Python Project - Predicting Breast Cancer using two Supervised Learning Models and Comparing their Efficiency - KNN

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Methodology

Classification, which is a data mining function that assigns items in a collection to target categories or classes, will be used to make a predictive model in this project. The goal of classification is to accurately predict the target class for each case in the data. Here, our goal is to predict if a patient has cancer or otherwise.

K-Nearest Neighbours:

This algorithm considers all samples including the new sample/data as points on a graph and finds the 'k' nearest points to the new point using euclidean distance or manhattan distance. Euclidean distance is the length of the line segment connecting two points, it is used when all the features are of the same type. In Cartesian coordinates, if p = (p1, p2,..., pn) and q = (q1, q2,..., qn) are two points in Euclidean space, then the distance (d) from p to q, or from q to p is given by the Pythagorean formula,

https://en.wikipedia.org/wiki/Euclidean_distance

DATASET

Cancer data set UCI ML Repository.

Now we will import dependencies as needed for our second part of the predictive analysis, using KNN algorithm.

In [1]:
```
import numpy as np
import matplotlib.pyplot as plt
from math import sqrt
from collections import Counter
import pandas as pd
import random
```

The dataset is a modified Text version of the same UCI Laboratory data and was obtained from UCI ML repository.

We will now create a dataframe from the file and drop Patient ID and missing values are replaced before we proceed further.

