a2_2018201036

February 2, 2019

```
In [1]: import pandas as pd
        from sklearn import neighbors
        import numpy as np
        from collections import Counter
        import matplotlib.pyplot as plt
        from matplotlib.colors import ListedColormap
        from sklearn.metrics import precision_recall_fscore_support
        from sklearn.metrics import accuracy_score
        from sklearn.model_selection import cross_val_score
        from sklearn.model_selection import KFold
```

0.0.1 Part 1

```
In [2]: train_df_1 = pd.read_csv('RobotDataset/Robot1',delimiter=' ', header=None, names = ['cla
        train_df_2 = pd.read_csv('RobotDataset/Robot2',delimiter=' ', header=None, names = ['cla
        train_df_3 = pd.read_csv('Iris/Iris.csv', header=None, names = ['sl', 'sw', 'pl', 'pw',

In [3]: train_df_1 = train_df_1.drop('id', axis=1)
        train_df_2 = train_df_2.drop('id', axis=1)
        #train_df_3 = train_df_3.drop('id', axis=1)

In [4]: # probs = np.random.rand(len(train_df_1))
        # training_mask = probs <= 0.8
        # validation_mask = probs > 0.8
        # train_1 =  train_df_1[training_mask]
        # val_1 = train_df_1[validation_mask]
        X_train_1, Y_train_1 = train_df_1.drop(['class'], axis = 1), train_df_1['class']
        # X_val_1, Y_val_1 = val_1.drop(['id', 'class'], axis=1), val_1['class']

In [5]: # probs = np.random.rand(len(train_df_1))
        # training_mask = probs <= 0.8
        # validation_mask = probs > 0.8
        # train_2 =  train_df_2[training_mask]
        # val_2 = train_df_2[validation_mask]
        X_train_2, Y_train_2 = train_df_2.drop(['class'], axis = 1), train_df_2['class']
        # X_val_2, Y_val_2 = val_1.drop(['id', 'class'], axis=1), val_1['class']

In [6]: # probs = np.random.rand(len(train_df_1))
        # training_mask = probs <= 0.8
```

```
# validation_mask = probs > 0.8
# train_3 =  train_df_3[training_mask]
# val_3 = train_df_3[validation_mask]
X_train_3, Y_train_3 = train_df_3.drop('class', axis = 1), train_df_3['class']
# X_val_3, Y_val_3 = val_3.drop('class', axis=1), val_3['class']
```

In [7]:
```
clf = neighbors.KNeighborsClassifier(n_neighbors=3, algorithm='brute', metric = 'euclide
clf.fit(X_train_1, Y_train_1)
```

Out[7]:
```
KNeighborsClassifier(algorithm='brute', leaf_size=30, metric='euclidean',
           metric_params=None, n_jobs=None, n_neighbors=3, p=2,
           weights='uniform')
```

In [8]:
```
class  knearestneighbors:
    def __init__(self, k=1, metric='euclidean'):
        self.k = k
        self.metric = metric
    def fit(self, X_train, Y_train, X_val):
        #self.k = kwargs['k']
        #self.metric = kwargs['metric']
        ans = [0]*len(X_val)
        for i in range(len(X_val)):
            lst = []
            for j in range(len(X_train)):
                s = 0.0
                #print(X_val.iloc[i,:])
                #print(X_train.iloc[j,:])
                #print()
                if self.metric == 'euclidean':
                    s = np.sum(np.square(np.subtract(X_val.iloc[i,:], X_train.iloc[j,:])
                elif self.metric == 'minkowski':
                    s = (np.sum((np.subtract(val.iloc[i,:], X_train.iloc[j,:]))**len(X_t
                #print(s)
                lst.append((s,Y_train.iloc[j]))
            lst = sorted(lst)
            #print(lst)
            trg = []
            for f in range(self.k):
                trg.append(lst[f][1])
            #print(i)
            #print(self.k)
            ans[i] = Counter(trg).most_common(1)[0][0]
            #print()
        return ans
    def predict(self, X_train, Y_train, X_val):
        ans = [0]*len(X_val)
        for i in range(len(X_val)):
            lst = []
```

```
                for j in range(len(X_train)):
                    s = 0.0
                    #print(X_val.iloc[i,:])
                    #print(X_train.iloc[j,:])
                    #print()
                    if self.metric == 'euclidean':
                        s = np.sum(np.square(np.subtract(X_val.iloc[i,:], X_train.iloc[j,:])
                    elif self.metric == 'minkowski':
                        s = (np.sum((np.subtract(val.iloc[i,:], X_train.iloc[j,:]))**len(X_t
                    #print(s)
                    lst.append((s,Y_train.iloc[j]))
                lst = sorted(lst)
                trg = []
                for f in range(self.k):
                    trg.append(lst[f][1])
                ans[i] = Counter(trg).most_common(1)[0][0]
                #print()
            return ans
```

```
In [9]: def k_fold_cross_val(X_train,Y_train, clf, k_fold=10):
            kf = KFold(n_splits=k_fold, shuffle=True)
            accuracy = []
            recall = []
            precision = []
            f1 = []
            for train, test in kf.split(X_train):
                #print(test)
                #X_train, Y_train = train.drop('class', axis = 1), train['class']
                Xtrain, Xtest = X_train.iloc[train], X_train.iloc[test]
                Ytrain, Ytest = Y_train.iloc[train], Y_train.iloc[test]
                ans = clf.fit(Xtrain, Ytrain, Xtest)
                accuracy.append(accuracy_score(Ytest, ans))
                res = precision_recall_fscore_support(Ytest, ans, average='weighted')
                precision.append(res[0])
                recall.append(res[1])
                f1.append(res[2])
            return sum(accuracy)/len(accuracy), sum(precision)/len(precision), sum(recall)/len(r
```

Question1: Implement a KNN classifier for each of the datasets. Report precision, recall, f1 score and accuracy. Compare your result with in-built(scikit-learn) KNN function to check correctness of your algorithm.

```
In [10]: clf1_me = knearestneighbors(k=3, metric='euclidean')
         #clf1_sk = neighbors.KNeighborsClassifier(n_neighbors=3, algorithm='brute', metric = 'e
```

```
In [11]: clf_sk = neighbors.KNeighborsClassifier(n_neighbors=3, algorithm='brute', metric = 'euc
         clf_sk.fit(X_train_1, Y_train_1)
```

```
Out[11]: KNeighborsClassifier(algorithm='brute', leaf_size=30, metric='euclidean',
                    metric_params=None, n_jobs=None, n_neighbors=3, p=2,
                    weights='uniform')
```

```
In [12]: acc_me, pre_me, re_me, f1_me = k_fold_cross_val(X_train_1, Y_train_1, clf1_me)
         acc_sk, pre_sk, re_sk, f1_sk = cross_val_score(clf, X_train_1, Y_train_1, cv=10, scorin
```

```
In [13]: print("                        My Classifier                        Sklearn Classifier")
         print("accuracy score:       {0}                  {1}".format(acc_me, acc_sk))
         print("precision score:      {0}                  {1}".format(pre_me, pre_sk))
         print("recall score:         {0}                  {1}".format(re_me, re_sk))
         print("f1 score:             {0}                  {1}".format(f1_me, f1_sk))
```

```
                        My Classifier                      Sklearn Classifier
accuracy score:       0.7352564102564103                 0.6392857142857142
precision score:      0.7623720029970029                 0.6921338383838384
recall score:         0.7352564102564103                 0.6392857142857142
f1 score:             0.7252285945049104                 0.6100351480305041
```

```
In [14]: acc_me, pre_me, re_me, f1_me = k_fold_cross_val(X_train_2, Y_train_2, clf1_me)
         acc_sk, pre_sk, re_sk, f1_sk = cross_val_score(clf, X_train_2, Y_train_2, cv=10, scorin
```

```
In [15]: print("                        My Classifier                        Sklearn Classifier")
         print("accuracy score:       {0}                  {1}".format(acc_me, acc_sk))
         print("precision score:      {0}                  {1}".format(pre_me, pre_sk))
         print("recall score:         {0}                  {1}".format(re_me, re_sk))
         print("f1 score:             {0}                  {1}".format(f1_me, f1_sk))
```

```
                        My Classifier                      Sklearn Classifier
accuracy score:       0.8294871794871794                 0.8461538461538461
precision score:      0.8649760887260888                 0.8790842490842492
recall score:         0.8294871794871794                 0.8461538461538461
f1 score:             0.8240336284086283                 0.8407725607725608
```

```
In [16]: acc_me, pre_me, re_me, f1_me = k_fold_cross_val(X_train_3, Y_train_3, clf1_me)
         acc_sk, pre_sk, re_sk, f1_sk = cross_val_score(clf, X_train_3, Y_train_3, cv=10, scorin
```

```
In [17]: print("                        My Classifier                        Sklearn Classifier")
         print("accuracy score:       {0}                  {1}".format(acc_me, acc_sk))
         print("precision score:      {0}                  {1}".format(pre_me, pre_sk))
         print("recall score:         {0}                  {1}".format(re_me, re_sk))
         print("f1 score:             {0}                  {1}".format(f1_me, f1_sk))
```

