train]
        ys_test = y[ix_test]

        neigh = KNeighborsClassifier(n_neighbors=k)
        neigh.fit(xs_train, ys_train)
        result_sk_classifier = neigh.predict(xs_test)

        result_own_classifier = k_nearest_neighbour(xs_train,xs_test,ys_train, k)

        _, percent_true_sk_kNN[i] = calc_true_pred(result_sk_classifier, ys_test)
        _, percent_true_own_kNN[i] = calc_true_pred(result_own_classifier, ys_test)
        # print(percent_true_kNN[i])
    # mean_perc = np.mean(percent_true_kNN)
    print('k: ' + str(k) + ' --- n: ' + str(folds) + ' --- mean success: ' + str(np.me
    print('k: ' + str(k) + ' --- n: ' + str(folds) + ' --- mean success: ' + str(np.me
```

```
In [46]: folds = [2, 5, 10]
         for k in k_tests:
             for n in folds:
                 cross_validation(digits.data, digits.target, k, n)
```

```
k: 1 --- n: 2 --- mean success: 0.95991091314 sk class.
k: 1 --- n: 2 --- mean success: 0.959354120267 own class.
k: 1 --- n: 5 --- mean success: 0.964902506964 sk class.
k: 1 --- n: 5 --- mean success: 0.964902506964 own class.
k: 1 --- n: 10 --- mean success: 0.975418994413 sk class.
k: 1 --- n: 10 --- mean success: 0.975418994413 own class.
k: 3 --- n: 2 --- mean success: 0.957683741648 sk class.
k: 3 --- n: 2 --- mean success: 0.957683741648 own class.
k: 3 --- n: 5 --- mean success: 0.966573816156 sk class.
k: 3 --- n: 5 --- mean success: 0.966573816156 own class.
k: 3 --- n: 10 --- mean success: 0.975977653631 sk class.
k: 3 --- n: 10 --- mean success: 0.975977653631 own class.
k: 5 --- n: 2 --- mean success: 0.951559020045 sk class.
k: 5 --- n: 2 --- mean success: 0.951559020045 own class.
k: 5 --- n: 5 --- mean success: 0.964902506964 sk class.
k: 5 --- n: 5 --- mean success: 0.965459610028 own class.
k: 5 --- n: 10 --- mean success: 0.973184357542 sk class.
k: 5 --- n: 10 --- mean success: 0.973184357542 own class.
k: 9 --- n: 2 --- mean success: 0.944320712695 sk class.
k: 9 --- n: 2 --- mean success: 0.944320712695 own class.
```

```
k: 9 --- n: 5 --- mean success: 0.957660167131 sk class.
k: 9 --- n: 5 --- mean success: 0.957660167131 own class.
k: 9 --- n: 10 --- mean success: 0.967039106145 sk class.
k: 9 --- n: 10 --- mean success: 0.967039106145 own class.
k: 17 --- n: 2 --- mean success: 0.938195991091 sk class.
k: 17 --- n: 2 --- mean success: 0.937639198218 own class.
k: 17 --- n: 5 --- mean success: 0.955431754875 sk class.
k: 17 --- n: 5 --- mean success: 0.955431754875 own class.
k: 17 --- n: 10 --- mean success: 0.964804469274 sk class.
k: 17 --- n: 10 --- mean success: 0.964804469274 own class.
k: 33 --- n: 2 --- mean success: 0.9214922049 sk class.
k: 33 --- n: 2 --- mean success: 0.922048997773 own class.
k: 33 --- n: 5 --- mean success: 0.940389972145 sk class.
k: 33 --- n: 5 --- mean success: 0.940947075209 own class.
k: 33 --- n: 10 --- mean success: 0.94748603352 sk class.
k: 33 --- n: 10 --- mean success: 0.948044692737 own class.
```

```
In [17]:
```