In [2]:
```
df = pd.read_csv('breast-cancer-wisconsin.data.txt')

df.replace('?',-99999, inplace=True)
df.drop(['id'], 1, inplace=True)
full_data = df.astype(float).values.tolist()
print(full_data)
```

```
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[1.0, 1.0, 1.0, 1.0, 2.0, 1.0, 3.0, 1.0, 1.0, 2.0], [3.0, 1.0, 1.0, 1.0, 2.0,
1.0, 2.0, 1.0, 1.0, 2.0], [4.0, 1.0, 1.0, 1.0, 2.0, 1.0, 3.0, 2.0, 1.0, 2.0],
[5.0, 7.0, 10.0, 10.0, 5.0, 10.0, 10.0, 10.0, 1.0, 4.0], [3.0, 1.0, 2.0, 1.0,
2.0, 1.0, 3.0, 1.0, 1.0, 2.0], [4.0, 1.0, 1.0, 1.0, 2.0, 3.0, 2.0, 1.0, 1.0,
2.0], [8.0, 4.0, 4.0, 1.0, 6.0, 10.0, 2.0, 5.0, 2.0, 4.0], [10.0, 10.0, 8.0, 1
0.0, 6.0, 5.0, 10.0, 3.0, 1.0, 4.0], [8.0, 10.0, 4.0, 4.0, 8.0, 10.0, 8.0, 2.
0, 1.0, 4.0], [7.0, 6.0, 10.0, 5.0, 3.0, 10.0, 9.0, 10.0, 2.0, 4.0], [3.0, 1.
0, 1.0, 1.0, 2.0, 1.0, 2.0, 1.0, 1.0, 2.0], [1.0, 1.0, 1.0, 1.0, 2.0, 1.0, 2.
0, 1.0, 1.0, 2.0], [10.0, 9.0, 7.0, 3.0, 4.0, 2.0, 7.0, 7.0, 1.0, 4.0], [5.0,
1.0, 2.0, 1.0, 2.0, 1.0, 3.0, 1.0, 1.0, 2.0], [5.0, 1.0, 1.0, 1.0, 2.0, 1.0,
2.0, 1.0, 1.0, 2.0], [1.0, 1.0, 1.0, 1.0, 2.0, 1.0, 2.0, 1.0, 1.0, 2.0], [1.0,
1.0, 1.0, 1.0, 2.0, 1.0, 2.0, 1.0, 1.0, 2.0], [1.0, 1.0, 1.0, 1.0, 2.0, 1.0,
3.0, 1.0, 1.0, 2.0], [5.0, 1.0, 2.0, 1.0, 2.0, 1.0, 2.0, 1.0, 1.0, 2.0], [5.0,
7.0, 10.0, 6.0, 5.0, 10.0, 7.0, 5.0, 1.0, 4.0], [6.0, 10.0, 5.0, 5.0, 4.0, 10.
0, 6.0, 10.0, 1.0, 4.0], [3.0, 1.0, 1.0, 1.0, 2.0, 1.0, 1.0, 1.0, 1.0, 2.0],
[5.0, 1.0, 1.0, 6.0, 3.0, 1.0, 1.0, 1.0, 1.0, 2.0], [1.0, 1.0, 1.0, 1.0, 2.0,
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4.0], [5.0, 1.0, 1.0, 1.0, 2.0, 1.0, 2.0, 2.0, 1.0, 2.0], [9.0, 8.0, 8.0, 9.0,
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2.0], [4.0, 10.0, 8.0, 5.0, 4.0, 1.0, 10.0, 1.0, 1.0, 4.0], [2.0, 5.0, 7.0, 6.
0, 4.0, 10.0, 7.0, 6.0, 1.0, 4.0], [10.0, 3.0, 4.0, 5.0, 3.0, 10.0, 4.0, 1.0,
1.0, 4.0], [5.0, 1.0, 2.0, 1.0, 2.0, 1.0, 1.0, 1.0, 1.0, 2.0], [4.0, 8.0, 6.0,
3.0, 4.0, 10.0, 7.0, 1.0, 1.0, 4.0], [5.0, 1.0, 1.0, 1.0, 2.0, 1.0, 2.0, 1.0,
1.0, 2.0], [4.0, 1.0, 2.0, 1.0, 2.0, 1.0, 2.0, 1.0, 1.0, 2.0], [5.0, 1.0, 3.0,
1.0, 2.0, 1.0, 3.0, 1.0, 1.0, 2.0], [3.0, 1.0, 1.0, 1.0, 2.0, 1.0, 2.0, 1.0,
1.0, 2.0], [5.0, 2.0, 4.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 2.0], [3.0, 1.0, 1.0,
1.0, 2.0, 1.0, 2.0, 1.0, 1.0, 2.0], [1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 2.0, 1.0,
1.0, 2.0], [4.0, 1.0, 1.0, 1.0, 2.0, 1.0, 2.0, 1.0, 1.0, 2.0], [5.0, 4.0, 6.0,
8.0, 4.0, 1.0, 8.0, 10.0, 1.0, 4.0], [5.0, 3.0, 2.0, 8.0, 5.0, 10.0, 8.0, 1.0,
2.0, 4.0], [10.0, 5.0, 10.0, 3.0, 5.0, 8.0, 7.0, 8.0, 3.0, 4.0], [4.0, 1.0, 1.
0, 2.0, 2.0, 1.0, 1.0, 1.0, 1.0, 2.0], [1.0, 1.0, 1.0, 1.0, 2.0, 1.0, 1.0, 1.
0, 1.0, 2.0], [5.0, 10.0, 10.0, 10.0, 10.0, 10.0, 10.0, 1.0, 1.0, 4.0], [5.0,
1.0, 1.0, 1.0, 2.0, 1.0, 1.0, 1.0, 1.0, 2.0], [10.0, 4.0, 3.0, 10.0, 3.0, 10.
0, 7.0, 1.0, 2.0, 4.0], [5.0, 10.0, 10.0, 10.0, 5.0, 2.0, 8.0, 5.0, 1.0, 4.0],
[8.0, 10.0, 10.0, 10.0, 6.0, 10.0, 10.0, 10.0, 10.0, 4.0], [2.0, 3.0, 1.0, 1.
0, 2.0, 1.0, 2.0, 1.0, 1.0, 2.0], [2.0, 1.0, 1.0, 1.0, 1.0, 1.0, 2.0, 1.0, 1.
0, 2.0], [4.0, 1.0, 3.0, 1.0, 2.0, 1.0, 2.0, 1.0, 1.0, 2.0], [3.0, 1.0, 1.0,
1.0, 2.0, 1.0, 2.0, 1.0, 1.0, 2.0], [1.0, 1.0, 1.0, 1.0, 1.0, -99999.0, 1.0,
1.0, 1.0, 2.0], [4.0, 1.0, 1.0, 1.0, 2.0, 1.0, 2.0, 1.0, 1.0, 2.0], [5.0, 1.0,
1.0, 1.0, 2.0, 1.0, 2.0, 1.0, 1.0, 2.0], [3.0, 1.0, 1.0, 1.0, 2.0, 1.0, 2.0,
1.0, 1.0, 2.0], [6.0, 3.0, 3.0, 3.0, 3.0, 2.0, 6.0, 1.0, 1.0, 2.0], [7.0, 1.0,