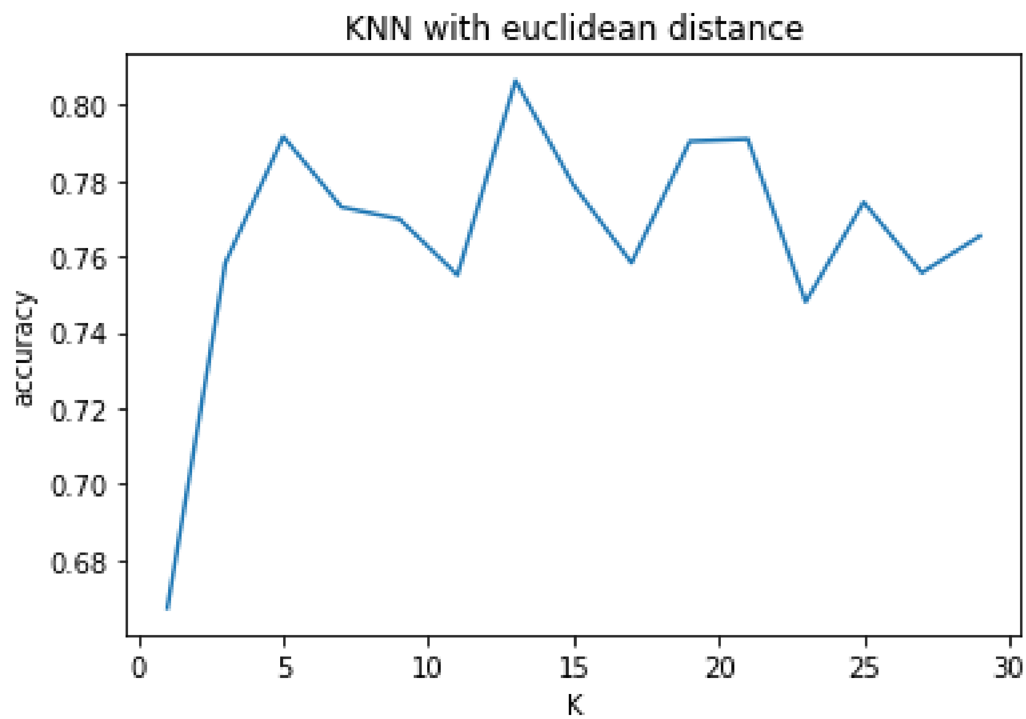
```
                        My Classifier                      Sklearn Classifier
accuracy score:       0.9626373626373628                 0.9566666666666667
precision score:      0.9711538461538461                 0.9676190476190476
recall score:         0.9626373626373628                 0.9566666666666667
f1 score:             0.9626047629021126                 0.9552910052910054
```

```
In [18]: #clf1_me.predict(X_train_1, Y_train_1, X_test_1)
```

Question 2: Use different distance measures as applicable. Plot graph to report accuracy with change in value of K. Also suggest possible reason for better performance.

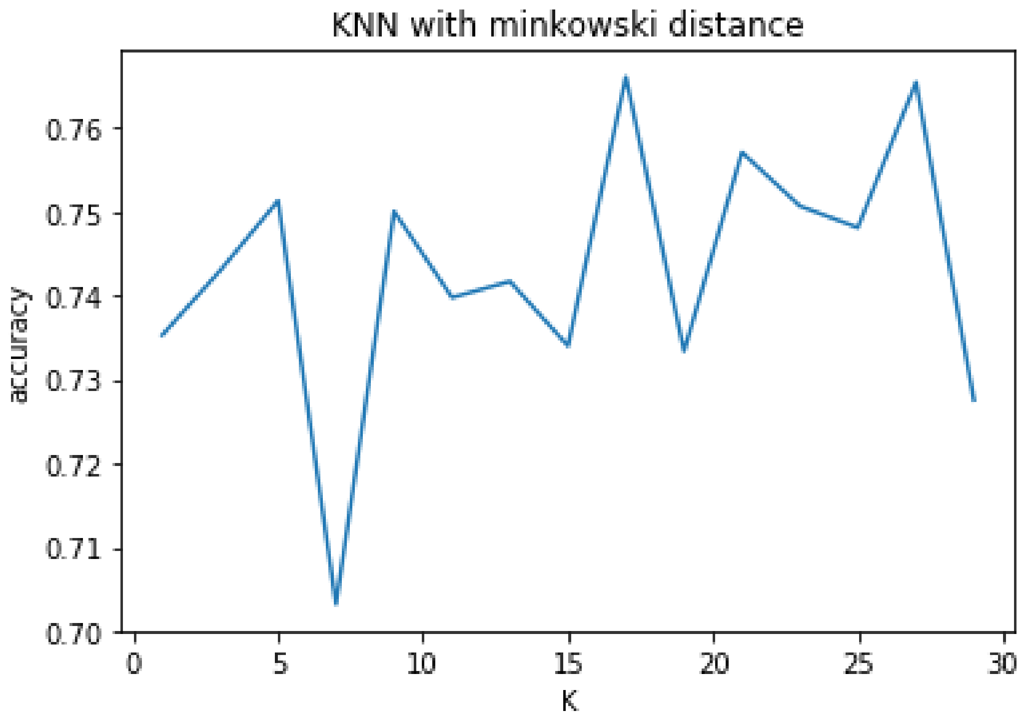
In [19]:
```
acc_lst = []
for i in range(1,30,2):
    clf = knearestneighbors(k=i, metric='euclidean')
    acc_lst.append((i,k_fold_cross_val(X_train_1, Y_train_1, clf)[0]))
```

In [20]:
```
X_lst = []
Y_lst = []
for i in range(0,len(acc_lst)):
    X_lst.append(acc_lst[i][0])
    Y_lst.append(acc_lst[i][1])
#print(X_lst)
#print(Y_lst)
plt.plot(X_lst,Y_lst)
plt.xlabel("K")
plt.ylabel("accuracy")
plt.title('KNN with euclidean distance')
plt.show()
```



In [21]:
```
acc_lst = []
for i in range(1,30,2):
    clf = knearestneighbors(k=i, metric='minkowski')
    acc_lst.append((i,k_fold_cross_val(X_train_1, Y_train_1, clf1_me)[0]))
```

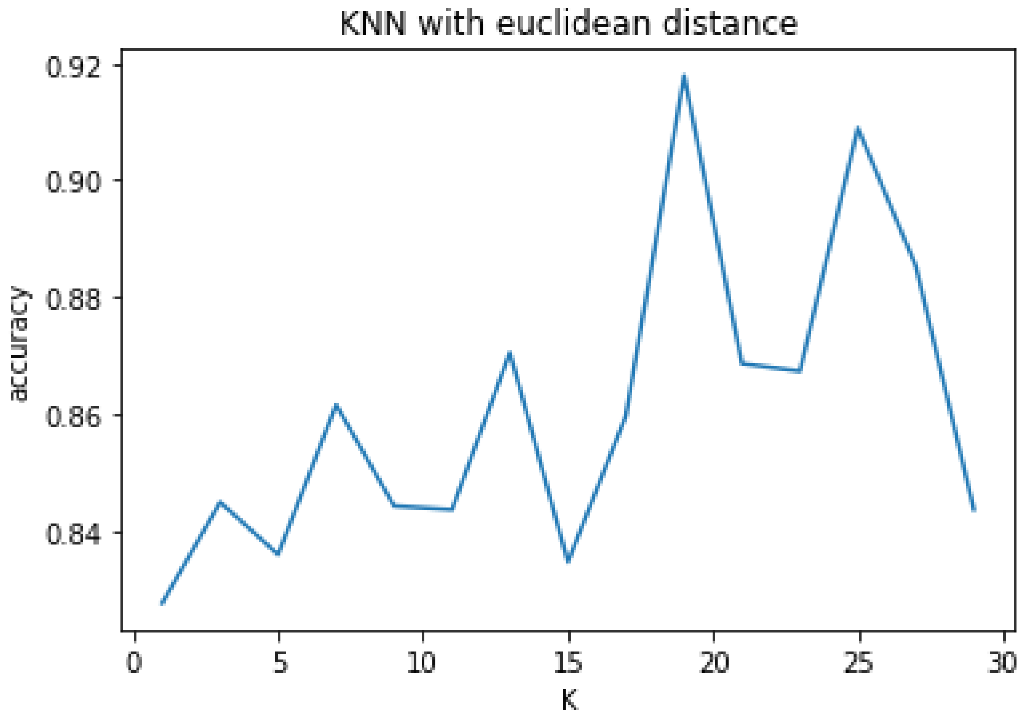
In [22]:
```
X_lst = []
Y_lst = []
for i in range(0,len(acc_lst)):
    X_lst.append(acc_lst[i][0])
    Y_lst.append(acc_lst[i][1])
#print(X_lst)
#print(Y_lst)
plt.plot(X_lst,Y_lst)
plt.xlabel("K")
plt.ylabel("accuracy")
plt.title('KNN with minkowski distance')
plt.show()
```



