 # CS156 (Introduction to AI), Fall 2022

Homework 2 submission

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References and sources

https://www.askpython.com/python/examples/k-nearest-neighbors-from-scratch
https://machinelearningmastery.com/tutorial-to-implement-k-nearest-neighbors-in-python-from-scratch/

Also took reference from knn.synthetic.data and from the examples

Solution

Load libraries and set random number generator seed

```
import pandas as pd
import numpy as np
from sklearn.model_selection import train_test_split
import matplotlib.pyplot as plt
from scipy.spatial import distance
import statistics


np.random.seed(42)
```

Code the solution

KNN implementation

```
def knn(newObservation, referenceData, k=3):
    distances = []
    for i in range(len(referenceData.index)):
        d = distance.euclidean(newObservation.iloc[0,:], referenceData.iloc[i,:-1])
        distances.append((d, i))

    sortedDistances = sorted(distances)
    kNearestDistances = sortedDistances[:3]

    kNearestLabels = [referenceData.iloc[i, -1] for d, i in kNearestDistances]

    return statistics.mode(kNearestLabels)
```

2D Data

```
n = 100

Class0Dim1 = np.random.normal(loc=-2.0, scale=2.0, size=int(n/2))
Class0Dim2 = np.random.normal(loc=0.0, scale=1.0, size=int(n/2))

Class1Dim1 = np.random.normal(loc=2.0, scale=2.0, size=int(n/2))
Class1Dim2 = np.random.normal(loc=0.0, scale=1.0, size=int(n/2))

Dim1 = np.concatenate((Class0Dim1, Class1Dim1), axis=0)
Dim2 = np.concatenate((Class0Dim2, Class1Dim2), axis=0)

s1 = [0]*int(n/2)
s2 = [1]*int(n/2)
labels = s1+s2

dt = pd.DataFrame({'Dim1':Dim1, 'Dim2':Dim2}, columns=['Dim1', 'Dim2'])
dt.head(100)
```

	Dim1	Dim2
0	-1.006572	0.324084
1	-2.276529	-0.385082

```
X_train, X_test, Y_train, Y_test = train_test_split(dt,labels, test_size=0.2, random_s

referenceData = pd.DataFrame({'Dim1':X_train.Dim1, 'Dim2':X_train.Dim2, 'Label':Y_trai
referenceData.head(100)
```

	Dim1	Dim2	Label
43	-2.602207	-0.327662	0
62	2.120460	1.158596	1
3	1.046060	0.611676	0
71	0.181225	-0.815810	1
45	-3.439688	-1.463515	0
...	...	...	...
96	-0.473901	-0.883857	1
67	-0.337356	1.896793	1
64	1.615278	0.963376	1
47	0.114244	0.261055	0
44	-4.957044	-0.392108	0

80 rows × 3 columns

```
newObservations = pd.DataFrame({'Dim1':X_test.Dim1, 'Dim2':X_test.Dim2}, columns=['Dir
newObservations.head(100)
```

	Dim1	Dim2
26	-4.301987	0.087047
86	0.433493	0.473238
2	-0.704623	-0.676922
55	2.808102	-0.714351
75	6.380911	0.827183
93	2.369268	-1.245739
16	-4.025662	-0.072010
73	-0.803702	0.341152
54	1.677429	0.293072
95	3.563646	0.385317
53	0.395445	0.232254

```
pred_results = []
for row in newObservations.itertuples():
    newObservation = pd.DataFrame({'Dim1':[row.Dim1], 'Dim2':[row.Dim2]}, columns=['Di
    pred_results.append((knn(newObservation, referenceData)))
print(pred_results)
```

```
[0, 0, 0, 1, 1, 1, 0, 1, 1, 1, 1, 0, 1, 0, 0, 0, 0, 0, 0, 0]
```

22	-1.864944	-0.035826

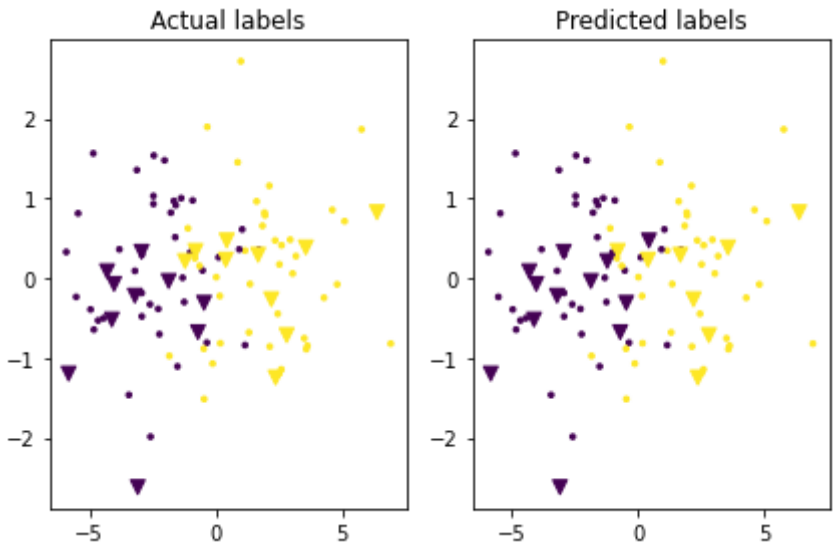
```
num = 0
for i in range(len(pred_results)):
    if pred_results[i] == Y_test[i]:
        num += 1
precision = num / len(Y_test)
print('Precision: %f'% precision)
```

```
Precision: 0.900000
```

```
plt.subplot(1, 2, 1)
plt.scatter(X_train.iloc[:,0],X_train.iloc[:,1], s=25, c=Y_train, marker=".")
plt.scatter(X_test.iloc[:,0],X_test.iloc[:,1], s=50, c=Y_test, marker="v")
plt.title("Actual labels")

plt.subplot(1, 2, 2)
plt.scatter(X_train.iloc[:,0],X_train.iloc[:,1], s=25, c=Y_train, marker=".")
plt.scatter(X_test.iloc[:,0],X_test.iloc[:,1], s=50, c=pred_results, marker="v")
plt.title("Predicted labels")

plt.tight_layout()
plt.show()
```