2.0, 3.0, 2.0, 1.0, 2.0, 1.0, 1.0, 2.0], [1.0, 1.0, 1.0, 1.0, 2.0, 1.0, 1.0,
1.0, 1.0, 2.0], [5.0, 1.0, 1.0, 2.0, 1.0, 1.0, 2.0, 1.0, 1.0, 2.0], [3.0, 1.0,
3.0, 1.0, 3.0, 4.0, 1.0, 1.0, 1.0, 2.0], [4.0, 6.0, 6.0, 5.0, 7.0, 6.0, 7.0,
7.0, 3.0, 4.0], [2.0, 1.0, 1.0, 1.0, 2.0, 5.0, 1.0, 1.0, 1.0, 2.0], [2.0, 1.0,
1.0, 1.0, 2.0, 1.0, 1.0, 1.0, 1.0, 2.0], [4.0, 1.0, 1.0, 1.0, 2.0, 1.0, 1.0,
1.0, 1.0, 2.0], [6.0, 2.0, 3.0, 1.0, 2.0, 1.0, 1.0, 1.0, 1.0, 2.0], [5.0, 1.0,
1.0, 1.0, 2.0, 1.0, 2.0, 1.0, 1.0, 2.0], [1.0, 1.0, 1.0, 1.0, 2.0, 1.0, 1.0,
1.0, 1.0, 2.0], [8.0, 7.0, 4.0, 4.0, 5.0, 3.0, 5.0, 10.0, 1.0, 4.0], [3.0, 1.
0, 1.0, 1.0, 2.0, 1.0, 1.0, 1.0, 1.0, 2.0], [3.0, 1.0, 4.0, 1.0, 2.0, 1.0, 1.
0, 1.0, 1.0, 2.0], [10.0, 10.0, 7.0, 8.0, 7.0, 1.0, 10.0, 10.0, 3.0, 4.0], [4.
0, 2.0, 4.0, 3.0, 2.0, 2.0, 2.0, 1.0, 1.0, 2.0], [4.0, 1.0, 1.0, 1.0, 2.0, 1.
0, 1.0, 1.0, 1.0, 2.0], [5.0, 1.0, 1.0, 3.0, 2.0, 1.0, 1.0, 1.0, 1.0, 2.0],
[4.0, 1.0, 1.0, 3.0, 2.0, 1.0, 1.0, 1.0, 1.0, 2.0], [3.0, 1.0, 1.0, 1.0, 2.0,
1.0, 2.0, 1.0, 1.0, 2.0], [3.0, 1.0, 1.0, 1.0, 2.0, 1.0, 2.0, 1.0, 1.0, 2.0],
[1.0, 1.0, 1.0, 1.0, 2.0, 1.0, 1.0, 1.0, 1.0, 2.0], [2.0, 1.0, 1.0, 1.0, 2.0,
1.0, 1.0, 1.0, 1.0, 2.0], [3.0, 1.0, 1.0, 1.0, 2.0, 1.0, 2.0, 1.0, 1.0, 2.0],
[1.0, 2.0, 2.0, 1.0, 2.0, 1.0, 1.0, 1.0, 1.0, 2.0], [1.0, 1.0, 1.0, 3.0, 2.0,
1.0, 1.0, 1.0, 1.0, 2.0], [5.0, 10.0, 10.0, 10.0, 10.0, 2.0, 10.0, 10.0, 10.0,
4.0], [3.0, 1.0, 1.0, 1.0, 2.0, 1.0, 2.0, 1.0, 1.0, 2.0], [3.0, 1.0, 1.0, 2.0,
3.0, 4.0, 1.0, 1.0, 1.0, 2.0], [1.0, 2.0, 1.0, 3.0, 2.0, 1.0, 2.0, 1.0, 1.0,
2.0], [5.0, 1.0, 1.0, 1.0, 2.0, 1.0, 2.0, 2.0, 1.0, 2.0], [4.0, 1.0, 1.0, 1.0,
2.0, 1.0, 2.0, 1.0, 1.0, 2.0], [3.0, 1.0, 1.0, 1.0, 2.0, 1.0, 3.0, 1.0, 1.0,
2.0], [3.0, 1.0, 1.0, 1.0, 2.0, 1.0, 2.0, 1.0, 1.0, 2.0], [5.0, 1.0, 1.0, 1.0,
2.0, 1.0, 2.0, 1.0, 1.0, 2.0], [5.0, 4.0, 5.0, 1.0, 8.0, 1.0, 3.0, 6.0, 1.0,
```

```
2.0], [7.0, 8.0, 8.0, 7.0, 3.0, 10.0, 7.0, 2.0, 3.0, 4.0], [1.0, 1.0, 1.0, 1.
0, 2.0, 1.0, 1.0, 1.0, 1.0, 2.0], [1.0, 1.0, 1.0, 1.0, 2.0, 1.0, 2.0, 1.0, 1.
0, 2.0], [4.0, 1.0, 1.0, 1.0, 2.0, 1.0, 3.0, 1.0, 1.0, 2.0], [1.0, 1.0, 3.0,
1.0, 2.0, 1.0, 2.0, 1.0, 1.0, 2.0], [1.0, 1.0, 3.0, 1.0, 2.0, 1.0, 2.0, 1.0,
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1.0, 6.0, 1.0, 7.0, 10.0, 3.0, 4.0], [5.0, 10.0, 10.0, 8.0, 5.0, 5.0, 7.0, 10.
0, 1.0, 4.0], [3.0, 10.0, 7.0, 8.0, 5.0, 8.0, 7.0, 4.0, 1.0, 4.0], [3.0, 2.0,
1.0, 2.0, 2.0, 1.0, 3.0, 1.0, 1.0, 2.0], [2.0, 1.0, 1.0, 1.0, 2.0, 1.0, 3.0,
1.0, 1.0, 2.0], [5.0, 3.0, 2.0, 1.0, 3.0, 1.0, 1.0, 1.0, 1.0, 2.0], [1.0, 1.0,
1.0, 1.0, 2.0, 1.0, 2.0, 1.0, 1.0, 2.0], [4.0, 1.0, 4.0, 1.0, 2.0, 1.0, 1.0,
1.0, 1.0, 2.0], [1.0, 1.0, 2.0, 1.0, 2.0, 1.0, 2.0, 1.0, 1.0, 2.0], [5.0, 1.0,
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10.0, 5.0, 6.0, 3.0, 4.0], [5.0, 1.0, 1.0, 1.0, 2.0, 1.0, 3.0, 2.0, 1.0, 2.0],
[1.0, 1.0, 1.0, 1.0, 2.0, 1.0, 1.0, 1.0, 1.0, 2.0], [1.0, 1.0, 1.0, 1.0, 2.0,
1.0, 1.0, 1.0, 1.0, 2.0], [1.0, 1.0, 1.0, 1.0, 2.0, 1.0, 1.0, 1.0, 1.0, 2.0],
[1.0, 1.0, 1.0, 1.0, 2.0, 1.0, 1.0, 1.0, 1.0, 2.0], [3.0, 1.0, 1.0, 1.0, 2.0,
1.0, 2.0, 3.0, 1.0, 2.0], [4.0, 1.0, 1.0, 1.0, 2.0, 1.0, 1.0, 1.0, 1.0, 2.0],
[1.0, 1.0, 1.0, 1.0, 2.0, 1.0, 1.0, 1.0, 8.0, 2.0], [1.0, 1.0, 1.0, 3.0, 2.0,
1.0, 1.0, 1.0, 1.0, 2.0], [5.0, 10.0, 10.0, 5.0, 4.0, 5.0, 4.0, 4.0, 1.0, 4.
0], [3.0, 1.0, 1.0, 1.0, 2.0, 1.0, 1.0, 1.0, 1.0, 2.0], [3.0, 1.0, 1.0, 1.0,
2.0, 1.0, 2.0, 1.0, 2.0, 2.0], [3.0, 1.0, 1.0, 1.0, 3.0, 2.0, 1.0, 1.0, 1.0,
```