In [23]:
```
acc_lst = []
for i in range(1,30,2):
    clf = knearestneighbors(k=i, metric='euclidean')
    acc_lst.append((i,k_fold_cross_val(X_train_2, Y_train_2, clf)[0]))
```

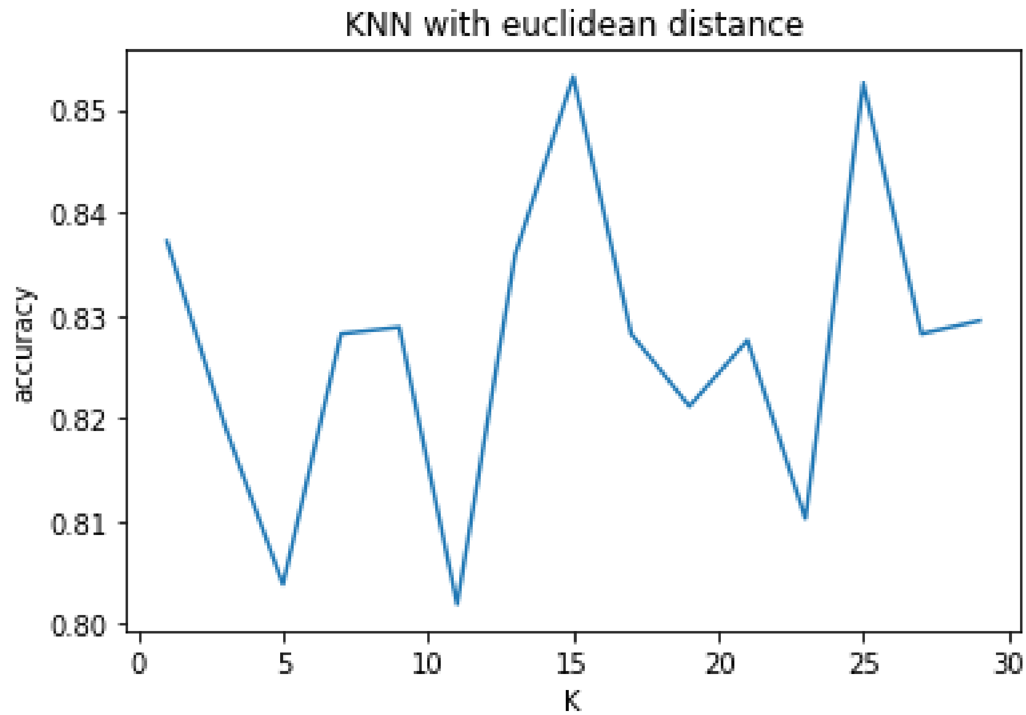
In [24]:
```
X_lst = []
Y_lst = []
for i in range(0,len(acc_lst)):
    X_lst.append(acc_lst[i][0])
    Y_lst.append(acc_lst[i][1])
#print(X_lst)
```

```
#print(Y_lst)
plt.plot(X_lst,Y_lst)
plt.xlabel("K")
plt.ylabel("accuracy")
plt.title('KNN with euclidean distance')
plt.show()
```




```
In [25]: acc_lst = []
         for i in range(1,30,2):
             clf = knearestneighbors(k=i, metric='euclidean')
             acc_lst.append((i,k_fold_cross_val(X_train_2, Y_train_2, clf1_me)[0]))
```

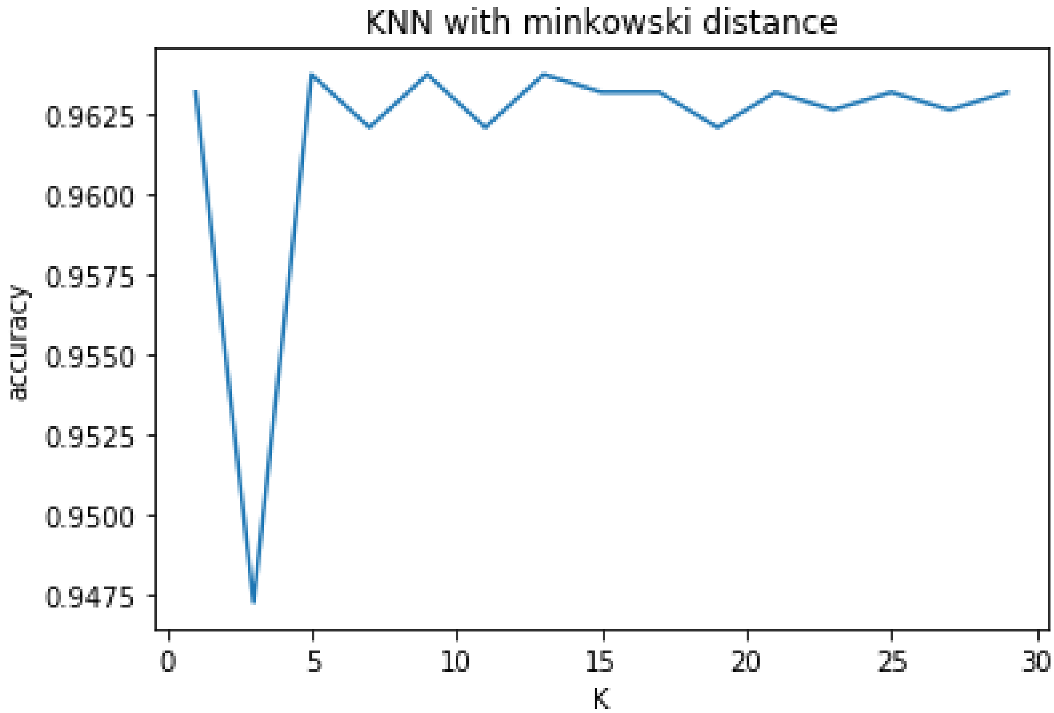
```
In [26]: X_lst = []
         Y_lst = []
         for i in range(0,len(acc_lst)):
             X_lst.append(acc_lst[i][0])
             Y_lst.append(acc_lst[i][1])
         #print(X_lst)
         #print(Y_lst)
         plt.plot(X_lst,Y_lst)
         plt.xlabel("K")
         plt.ylabel("accuracy")
         plt.title('KNN with euclidean distance')
         plt.show()
```




```
In [27]: acc_lst = []
         for i in range(1,30,2):
             clf = knearestneighbors(k=i, metric='minkowski')
             acc_lst.append((i,k_fold_cross_val(X_train_3, Y_train_3, clf1_me)[0]))
```

```
/home/neil/.local/lib/python3.6/site-packages/sklearn/metrics/classification.py:1145: UndefinedM
  'recall', 'true', average, warn_for)
```

```
In [28]: X_lst = []
         Y_lst = []
         for i in range(0,len(acc_lst)):
             X_lst.append(acc_lst[i][0])
             Y_lst.append(acc_lst[i][1])
         #print(X_lst)
         #print(Y_lst)
         plt.plot(X_lst,Y_lst)
         plt.xlabel("K")
         plt.ylabel("accuracy")
         plt.title('KNN with minkowski distance')
         plt.show()
```



Report The other distance measure in KNN algorith that I've used is minkowski's distance.
Apart from that the accuracy varies with the value of k and it doesn't show any increase in accuracy when k is increased. So we need to train for quite a few values of K and choose the K that has best accuracy.