3D data

```
n = 1000

Class0Dim1 = np.random.normal(loc=0.0, scale=3.0, size=int(n/4))
Class0Dim2 = np.random.normal(loc=-3.0, scale=1.0, size=int(n/4))
Class0Dim3 = np.random.normal(loc=-1.0, scale=1.0, size=int(n/4))

Class1Dim1 = np.random.normal(loc=0.0, scale=3.0, size=int(n/4))
Class1Dim2 = np.random.normal(loc=1.0, scale=2.0, size=int(n/4))
Class1Dim3 = np.random.normal(loc=1.0, scale=1.0, size=int(n/4))

Class2Dim1 = np.random.normal(loc=0.0, scale=3.0, size=int(n/4))
Class2Dim2 = np.random.normal(loc=3.0, scale=1.0, size=int(n/4))
Class2Dim3 = np.random.normal(loc=4.0, scale=1.0, size=int(n/4))

Class3Dim1 = np.random.normal(loc=0.0, scale=3.0, size=int(n/4))
Class3Dim2 = np.random.normal(loc=5.0, scale=3.0, size=int(n/4))
Class3Dim3 = np.random.normal(loc=-3.0, scale=1.0, size=int(n/4))

Dim1 = np.concatenate((Class0Dim1, Class1Dim1, Class2Dim1, Class3Dim1), axis=0)
Dim2 = np.concatenate((Class0Dim2, Class1Dim2, Class2Dim2, Class3Dim2), axis=0)
Dim3 = np.concatenate((Class0Dim3, Class1Dim3, Class2Dim3, Class3Dim3), axis=0)

s1 = [0]*int(n/4)
s2 = [1]*int(n/4)
s3 = [2]*int(n/4)
s4 = [3]*int(n/4)
labels = s1+s2+s3+s4

dt = pd.DataFrame({'Dim1':Dim1, 'Dim2':Dim2, 'Dim3':Dim3}, columns=['Dim1', 'Dim2', 'I
dt.head(1000)
```

	Dim1	Dim2	Dim3
0	1.073362	-3.062679	-1.522723
1	1.682354	-2.044858	0.049009
2	3.249154	-3.985726	-1.704344
3	3.161406	-2.495953	-2.408461
4	-4.133008	-3.530258	-2.556629
...	...	...	...
995	4.294100	1.556926	-4.880010
996	3.245300	5.255628	-2.287288
997	-3.936658	-3.973408	-4.883150
998	1.866210	4.439312	-3.372319
999	3.986800	0.108580	-2.562687

1000 rows × 3 columns

```
X_train, X_test, Y_train, Y_test = train_test_split(dt,labels, test_size=0.2, random_s

referenceData = pd.DataFrame({'Dim1':X_train.Dim1, 'Dim2':X_train.Dim2, 'Dim3':X_trair
referenceData.head(1000)
```

	Dim1	Dim2	Dim3	Label
687	1.272183	4.549020	3.075767	2
500	1.051890	1.226968	5.804348	2
332	1.197669	2.416217	1.323168	1
979	-0.790345	7.956349	-2.484372	3
817	-6.657901	6.364223	-5.832156	3
...	...	...	...	...
835	-0.885270	3.944236	-2.553127	3
192	-3.960700	-3.259591	0.066675	0
629	0.056549	2.549811	4.849102	2
559	3.944743	3.937570	4.198948	2
684	-0.079217	2.645959	4.032797	2

800 rows × 4 columns

```
newObservations = pd.DataFrame({'Dim1':X_test.Dim1, 'Dim2':X_test.Dim2, 'Dim3':X_test.
```

```
newObservations.head(1000)
```

	Dim1	Dim2	Dim3
993	-0.403490	4.428491	-3.617642
859	2.772810	3.351379	-3.395681
298	-1.713537	1.467572	2.024063
553	-5.491899	2.692038	3.987911
672	-0.924103	2.980740	4.160018
...	...	...	...
679	-2.417610	3.718186	4.260281
722	-3.218229	2.680152	3.770609
215	-2.245460	-2.893570	-0.720978
653	2.757463	4.125435	2.634044
150	0.932723	-2.243011	-1.623141

200 rows × 3 columns

```
pred_results = []
for row in newObservations.itertuples():
    newObservation = pd.DataFrame({'Dim1':[row.Dim1], 'Dim2':[row.Dim2], 'Dim3':[row.I
    pred_results.append((knn(newObservation, referenceData)))
print(pred_results)
```

```
[3, 3, 1, 2, 2, 3, 0, 0, 2, 2, 1, 1, 3, 0, 2, 1, 3, 0, 0, 0, 0, 1, 1, 1, 3, 3, 0
```

```
num = 0
for j in range(len(pred_results)):
    if pred_results[j] == Y_test[j]:
        num += 1
precision = num / len(Y_test)
print('precision: %f'% precision)
```

```
precision: 0.915000
```

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