Now, we will Random Shuffle the dataframe, split them in a fashion similar to the last time. We go for a test size of 0.2. The response variable holds a numerical value as well, with 2 representing benign tumors and 4 representing malignant.

We then verify the test set.

In [3]:
```
random.shuffle(full_data)
test_size = 0.2
train_set = {2:[], 4:[]} #2 & 4 is output data
test_set = {2:[], 4:[]}  #2 is for the benign tumors   4 is for malignant tum

train_data = full_data[0:-int(test_size*len(full_data))]
test_data = full_data[-int(test_size*len(full_data)):]

for data in train_data:
    train_set[data[-1]].append(data[0:-1])
for data in test_data:
    test_set[data[-1]].append(data[0:-1])
test_set
```

Out[3]:
```
{2: [[5.0, 1.0, 1.0, 1.0, 2.0, 1.0, 1.0, 1.0, 1.0],
  [5.0, 3.0, 6.0, 1.0, 2.0, 1.0, 1.0, 1.0, 1.0],
  [5.0, 1.0, 1.0, 1.0, 2.0, 1.0, 1.0, 1.0, 1.0],
  [5.0, 3.0, 1.0, 2.0, 2.0, 1.0, 2.0, 1.0, 1.0],
  [4.0, 1.0, 1.0, 2.0, 2.0, 1.0, 2.0, 1.0, 1.0],
  [3.0, 1.0, 1.0, 1.0, 2.0, 1.0, 2.0, 1.0, 1.0],
  [3.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0],
  [5.0, 1.0, 1.0, 1.0, 2.0, 1.0, 2.0, 2.0, 1.0],
  [1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 2.0, 1.0, 1.0],
  [3.0, 1.0, 1.0, 1.0, 2.0, 1.0, 2.0, 1.0, 1.0],
  [2.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0],
  [5.0, 1.0, 1.0, 1.0, 2.0, 1.0, 3.0, 1.0, 2.0],
  [3.0, 1.0, 1.0, 1.0, 2.0, 1.0, 1.0, 1.0, 1.0],
  [5.0, 1.0, 2.0, 1.0, 2.0, 1.0, 1.0, 1.0, 1.0],
  [1.0, 2.0, 3.0, 1.0, 2.0, 1.0, 2.0, 1.0, 1.0],
  [4.0, 1.0, 1.0, 1.0, 2.0, 1.0, 3.0, 1.0, 1.0],
```

```
[1.0, 1.0, 1.0, 1.0, 2.0, 1.0, 2.0, 1.0, 1.0],
[2.0, 3.0, 1.0, 1.0, 5.0, 1.0, 1.0, 1.0, 1.0],
[4.0, 2.0, 1.0, 1.0, 2.0, 1.0, 1.0, 1.0, 1.0],
[6.0, 3.0, 3.0, 5.0, 3.0, 10.0, 3.0, 5.0, 3.0],
[3.0, 3.0, 2.0, 1.0, 3.0, 1.0, 3.0, 6.0, 1.0],
[1.0, 1.0, 1.0, 1.0, 2.0, 1.0, 1.0, 1.0, 1.0],
[3.0, 1.0, 1.0, 1.0, 2.0, 1.0, 1.0, 1.0, 1.0],
[3.0, 1.0, 1.0, 1.0, 2.0, 2.0, 3.0, 1.0, 1.0],
[1.0, 2.0, 2.0, 1.0, 2.0, 1.0, 1.0, 1.0, 1.0],
[4.0, 2.0, 1.0, 1.0, 2.0, 1.0, 2.0, 1.0, 1.0],
[5.0, 1.0, 1.0, 1.0, 2.0, 1.0, 1.0, 1.0, 1.0],
[3.0, 1.0, 1.0, 1.0, 2.0, 1.0, 2.0, 1.0, 1.0],
[1.0, 1.0, 1.0, 3.0, 2.0, 3.0, 1.0, 1.0, 1.0],
[5.0, 1.0, 1.0, 6.0, 3.0, 1.0, 2.0, 1.0, 1.0],
[1.0, 1.0, 1.0, 1.0, 2.0, 4.0, 1.0, 1.0, 1.0],
[1.0, 1.0, 1.0, 1.0, 10.0, 1.0, 1.0, 1.0, 1.0],
[3.0, 4.0, 5.0, 3.0, 7.0, 3.0, 4.0, 6.0, 1.0],
[2.0, 1.0, 1.0, 1.0, 2.0, 1.0, 1.0, 1.0, 1.0],
[8.0, 2.0, 1.0, 1.0, 5.0, 1.0, 1.0, 1.0, 1.0],
[5.0, 1.0, 1.0, 1.0, 3.0, 2.0, 2.0, 2.0, 1.0],
[1.0, 1.0, 1.0, 3.0, 2.0, 1.0, 1.0, 1.0, 1.0],
[1.0, 1.0, 1.0, 1.0, 2.0, 1.0, 1.0, 1.0, 8.0],
[5.0, 1.0, 1.0, 1.0, 2.0, 1.0, 1.0, 1.0, 1.0],
[1.0, 1.0, 1.0, 2.0, 1.0, 1.0, 1.0, 1.0, 1.0],
[1.0, 1.0, 3.0, 1.0, 2.0, -99999.0, 2.0, 1.0, 1.0],
[1.0, 1.0, 1.0, 1.0, 2.0, 1.0, 3.0, 1.0, 1.0],
[2.0, 1.0, 1.0, 2.0, 3.0, 1.0, 2.0, 1.0, 1.0],
[1.0, 1.0, 1.0, 1.0, 2.0, 5.0, 1.0, 1.0, 1.0],
[3.0, 1.0, 1.0, 1.0, 2.0, 1.0, 2.0, 1.0, 1.0],
[4.0, 1.0, 1.0, 1.0, 2.0, 1.0, 3.0, 1.0, 1.0],
[1.0, 1.0, 1.0, 1.0, 2.0, 1.0, 2.0, 3.0, 1.0],
[1.0, 1.0, 1.0, 1.0, 2.0, 1.0, 1.0, 1.0, 1.0],
[1.0, 1.0, 1.0, 1.0, 2.0, 1.0, 1.0, 1.0, 1.0],
[1.0, 1.0, 1.0, 1.0, 2.0, 1.0, 2.0, 1.0, 1.0],
[2.0, 1.0, 1.0, 1.0, 2.0, 1.0, 2.0, 2.0, 1.0],
[5.0, 1.0, 1.0, 1.0, 2.0, 1.0, 1.0, 1.0, 1.0],
[3.0, 1.0, 1.0, 1.0, 2.0, 1.0, 3.0, 1.0, 1.0],
[1.0, 1.0, 1.0, 1.0, 2.0, 1.0, 2.0, 1.0, 1.0],
[3.0, 1.0, 3.0, 1.0, 3.0, 4.0, 1.0, 1.0, 1.0],
[1.0, 1.0, 2.0, 1.0, 2.0, 1.0, 2.0, 1.0, 1.0],
[1.0, 1.0, 1.0, 1.0, 2.0, 1.0, 1.0, 1.0, 1.0],
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[1.0, 1.0, 1.0, 1.0, 2.0, 1.0, 1.0, 1.0, 1.0],