1 Part 2:

A bank is implementing a system to identify potential customers who have higher probablity of availing loans to increase its profit. Implement Naive Bayes classifier on this dataset to help bank achieve its goal. Report your observations and accuracy of the model.

```
In [29]: train_df = pd.read_csv('LoanDataset/data.csv', header=None, names = ['id', 'age', 'expe

In [30]: mp = {x:i for x,i in zip(train_df['zip'].unique().tolist(),range(len(train_df['zip'].un

In [31]: train_df['zip'] = train_df['zip'].map(mp)

In [32]: train_df = train_df.drop('id', axis=1)

In [33]: from sklearn.model_selection import train_test_split
         X_train, X_test, Y_train, Y_test = train_test_split(train_df.drop('accepted loan', axis

In [34]: discrete = ['education', 'family size', 'security account', 'certificate of deposit', '
         continuous = ['age', 'experience', 'income', 'mortage']
```

In [35]:
```
class NaiveBayesClassifier:
    def __init__(self):
        self.mean_X_C_Y = 0
        self.mean_X_C_N = 0
        self.var_X_C_Y = 0
        self.var_X_C_N = 0
        self.priors = 0
        self.prob_Y = []
        self.prob_N = []
        self.discrete_map = {}
        self.l_X_train_Y = 0
        self.l_X_train_N = 0
        self.l_X_train = 0
        self.discrete = []
        self.continuous = []
    def fit(self, X_train, Y_train, discrete, continuous):
        self.discrete = discrete
        self.continuous = continuous
        self.mean_X_C_Y = X_train[continuous][Y_train==1].mean()
        self.mean_X_C_N = X_train[continuous][Y_train==0].mean()
        self.var_X_C_Y = X_train[continuous][Y_train==1].var()
        self.var_X_C_N = X_train[continuous][Y_train==0].var()
        self.priors = [Counter(Y_train).most_common()[0][1]/len(Y_train),Counter(Y_trai
        X_train_Y = X_train[Y_train == 1]
        X_train_N = X_train[Y_train == 0]
        self.l_X_train_Y = len(X_train_Y)
        self.l_X_train_N = len(X_train_N)
        self.l_X_train = len(X_train)
        for x in discrete:
            self.prob_Y.append(Counter(X_train_Y[x]))
            self.prob_N.append(Counter(X_train_N[x]))
        for i in range(len(self.prob_Y)):
            for key in self.prob_Y[i]:
                self.prob_Y[i][key]/=len(X_train_Y)
        for i in range(len(self.prob_N)):
            for key in self.prob_N[i]:
                self.prob_N[i][key]/=len(X_train_N)
        self.discrete_map = {x:i for x,i in zip(discrete, range(len(discrete)))}
    def likelihood(self, X, mean, variance):
        return (1 / np.sqrt(2 * np.pi * variance)) * np.exp((-(X - mean) ** 2) / (2 * v
    def predict(self, X_test):
        ans = []
        X_ts = X_test[self.discrete].to_dict('records')
        for i in range(len(X_test)):
            yn = (self.l_X_train_N/self.l_X_train) * np.prod([self.prob_N[self.discrete
            yy = (self.l_X_train_Y/self.l_X_train) * np.prod([self.prob_Y[self.discrete
            a = 0 if yn>yy else 1
            ans.append(a)
```

```
            return ans
```

```
In [36]: clf = NaiveBayesClassifier()
```

```
In [37]: clf.fit(X_train, Y_train, discrete, continuous)
```

```
In [38]: from sklearn.naive_bayes import GaussianNB
         gnb = GaussianNB()
         gnb.fit(X_train, Y_train)
```

```
Out[38]: GaussianNB(priors=None, var_smoothing=1e-09)
```

```
In [39]: acc_me = accuracy_score(clf.predict(X_test), Y_test)
         res = precision_recall_fscore_support(clf.predict(X_test), Y_test, average = 'binary')
         pre_me, re_me, f1_me = res[0], res[1], res[2]
```

```
In [40]: acc_sk = accuracy_score(gnb.predict(X_test), Y_test)
         res = precision_recall_fscore_support(gnb.predict(X_test), Y_test, average = 'binary')
         pre_sk, re_sk, f1_sk = res[0], res[1], res[2]
```

```
In [41]: print("                        My Classifier                         Sklearn Classifier")
         print("accuracy score:        {0}                  {1}".format(acc_me, acc_sk))
         print("precision score:       {0}                  {1}".format(pre_me, pre_sk))
         print("recall score:          {0}                  {1}".format(re_me, re_sk))
         print("f1 score:              {0}                  {1}".format(f1_me, f1_sk))
```

```
                        My Classifier                         Sklearn Classifier
accuracy score:        0.9022222222222223                  0.88
precision score:       0.4157303370786517                  0.5730337078651685
recall score:          0.5068493150684932                  0.4214876033057851
f1 score:              0.45679012345679015                  0.4857142857142857
```

Report: The probabilty of continous features has been found using Gaussian function and for discrete features I've found Conditional Probablity with respect to each output label for each class of the feature. To find the final probability I've used

$$\hat{y} = \underset{k \in \{1,..K\}}{\operatorname{argmax}} \; P(C_k) \prod_{i=1}^{m} p\left(x_i \mid C_k\right) \prod_{j=m}^{n} P\left(x_j \mid C_k\right) \;\; ?$$

1.1 Part 3:

We are given a dataset containing various criteria important to get admissions into Master's program and probablity of getting an admit

```
In [42]: train_df = pd.read_csv('AdmissionDataset/data.csv')
```

```
In [43]: from sklearn.model_selection import train_test_split
         X_train, X_val, Y_train, Y_val = train_test_split(train_df.drop(['Serial No.','Chance o
```

```
In [44]: class linear_regression:
             def __init__(self, alpha=0.1, iteration=1000, loss_func = "MSE"):
                 self.alpha = alpha
                 self.iterations = iteration
                 self.loss_func = loss_func
                 self.mean = 0
                 self.std = 0
                 self.m = 0
                 self.theta = []
             def fit(self,x_tr, y_tr):
                 self.m = x_tr.size
                 self.mean = x_tr.mean()
                 self.std = x_tr.std()
                 x_tr = (x_tr - self.mean)/self.std
                 theta = np.random.rand(len(x_tr.iloc[0])+1)
                 past_costs = []
                 past_thetas = [theta]
                 x = np.c_[np.ones(len(x_tr.iloc[:,0])),x_tr]
                 for i in range(self.iterations):
                     prediction = np.dot(x, theta.T)
                     #print(len(prediction) == len(x_tr))
                     error = prediction - y_tr
                     #print(error)
                     if self.loss_func == 'MSE':
                         cost = 1/(2*self.m) * np.dot(error.T, error)
                         past_costs.append(cost)
                         theta = theta - (self.alpha * (1/self.m) * np.dot(x.T, error))
                     elif self.loss_func == 'MAE':
                             cost = 1/(self.m)*np.sum(np.abs(error))
                             past_costs.append(cost)
                             theta = theta - (self.alpha * (1/self.m) *( np.dot(x.T, error/np.ab
                     elif self.loss_func == 'MAPE':
                         cost = 1/(self.m)*np.sum(np.abs(error)/y_tr)
                         past_costs.append(cost)
                         theta = theta - (self.alpha * (1/self.m) *( np.dot(x.T, error/(y_tr*np.
                     past_thetas.append(theta)
                     self.theta = past_thetas[-1]
                 return past_thetas, past_costs
             def predict(self, x_val):
                 x_val = (x_val - self.mean)/self.std
                 x = np.c_[np.ones(len(x_val.iloc[:,0])),x_val]
                 return np.dot(x, self.theta.T)
             #past_thetas, past_costs = gradient_descent(X_train_4, Y_train_4, theta, iterations
             #theta = past_thetas[-1]
             def mean_abs_error(self, y_pred, y_true):
                 return (1/len(y_pred))*np.sum(np.abs((y_pred-y_true)))
             def mean_square_error(self, y_pred, y_true):
                 return (1/(2*len(y_pred)))*np.sum(np.square((y_pred-y_true)))
```

```
        def mean_abs_per_error(self, y_pred, y_true):
            return (1/len(y_pred))*np.sum(np.abs((y_pred-y_true)/y_true))
```

```
In [45]: class linear_regression_normal:
             def __init__(self):
                 self.theta = []
                 self.mean = 0
                 self.std = 0
             def fit(self, x_tr, y_tr):
                 self.m = x_tr.size
                 self.mean = x_tr.mean()
                 self.std = x_tr.std()
                 x_tr = (x_tr - self.mean)/self.std
                 x = np.c_[np.ones(len(x_tr.iloc[:,0])),x_tr]
                 self.theta = np.dot(np.linalg.pinv(np.dot(x.T,x)),np.dot(x.T,y_tr))
             def predict(self, x_val):
                 x_val = (x_val - self.mean)/self.std
                 x = np.c_[np.ones(len(x_val.iloc[:,0])),x_val]
                 return np.dot(x, self.theta.T)
```