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[6.0, 1.0, 3.0, 1.0, 2.0, 1.0, 3.0, 1.0, 1.0],
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[1.0, 1.0, 1.0, 1.0, 2.0, 1.0, 2.0, 1.0, 1.0],
[2.0, 1.0, 1.0, 1.0, 3.0, 1.0, 2.0, 1.0, 1.0],
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[2.0, 1.0, 1.0, 1.0, 2.0, 1.0, 1.0, 1.0, 1.0],
[3.0, 1.0, 3.0, 1.0, 2.0, -99999.0, 2.0, 1.0, 1.0],
[1.0, 1.0, 4.0, 1.0, 2.0, 1.0, 2.0, 1.0, 1.0],
[1.0, 2.0, 2.0, 1.0, 2.0, 1.0, 2.0, 1.0, 1.0],
[1.0, 1.0, 1.0, 1.0, 5.0, 1.0, 3.0, 1.0, 1.0],
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[5.0, 1.0, 1.0, 3.0, 2.0, 1.0, 1.0, 1.0, 1.0],
[5.0, 2.0, 4.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0],
```

```
  [2.0, 1.0, 1.0, 1.0, 2.0, 1.0, 3.0, 1.0, 1.0],
  [1.0, 1.0, 1.0, 1.0, 2.0, 1.0, 3.0, 1.0, 1.0],
  [5.0, 2.0, 2.0, 2.0, 3.0, 1.0, 1.0, 3.0, 1.0],
  [4.0, 1.0, 1.0, 1.0, 2.0, 3.0, 1.0, 1.0, 1.0],
  [1.0, 1.0, 1.0, 1.0, 2.0, 1.0, 1.0, 1.0, 1.0],
  [2.0, 3.0, 1.0, 1.0, 3.0, 1.0, 1.0, 1.0, 1.0],
  [4.0, 1.0, 1.0, 1.0, 2.0, 1.0, 1.0, 1.0, 1.0],
  [1.0, 1.0, 1.0, 1.0, 2.0, 1.0, 1.0, 1.0, 1.0],
  [3.0, 1.0, 1.0, 1.0, 1.0, 1.0, 2.0, 1.0, 1.0],
  [5.0, 1.0, 1.0, 1.0, 2.0, 1.0, 3.0, 1.0, 1.0],
  [2.0, 1.0, 1.0, 1.0, 1.0, 1.0, 3.0, 1.0, 1.0],
  [1.0, 2.0, 3.0, 1.0, 2.0, 1.0, 1.0, 1.0, 1.0]],
4: [[10.0, 6.0, 4.0, 3.0, 10.0, 10.0, 9.0, 10.0, 1.0],
  [5.0, 6.0, 5.0, 6.0, 10.0, 1.0, 3.0, 1.0, 1.0],
  [4.0, 6.0, 6.0, 5.0, 7.0, 6.0, 7.0, 7.0, 3.0],
  [10.0, 9.0, 7.0, 3.0, 4.0, 2.0, 7.0, 7.0, 1.0],
  [5.0, 8.0, 7.0, 7.0, 10.0, 10.0, 5.0, 7.0, 1.0],
  [7.0, 4.0, 5.0, 10.0, 2.0, 10.0, 3.0, 8.0, 2.0],
  [10.0, 6.0, 5.0, 8.0, 5.0, 10.0, 8.0, 6.0, 1.0],
  [10.0, 10.0, 10.0, 7.0, 10.0, 10.0, 8.0, 2.0, 1.0],
  [5.0, 10.0, 10.0, 10.0, 4.0, 10.0, 5.0, 6.0, 3.0],
  [3.0, 6.0, 4.0, 10.0, 3.0, 3.0, 3.0, 4.0, 1.0],
  [9.0, 5.0, 5.0, 2.0, 2.0, 2.0, 5.0, 1.0, 1.0],
  [3.0, 4.0, 5.0, 2.0, 6.0, 8.0, 4.0, 1.0, 1.0],
  [6.0, 10.0, 5.0, 5.0, 4.0, 10.0, 6.0, 10.0, 1.0],
  [6.0, 5.0, 4.0, 4.0, 3.0, 9.0, 7.0, 8.0, 3.0],
  [5.0, 10.0, 10.0, 8.0, 5.0, 5.0, 7.0, 10.0, 1.0],
  [6.0, 6.0, 7.0, 10.0, 3.0, 10.0, 8.0, 10.0, 2.0],
  [10.0, 6.0, 6.0, 3.0, 4.0, 5.0, 3.0, 6.0, 1.0],
  [6.0, 10.0, 10.0, 2.0, 8.0, 10.0, 7.0, 3.0, 3.0],
  [9.0, 10.0, 10.0, 1.0, 10.0, 8.0, 3.0, 3.0, 1.0],
  [10.0, 3.0, 4.0, 5.0, 3.0, 10.0, 4.0, 1.0, 1.0],
  [5.0, 10.0, 10.0, 3.0, 8.0, 1.0, 5.0, 10.0, 3.0],
  [7.0, 6.0, 4.0, 8.0, 10.0, 10.0, 9.0, 5.0, 3.0],
  [5.0, 4.0, 6.0, 7.0, 9.0, 7.0, 8.0, 10.0, 1.0],
  [10.0, 10.0, 10.0, 8.0, 6.0, 1.0, 8.0, 9.0, 1.0],
  [1.0, 5.0, 8.0, 6.0, 5.0, 8.0, 7.0, 10.0, 1.0],
  [10.0, 10.0, 10.0, 1.0, 6.0, 1.0, 2.0, 8.0, 1.0],
  [8.0, 8.0, 9.0, 4.0, 5.0, 10.0, 7.0, 8.0, 1.0],
  [10.0, 7.0, 7.0, 4.0, 5.0, 10.0, 5.0, 7.0, 2.0],
  [5.0, 3.0, 3.0, 3.0, 6.0, 10.0, 3.0, 1.0, 1.0],
  [8.0, 10.0, 10.0, 7.0, 10.0, 10.0, 7.0, 3.0, 8.0],
  [10.0, 8.0, 8.0, 4.0, 10.0, 10.0, 8.0, 1.0, 1.0],
  [9.0, 8.0, 8.0, 5.0, 6.0, 2.0, 4.0, 10.0, 4.0],
  [8.0, 7.0, 8.0, 5.0, 5.0, 10.0, 9.0, 10.0, 1.0],
  [2.0, 5.0, 7.0, 6.0, 4.0, 10.0, 7.0, 6.0, 1.0],
  [5.0, 10.0, 8.0, 10.0, 8.0, 10.0, 3.0, 6.0, 3.0],
  [8.0, 10.0, 10.0, 8.0, 6.0, 9.0, 3.0, 10.0, 10.0],
  [8.0, 10.0, 8.0, 8.0, 4.0, 8.0, 7.0, 7.0, 1.0],
  [8.0, 3.0, 8.0, 3.0, 4.0, 9.0, 8.0, 9.0, 8.0],
  [4.0, 1.0, 1.0, 3.0, 1.0, 5.0, 2.0, 1.0, 1.0],
  [7.0, 4.0, 7.0, 4.0, 3.0, 7.0, 7.0, 6.0, 1.0],
  [4.0, 5.0, 5.0, 8.0, 6.0, 10.0, 10.0, 7.0, 1.0],
  [10.0, 5.0, 10.0, 3.0, 5.0, 8.0, 7.0, 8.0, 3.0],
  [7.0, 5.0, 10.0, 10.0, 10.0, 10.0, 4.0, 10.0, 3.0],
  [9.0, 4.0, 5.0, 10.0, 6.0, 10.0, 4.0, 8.0, 1.0],
  [10.0, 8.0, 8.0, 2.0, 3.0, 4.0, 8.0, 7.0, 8.0],
```

Now we create a function that applies the K-Nearest Neighbors algorithm to our dataframe and run it on our training set, it outputs the number of clusters we have, in this case, Malignant and Benign.

In [4]:
```
def knn(data, predict, k=3):
    distances = []
    for group in data:
        for features in data[group]:
            euclidean_distance = np.linalg.norm(np.array(features)-np.array(pr
            distances.append([euclidean_distance,group])
    votes = [i[1] for i in sorted(distances)[:k]]

    vote_result = Counter(votes).most_common(1)[0][0]
    return vote_result    # 2,4
new_pt = [4,1,4,1,2,1,1,1,1]

knn(train_set,new_pt,500)
```

Out[4]: 2

Now, we apply the algorithm on the test set and we check for a confusion matrix styled efficiency calculation.

In [5]:
```
#test_set = {2:[ [7,8,8,7,3,10,7,2,3]] , 4:[[7,8,8,7,3,10,7,2,3]]}
correct=0
total =0

for i  in test_set:#4
    for pt in test_set[i]:
        pr = knn(train_set,pt,200)
        if (pr == i):
            correct +=1
        total +=1
```

Now we print the predicted result and the actual diagnosis side by side with the features of the data set, the "vote" variable is the prediction and the "group" is the actual result. Here, we calculate and print accuracy, which is the no. of correct results divided by total.