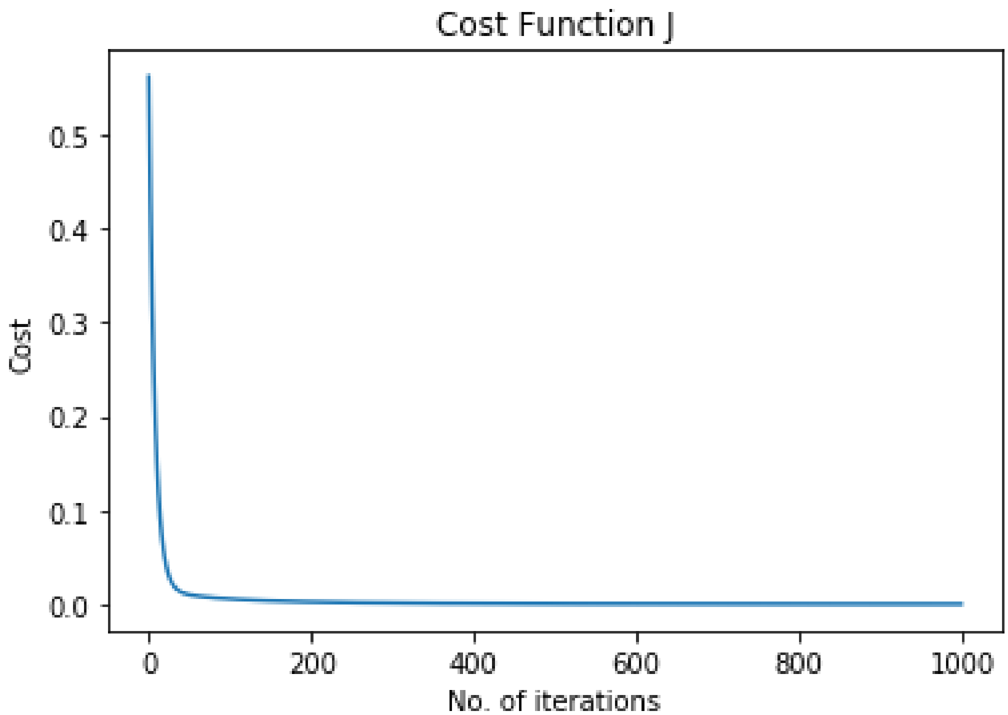
```
In [46]: clf = linear_regression(loss_func='MSE')
         clfne = linear_regression_normal()
```

```
In [47]: from sklearn.linear_model import LinearRegression
         reg = LinearRegression()
```

```
In [48]: past_thetas, past_costs = clf.fit(X_train, Y_train)
         clfne.fit(X_train, Y_train)
         reg.fit(X_train, Y_train)
```

```
Out[48]: LinearRegression(copy_X=True, fit_intercept=True, n_jobs=None,
                  normalize=False)
```

```
In [49]: plt.title('Cost Function J')
         plt.xlabel('No. of iterations')
         plt.ylabel('Cost')
         plt.plot(past_costs)
         plt.show()
```




```
In [50]: Y_pred_me = clf.predict(X_val)
         Y_pred_sk = reg.predict(X_val)
         Y_pred_ne = clfne.predict(X_val)
```

```
In [51]: from sklearn.metrics import r2_score
         r2_me = r2_score(Y_pred_me, Y_val)
         r2_sk = r2_score(Y_pred_sk, Y_val)
         r2_ne = r2_score(Y_pred_ne, Y_val)
         print("                    My Classifier            Sklearn Classifier      Normal Equati
         print("r2 score:          {0}          {1}          {2}".format(r2_me, r2_sk, r2_ne))
```

```
                  My Classifier           Sklearn Classifier      Normal Equation Classifier
r2 score:        0.7671539661923364        0.7830442802778002        0.7830442802777986
```

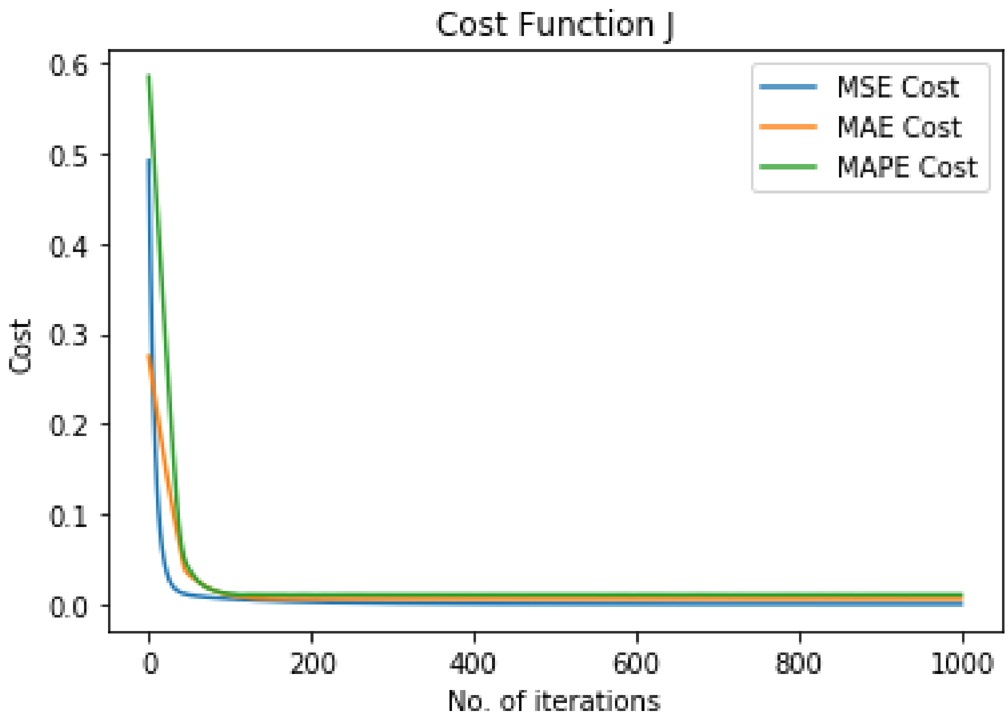
```
In [52]: #y_test = clf.predict(X_test)
```

Question 2: Compare the performance of Mean square error loss function vs Mean Absolute error function vs Mean absolute percentage error function and explain the reasons for the observed behaviour.

```
In [53]: clf1 = linear_regression(loss_func='MSE')
         clf2 = linear_regression(loss_func='MAE')
         clf3 = linear_regression(loss_func='MAPE')
```