In [6]:
```
correct = 0
total=0
for group in test_set:
    for data in test_set[group]:
        print(group,end='->')
        print(data,end='->')
        vote = knn(train_set, data, k=6)
        print(vote)

        if group == vote:
            correct += 1
        total += 1
print('Accuracy:', (correct/total)*100)
```

```
2->[5.0, 1.0, 1.0, 1.0, 2.0, 1.0, 1.0, 1.0, 1.0]->2
2->[5.0, 3.0, 6.0, 1.0, 2.0, 1.0, 1.0, 1.0, 1.0]->2
2->[5.0, 1.0, 1.0, 1.0, 2.0, 1.0, 1.0, 1.0, 1.0]->2
2->[5.0, 3.0, 1.0, 2.0, 2.0, 1.0, 2.0, 1.0, 1.0]->2
2->[4.0, 1.0, 1.0, 2.0, 2.0, 1.0, 2.0, 1.0, 1.0]->2
2->[3.0, 1.0, 1.0, 1.0, 2.0, 1.0, 2.0, 1.0, 1.0]->2
2->[3.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0]->2
2->[5.0, 1.0, 1.0, 1.0, 2.0, 1.0, 2.0, 2.0, 1.0]->2
2->[1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 2.0, 1.0, 1.0]->2
2->[3.0, 1.0, 1.0, 1.0, 2.0, 1.0, 2.0, 1.0, 1.0]->2
```

```
2->[2.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0]->2
2->[5.0, 1.0, 1.0, 1.0, 2.0, 1.0, 3.0, 1.0, 2.0]->2
2->[3.0, 1.0, 1.0, 1.0, 2.0, 1.0, 1.0, 1.0, 1.0]->2
2->[5.0, 1.0, 2.0, 1.0, 2.0, 1.0, 1.0, 1.0, 1.0]->2
2->[1.0, 2.0, 3.0, 1.0, 2.0, 1.0, 2.0, 1.0, 1.0]->2
2->[4.0, 1.0, 1.0, 1.0, 2.0, 1.0, 3.0, 1.0, 1.0]->2
2->[1.0, 1.0, 1.0, 1.0, 2.0, 1.0, 2.0, 1.0, 1.0]->2
2->[2.0, 3.0, 1.0, 1.0, 5.0, 1.0, 1.0, 1.0, 1.0]->2
2->[4.0, 2.0, 1.0, 1.0, 2.0, 1.0, 1.0, 1.0, 1.0]->2
2->[6.0, 3.0, 3.0, 5.0, 3.0, 10.0, 3.0, 5.0, 3.0]->4
2->[3.0, 3.0, 2.0, 1.0, 3.0, 1.0, 3.0, 6.0, 1.0]->2
2->[1.0, 1.0, 1.0, 1.0, 2.0, 1.0, 1.0, 1.0, 1.0]->2
2->[3.0, 1.0, 1.0, 1.0, 2.0, 1.0, 1.0, 1.0, 1.0]->2
2->[3.0, 1.0, 1.0, 1.0, 2.0, 2.0, 3.0, 1.0, 1.0]->2
2->[1.0, 2.0, 2.0, 1.0, 2.0, 1.0, 1.0, 1.0, 1.0]->2
2->[4.0, 2.0, 1.0, 1.0, 2.0, 1.0, 2.0, 1.0, 1.0]->2
2->[5.0, 1.0, 1.0, 1.0, 2.0, 1.0, 1.0, 1.0, 1.0]->2
2->[3.0, 1.0, 1.0, 1.0, 2.0, 1.0, 2.0, 1.0, 1.0]->2
2->[1.0, 1.0, 1.0, 3.0, 2.0, 3.0, 1.0, 1.0, 1.0]->2
2->[5.0, 1.0, 1.0, 6.0, 3.0, 1.0, 2.0, 1.0, 1.0]->2
2->[1.0, 1.0, 1.0, 1.0, 2.0, 4.0, 1.0, 1.0, 1.0]->2
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2->[3.0, 4.0, 5.0, 3.0, 7.0, 3.0, 4.0, 6.0, 1.0]->2
2->[2.0, 1.0, 1.0, 1.0, 2.0, 1.0, 1.0, 1.0, 1.0]->2
2->[8.0, 2.0, 1.0, 1.0, 5.0, 1.0, 1.0, 1.0, 1.0]->2
2->[5.0, 1.0, 1.0, 1.0, 3.0, 2.0, 2.0, 2.0, 1.0]->2
2->[1.0, 1.0, 1.0, 3.0, 2.0, 1.0, 1.0, 1.0, 1.0]->2
2->[1.0, 1.0, 1.0, 1.0, 2.0, 1.0, 1.0, 1.0, 8.0]->2
2->[5.0, 1.0, 1.0, 1.0, 2.0, 1.0, 1.0, 1.0, 1.0]->2
2->[1.0, 1.0, 1.0, 2.0, 1.0, 1.0, 1.0, 1.0, 1.0]->2
2->[1.0, 1.0, 3.0, 1.0, 2.0, -99999.0, 2.0, 1.0, 1.0]->2
2->[1.0, 1.0, 1.0, 1.0, 2.0, 1.0, 3.0, 1.0, 1.0]->2
2->[2.0, 1.0, 1.0, 2.0, 3.0, 1.0, 2.0, 1.0, 1.0]->2
2->[1.0, 1.0, 1.0, 1.0, 2.0, 5.0, 1.0, 1.0, 1.0]->2
2->[3.0, 1.0, 1.0, 1.0, 2.0, 1.0, 2.0, 1.0, 1.0]->2
2->[4.0, 1.0, 1.0, 1.0, 2.0, 1.0, 3.0, 1.0, 1.0]->2
2->[1.0, 1.0, 1.0, 1.0, 2.0, 1.0, 2.0, 3.0, 1.0]->2
2->[1.0, 1.0, 1.0, 1.0, 2.0, 1.0, 1.0, 1.0, 1.0]->2
2->[1.0, 1.0, 1.0, 1.0, 2.0, 1.0, 1.0, 1.0, 1.0]->2
2->[1.0, 1.0, 1.0, 1.0, 2.0, 1.0, 2.0, 1.0, 1.0]->2
2->[2.0, 1.0, 1.0, 1.0, 2.0, 1.0, 2.0, 2.0, 1.0]->2
2->[5.0, 1.0, 1.0, 1.0, 2.0, 1.0, 1.0, 1.0, 1.0]->2
2->[3.0, 1.0, 1.0, 1.0, 2.0, 1.0, 3.0, 1.0, 1.0]->2
2->[1.0, 1.0, 1.0, 1.0, 2.0, 1.0, 2.0, 1.0, 1.0]->2
2->[3.0, 1.0, 3.0, 1.0, 3.0, 4.0, 1.0, 1.0, 1.0]->2
2->[1.0, 1.0, 2.0, 1.0, 2.0, 1.0, 2.0, 1.0, 1.0]->2
2->[1.0, 1.0, 1.0, 1.0, 2.0, 1.0, 1.0, 1.0, 1.0]->2
2->[3.0, 1.0, 1.0, 1.0, 1.0, 1.0, 2.0, 1.0, 1.0]->2
2->[1.0, 1.0, 1.0, 1.0, 1.0, -99999.0, 2.0, 1.0, 1.0]->2
2->[1.0, 1.0, 1.0, 1.0, 2.0, 1.0, 1.0, 1.0, 1.0]->2
2->[2.0, 2.0, 2.0, 1.0, 1.0, 1.0, 7.0, 1.0, 1.0]->2
2->[6.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0]->2
2->[1.0, 1.0, 1.0, 1.0, 2.0, 1.0, 1.0, 1.0, 1.0]->2
2->[2.0, 1.0, 1.0, 1.0, 2.0, 1.0, 1.0, 1.0, 1.0]->2
2->[6.0, 1.0, 3.0, 1.0, 2.0, 1.0, 3.0, 1.0, 1.0]->2
2->[3.0, 1.0, 1.0, 1.0, 2.0, 1.0, 2.0, 1.0, 2.0]->2
2->[3.0, 1.0, 1.0, 1.0, 2.0, 1.0, 3.0, 1.0, 1.0]->2
2->[3.0, 1.0, 1.0, 1.0, 2.0, 3.0, 3.0, 1.0, 1.0]->2