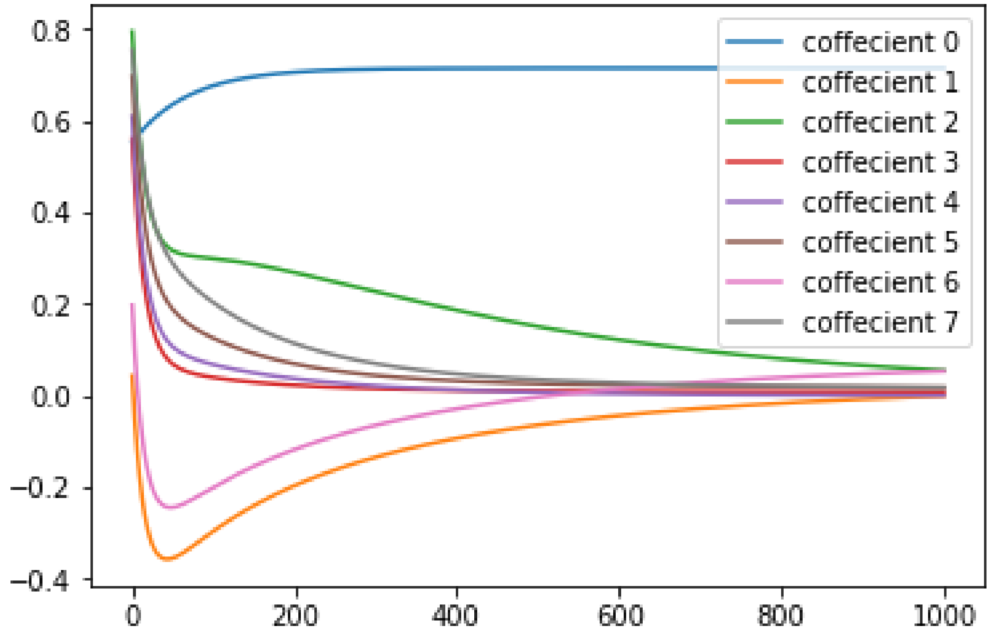
```
        _,pc1 = clf1.fit(X_train, Y_train)
        _,pc2 = clf2.fit(X_train, Y_train)
        _,pc3 = clf3.fit(X_train, Y_train)
        Y_pred_me1 = clf1.predict(X_val)
        Y_pred_me2 = clf2.predict(X_val)
        Y_pred_me3 = clf3.predict(X_val)
        mse_error = clf1.mean_square_error(Y_pred_me1, Y_val)
        mae_error = clf2.mean_abs_error(Y_pred_me2, Y_val)
        mape_error = clf3.mean_abs_per_error(Y_pred_me3, Y_val)
        print("Mean Square error:                {0}".format(mse_error))
        print("Mean absolute error:              {0}".format(mae_error))
        print("Mean absolute percentage error:   {0}".format(mape_error))
        print("                         MSE Classifier                   MAE Classifier
        print("r2 score:               {0}                  {1}           {2}".format(r2_score(Y_

Mean Square error:                0.0017756050372874277
Mean absolute error:              0.04038449062189775
Mean absolute percentage error:   0.06305757149591333
                         MSE Classifier                   MAE Classifier                 MAPE Cla
r2 score:               0.767635149506804               0.7632775874819664              0.72074560
```

```
In [54]: plt.title('Cost Function J')
         plt.plot(pc1, label='MSE Cost')
         plt.plot(pc2, label='MAE Cost')
         plt.plot(pc3, label='MAPE Cost')
         plt.xlabel('No. of iterations')
         plt.ylabel('Cost')
         plt.legend()
         plt.show()
```

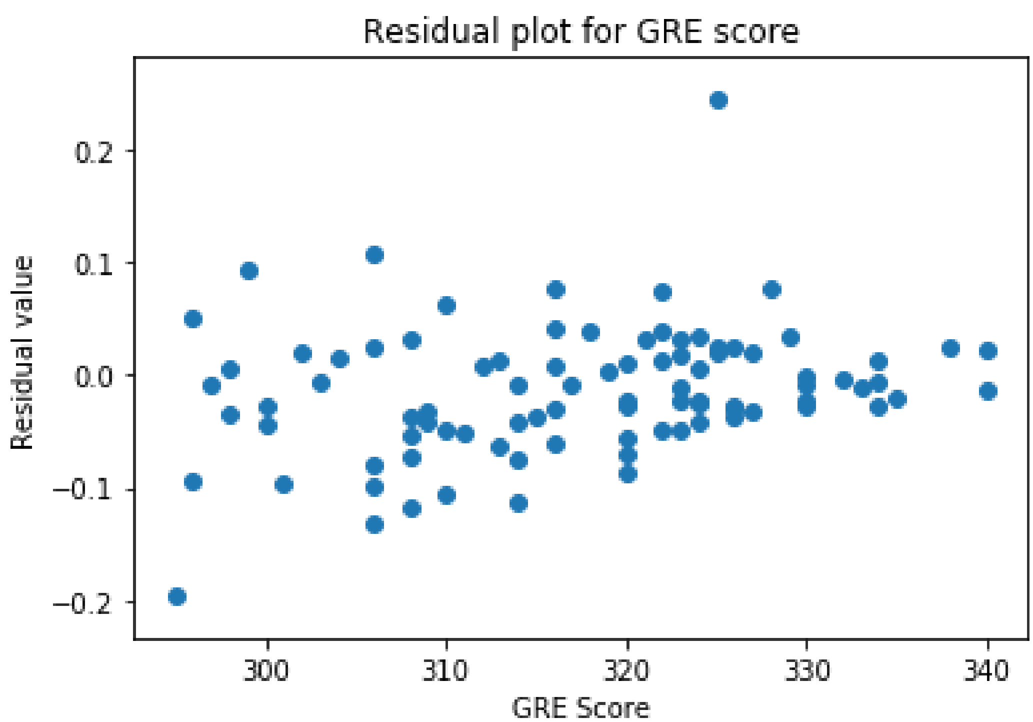


Question 3: Analyse and report the behaviour of the coefficients(for example: sign of coefficients, value of coefficients etc.) and support it with appropriate plots as neces- sary

```
In [55]: past_thtas = np.asarray(past_thetas).T
         for i in range(len(X_train.iloc[0])+1):
             plt.plot(past_thtas[i,:], label = 'coffecient '+str(i))
         plt.legend()
         plt.show()
         #past_thtas.shape
```



In [56]:
```
plt.scatter(X_val.iloc[:, 0], Y_pred_me1 - Y_val)
plt.ylabel("Residual value")
plt.xlabel("GRE Score")
plt.title("Residual plot for GRE score")
plt.show()
```



Report: It can be seen that the cofficients decreases with increase in iteration and finally get to a almost constant value

1.2 Part 4:

Use the Admission dataset as in the third question for logistic regression.

Question 1: Implement logistic regression model to predict if the student will get admit

```
In [104]: train_df = pd.read_csv('AdmissionDataset/data.csv')

In [105]: from sklearn.model_selection import train_test_split
          X_train, X_val, Y_train, Y_val = train_test_split(train_df.drop(['Serial No.','Chance

In [106]: class logistic_regression:
              def __init__(self, alpha=0.1, iteration=1000, threshold = 0.5):
                  self.alpha = alpha
                  self.iterations = iteration
                  self.mean = 0
                  self.std = 0
                  self.theta = []
                  self.threshold = threshold
              def fit(self,x_tr, y_tr):
                  m = x_tr.size
                  self.mean = x_tr.mean()
                  self.std = x_tr.std()
                  x_tr = (x_tr - self.mean)/self.std
                  theta = np.random.rand(len(x_tr.iloc[0])+1)
                  past_costs = []
                  past_thetas = [theta]
                  x = np.c_[np.ones(len(x_tr.iloc[:,0])),x_tr]
                  for i in range(self.iterations):
                      prediction = self.sigmoid(np.dot(x, theta.T))
                      #prediction[prediction>=0.5] = 1
                      #prediction[prediction<0.5] = 0
                      #print(len(prediction) == len(x_tr))
                      error = prediction - y_tr
                      #print(error)
                      cost = - 1/(m) * (np.dot(y_tr.T, error) + np.dot(1-y_tr,1-error))
                      past_costs.append(cost)
                      theta = theta - (self.alpha * (1/m) * np.dot(x.T, error))
                      past_thetas.append(theta)
                      self.theta = past_thetas[-1]
                  return past_thetas, past_costs
              def predict(self, x_val):
```

```
            x_val = (x_val - self.mean)/self.std
            x = np.c_[np.ones(len(x_val.iloc[:,0])),x_val]
            prediction = self.sigmoid(np.dot(x, self.theta.T))
            prediction[prediction>=self.threshold] = 1
            prediction[prediction<self.threshold] = 0
            return prediction
        def sigmoid(self,x):
            return (np.exp(x)/(1+np.exp(x)))
        #past_thetas, past_costs = gradient_descent(X_train_4, Y_train_4, theta, iteration
        #theta = past_thetas[-1]
```

In [107]:
```
Y_train[Y_train>=0.5] = 1
Y_train[Y_train<0.5] = 0
Y_val[Y_val>=0.5] = 1
Y_val[Y_val<0.5] = 0
```

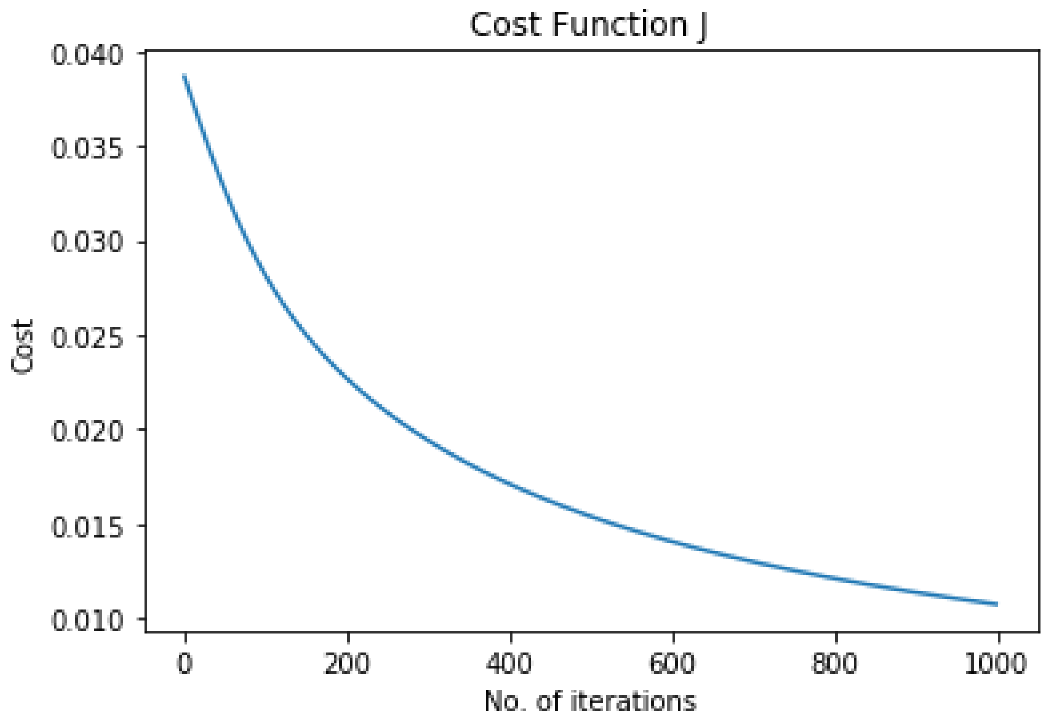
In [108]:
```
from sklearn.linear_model import LogisticRegression
clf_me = logistic_regression()
clf_sk = LogisticRegression()
```

In [109]:
```
past_thetas, past_costs = clf_me.fit(X_train, Y_train)
clf_sk.fit(X_train, Y_train)
```

```
/home/neil/.local/lib/python3.6/site-packages/sklearn/linear_model/logistic.py:432: FutureWarnin
  FutureWarning)
```

Out[109]:
```
LogisticRegression(C=1.0, class_weight=None, dual=False, fit_intercept=True,
          intercept_scaling=1, max_iter=100, multi_class='warn',
          n_jobs=None, penalty='l2', random_state=None, solver='warn',
          tol=0.0001, verbose=0, warm_start=False)
```

In [110]:
```
plt.title('Cost Function J')
plt.xlabel('No. of iterations')
plt.ylabel('Cost')
plt.plot(past_costs)
plt.show()
```




```
In [111]: Y_pred_me = clf_me.predict(X_val)
          acc_me = accuracy_score(Y_pred_me, Y_val)
          res = precision_recall_fscore_support(Y_pred_me, Y_val, average = 'binary')
          pre_me, re_me, f1_me = res[0], res[1], res[2]
          Y_pred_sk = clf_sk.predict(X_val)
          acc_sk = accuracy_score(Y_pred_sk, Y_val)
          res = precision_recall_fscore_support(Y_pred_sk, Y_val, average = 'binary')
          pre_sk, re_sk, f1_sk = res[0], res[1], res[2]
```

```
In [112]: print("                         My Classifier                        Sklearn Classifier")
          print("accuracy score:        {0}                  {1}".format(acc_me, acc_sk))
          print("precision score:       {0}                  {1}".format(pre_me, pre_sk))
          print("recall score:          {0}                  {1}".format(re_me, re_sk))
          print("f1 score:              {0}                  {1}".format(f1_me, f1_sk))
```

```
                         My Classifier                    Sklearn Classifier
accuracy score:        0.9111111111111111                0.9111111111111111
precision score:       1.0                  0.9876543209876543
recall score:          0.9101123595505618                0.9195402298850575
f1 score:              0.9529411764705883                0.9523809523809523
```

Question 2: Compare the performances of logistic regression model with KNN model on the Admission dataset

In [113]:
```
clf_lg = logistic_regression()
clf_knn = knearestneighbors()
```

In [114]:
```
acc_knn, pre_knn, re_knn, f1_knn = k_fold_cross_val(X_train, Y_train, clf_knn)
clf_lg.fit(X_train, Y_train)
Y_pred_lg = clf_lg.predict(X_val)
acc_lg = accuracy_score(Y_pred_lg, Y_val)
res = precision_recall_fscore_support(Y_pred_lg, Y_val, average = 'binary')
pre_lg, re_lg, f1_lg = res[0], res[1], res[2]
```

```
/home/neil/.local/lib/python3.6/site-packages/sklearn/metrics/classification.py:1145: UndefinedM
  'recall', 'true', average, warn_for)
```

In [115]:
```
print("                    logistic regression Classifier      KNN Classifier")
print("accuracy score:        {0}                   {1}".format(acc_lg, acc_knn))
print("precision score:       {0}                   {1}".format(pre_lg, pre_knn))
print("recall score:          {0}                   {1}".format(re_lg, re_knn))
print("f1 score:              {0}                   {1}".format(f1_lg, f1_knn))
```

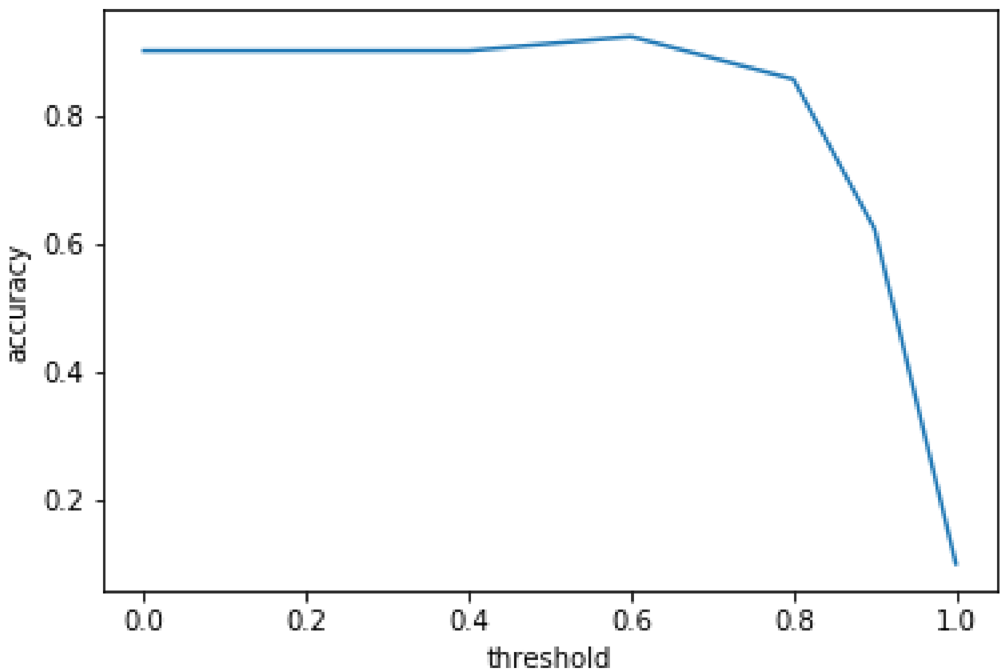
```
                     logistic regression Classifier      KNN Classifier
accuracy score:        0.9                   0.9194444444444445
precision score:       1.0                   0.9281434884559886
recall score:          0.9                   0.9194444444444445
f1 score:              0.9473684210526316               0.9177305696349325
```

Question 3: Plot a graph explaining the co-relation between threshold value vs precision and recall. Report the criteria one should use while deciding the threshold value. Explain the reason behind your choice of threshold in your model