2->[1.0, 1.0, 1.0, 1.0, 2.0, 1.0, 2.0, 1.0, 1.0]->2
2->[2.0, 1.0, 1.0, 1.0, 3.0, 1.0, 2.0, 1.0, 1.0]->2
2->[4.0, 1.0, 1.0, 1.0, 2.0, 1.0, 2.0, 1.0, 1.0]->2
2->[1.0, 1.0, 1.0, 1.0, 2.0, 1.0, 2.0, 1.0, 1.0]->2
2->[1.0, 1.0, 1.0, 1.0, 3.0, 1.0, 1.0, 1.0, 1.0]->2
2->[2.0, 1.0, 1.0, 1.0, 2.0, 1.0, 1.0, 1.0, 1.0]->2
2->[3.0, 1.0, 3.0, 1.0, 2.0, -99999.0, 2.0, 1.0, 1.0]->2
```

```
2->[1.0, 1.0, 4.0, 1.0, 2.0, 1.0, 2.0, 1.0, 1.0]->2
2->[1.0, 2.0, 2.0, 1.0, 2.0, 1.0, 2.0, 1.0, 1.0]->2
2->[1.0, 1.0, 1.0, 1.0, 5.0, 1.0, 3.0, 1.0, 1.0]->2
2->[4.0, 1.0, 1.0, 1.0, 2.0, 1.0, 3.0, 6.0, 1.0]->2
2->[5.0, 1.0, 1.0, 3.0, 2.0, 1.0, 1.0, 1.0, 1.0]->2
2->[5.0, 2.0, 4.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0]->2
2->[2.0, 1.0, 1.0, 1.0, 2.0, 1.0, 3.0, 1.0, 1.0]->2
2->[1.0, 1.0, 1.0, 1.0, 2.0, 1.0, 3.0, 1.0, 1.0]->2
2->[5.0, 2.0, 2.0, 2.0, 3.0, 1.0, 1.0, 3.0, 1.0]->2
2->[4.0, 1.0, 1.0, 1.0, 2.0, 3.0, 1.0, 1.0, 1.0]->2
2->[1.0, 1.0, 1.0, 1.0, 2.0, 1.0, 1.0, 1.0, 1.0]->2
2->[2.0, 3.0, 1.0, 1.0, 3.0, 1.0, 1.0, 1.0, 1.0]->2
2->[4.0, 1.0, 1.0, 1.0, 2.0, 1.0, 1.0, 1.0, 1.0]->2
2->[1.0, 1.0, 1.0, 1.0, 2.0, 1.0, 1.0, 1.0, 1.0]->2
2->[3.0, 1.0, 1.0, 1.0, 1.0, 1.0, 2.0, 1.0, 1.0]->2
2->[5.0, 1.0, 1.0, 1.0, 2.0, 1.0, 3.0, 1.0, 1.0]->2
2->[2.0, 1.0, 1.0, 1.0, 1.0, 1.0, 3.0, 1.0, 1.0]->2
2->[1.0, 2.0, 3.0, 1.0, 2.0, 1.0, 1.0, 1.0, 1.0]->2
4->[10.0, 6.0, 4.0, 3.0, 10.0, 10.0, 9.0, 10.0, 1.0]->4
4->[5.0, 6.0, 5.0, 6.0, 10.0, 1.0, 3.0, 1.0, 1.0]->4
4->[4.0, 6.0, 6.0, 5.0, 7.0, 6.0, 7.0, 7.0, 3.0]->4
4->[10.0, 9.0, 7.0, 3.0, 4.0, 2.0, 7.0, 7.0, 1.0]->4
4->[5.0, 8.0, 7.0, 7.0, 10.0, 10.0, 5.0, 7.0, 1.0]->4
4->[7.0, 4.0, 5.0, 10.0, 2.0, 10.0, 3.0, 8.0, 2.0]->4
4->[10.0, 6.0, 5.0, 8.0, 5.0, 10.0, 8.0, 6.0, 1.0]->4
4->[10.0, 10.0, 10.0, 7.0, 10.0, 10.0, 8.0, 2.0, 1.0]->4
4->[5.0, 10.0, 10.0, 10.0, 4.0, 10.0, 5.0, 6.0, 3.0]->4
4->[3.0, 6.0, 4.0, 10.0, 3.0, 3.0, 3.0, 4.0, 1.0]->4
4->[9.0, 5.0, 5.0, 2.0, 2.0, 2.0, 5.0, 1.0, 1.0]->2
4->[3.0, 4.0, 5.0, 2.0, 6.0, 8.0, 4.0, 1.0, 1.0]->4
4->[6.0, 10.0, 5.0, 5.0, 4.0, 10.0, 6.0, 10.0, 1.0]->4
4->[6.0, 5.0, 4.0, 4.0, 3.0, 9.0, 7.0, 8.0, 3.0]->4
4->[5.0, 10.0, 10.0, 8.0, 5.0, 5.0, 7.0, 10.0, 1.0]->4
4->[6.0, 6.0, 7.0, 10.0, 3.0, 10.0, 8.0, 10.0, 2.0]->4
4->[10.0, 6.0, 6.0, 3.0, 4.0, 5.0, 3.0, 6.0, 1.0]->4
4->[6.0, 10.0, 10.0, 2.0, 8.0, 10.0, 7.0, 3.0, 3.0]->4
4->[9.0, 10.0, 10.0, 1.0, 10.0, 8.0, 3.0, 3.0, 1.0]->4
4->[10.0, 3.0, 4.0, 5.0, 3.0, 10.0, 4.0, 1.0, 1.0]->4
4->[5.0, 10.0, 10.0, 3.0, 8.0, 1.0, 5.0, 10.0, 3.0]->4
4->[7.0, 6.0, 4.0, 8.0, 10.0, 10.0, 9.0, 5.0, 3.0]->4
4->[5.0, 4.0, 6.0, 7.0, 9.0, 7.0, 8.0, 10.0, 1.0]->4
4->[10.0, 10.0, 10.0, 8.0, 6.0, 1.0, 8.0, 9.0, 1.0]->4
4->[1.0, 5.0, 8.0, 6.0, 5.0, 8.0, 7.0, 10.0, 1.0]->4
4->[10.0, 10.0, 10.0, 1.0, 6.0, 1.0, 2.0, 8.0, 1.0]->4
4->[8.0, 8.0, 9.0, 4.0, 5.0, 10.0, 7.0, 8.0, 1.0]->4
4->[10.0, 7.0, 7.0, 4.0, 5.0, 10.0, 5.0, 7.0, 2.0]->4
4->[5.0, 3.0, 3.0, 3.0, 6.0, 10.0, 3.0, 1.0, 1.0]->4
4->[8.0, 10.0, 10.0, 7.0, 10.0, 10.0, 7.0, 3.0, 8.0]->4
4->[10.0, 8.0, 8.0, 4.0, 10.0, 10.0, 8.0, 1.0, 1.0]->4
4->[9.0, 8.0, 8.0, 5.0, 6.0, 2.0, 4.0, 10.0, 4.0]->4
4->[8.0, 7.0, 8.0, 5.0, 5.0, 10.0, 9.0, 10.0, 1.0]->4
4->[2.0, 5.0, 7.0, 6.0, 4.0, 10.0, 7.0, 6.0, 1.0]->4
4->[5.0, 10.0, 8.0, 10.0, 8.0, 10.0, 3.0, 6.0, 3.0]->4
4->[8.0, 10.0, 10.0, 8.0, 6.0, 9.0, 3.0, 10.0, 10.0]->4
4->[8.0, 10.0, 8.0, 8.0, 4.0, 8.0, 7.0, 7.0, 1.0]->4
4->[8.0, 3.0, 8.0, 3.0, 4.0, 9.0, 8.0, 9.0, 8.0]->4
4->[4.0, 1.0, 1.0, 3.0, 1.0, 5.0, 2.0, 1.0, 1.0]->2
4->[7.0, 4.0, 7.0, 4.0, 3.0, 7.0, 7.0, 6.0, 1.0]->4
4->[4.0, 5.0, 5.0, 8.0, 6.0, 10.0, 10.0, 7.0, 1.0]->4
4->[10.0, 5.0, 10.0, 3.0, 5.0, 8.0, 7.0, 8.0, 3.0]->4
4->[7.0, 5.0, 10.0, 10.0, 10.0, 10.0, 4.0, 10.0, 3.0]->4
4->[9.0, 4.0, 5.0, 10.0, 6.0, 10.0, 4.0, 8.0, 1.0]->4
4->[10.0, 8.0, 8.0, 2.0, 3.0, 4.0, 8.0, 7.0, 8.0]->4
4->[3.0, 10.0, 8.0, 7.0, 6.0, 9.0, 9.0, 3.0, 8.0]->4
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Thus we can conclude that KNN produces an accuracy of 97.8%