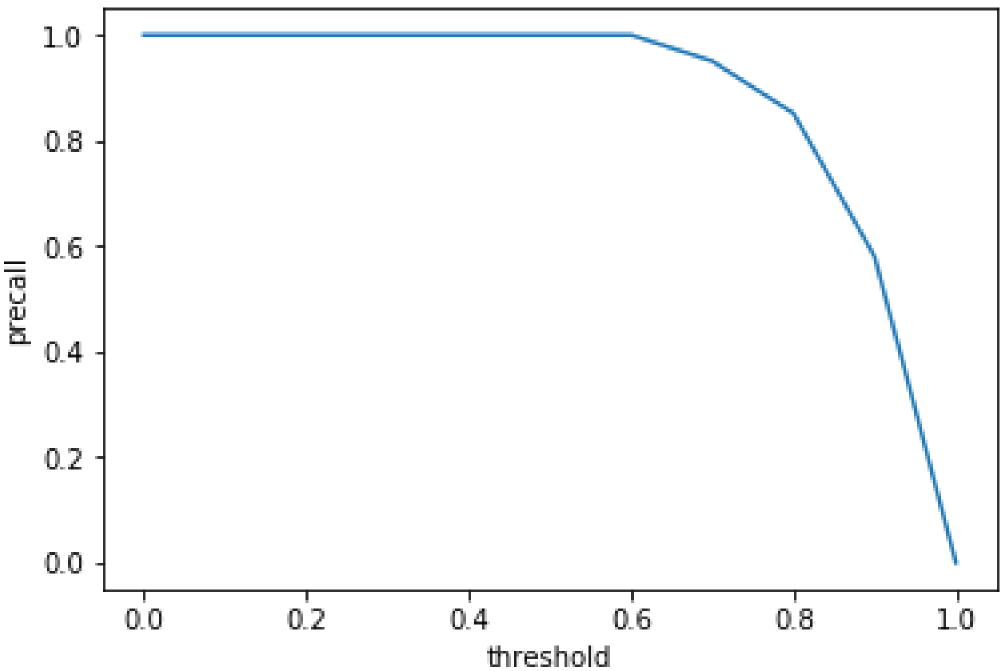
In [116]:
```
acc = []
pre = []
rec = []
f1 = []
for i in  np.linspace(0,1,11):
    clf_lg = logistic_regression(threshold = i)
    clf_lg.fit(X_train, Y_train)
    Y_pred_lg = clf_lg.predict(X_val)
    acc_lg = accuracy_score(Y_pred_lg, Y_val)
    res = precision_recall_fscore_support(Y_pred_lg, Y_val, average = 'binary')
    pre_lg, re_lg, f1_lg = res[0], res[1], res[2]
    #print(i, acc_lg, pre_lg, re_lg, f1_lg)
    acc.append((i,acc_lg))
    pre.append((i,pre_lg))
    rec.append((i,re_lg))
    f1.append((i,f1_lg))
```

```
/home/neil/.local/lib/python3.6/site-packages/sklearn/metrics/classification.py:1145: UndefinedM
  'recall', 'true', average, warn_for)
```

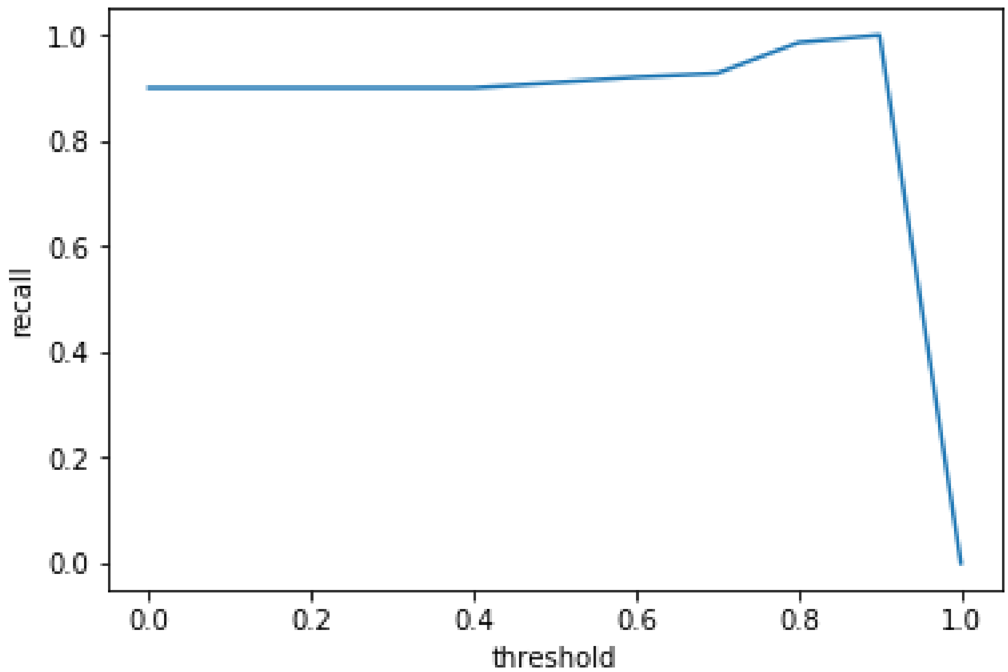
In [117]:
```
X_lst = []
Y_lst = []
for i in range(len(acc)):
    X_lst.append(acc[i][0])
    Y_lst.append(acc[i][1])
plt.plot(X_lst,Y_lst)
plt.xlabel('threshold')
plt.ylabel('accuracy')
plt.show()
```



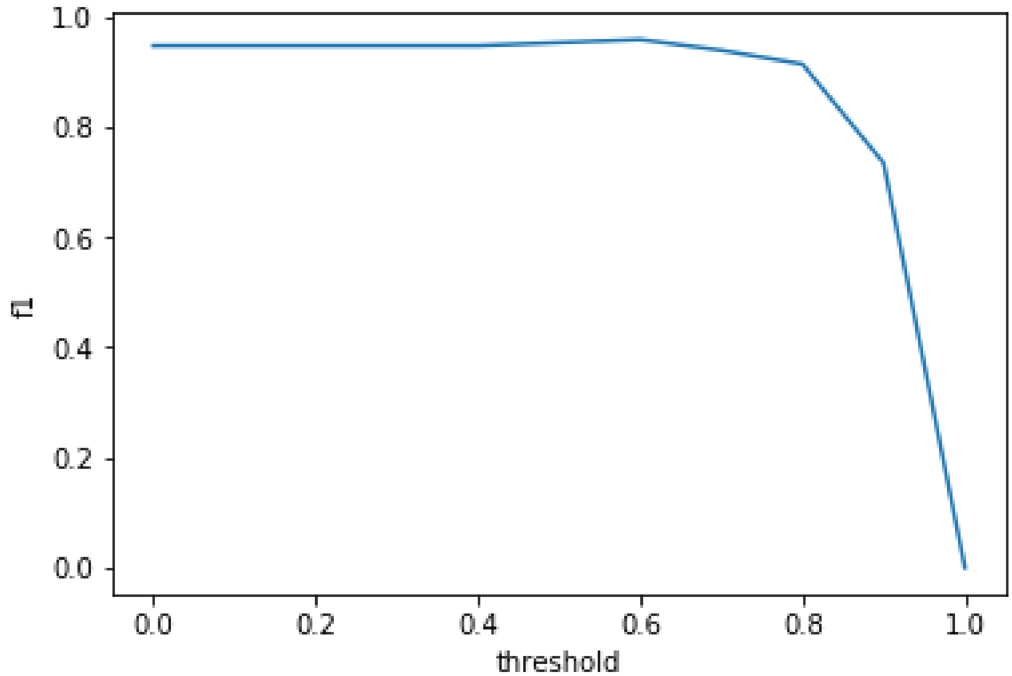
In [118]:
```
X_lst = []
Y_lst = []
for i in range(len(acc)):
    X_lst.append(pre[i][0])
    Y_lst.append(pre[i][1])
plt.plot(X_lst,Y_lst)
plt.xlabel('threshold')
plt.ylabel('precall')
plt.show()
```




```
In [119]: X_lst = []
          Y_lst = []
          for i in range(len(acc)):
              X_lst.append(rec[i][0])
              Y_lst.append(rec[i][1])
          plt.plot(X_lst,Y_lst)
          plt.xlabel('threshold')
          plt.ylabel('recall')
          plt.show()
```



In [120]:
```
X_lst = []
Y_lst = []
for i in range(len(acc)):
    X_lst.append(f1[i][0])
    Y_lst.append(f1[i][1])
plt.plot(X_lst,Y_lst)
plt.xlabel('threshold')
plt.ylabel('f1')
plt.show()
```



1.3 Part 5:

Implement logistic regression using One vs All and One vs One approaches. Use the following dataset http://preon.iiit.ac.in/~sanjoy_chowdhury/wine-quality. zip for completing the task. Report your observations and accuracy of the model.

```
In [379]: train_df = pd.read_csv('wine-quality/data.csv', delimiter=';')
```

```
In [380]: from sklearn.model_selection import train_test_split
          X_train, X_val, Y_train, Y_val = train_test_split(train_df.drop('quality', axis=1),tra
```

```
In [381]: class logistic_regressionOVA:
              def __init__(self, alpha=0.1, iteration=1000, classes=2, threshold=0.5):
                  self.alpha = alpha
                  self.iterations = iteration
                  self.classes = classes
                  self.mean = 0
                  self.std = 0
                  self.theta = []
                  self.threshold = threshold
                  self.theta_c = []
              def fit(self,x_tr, y_tr):
                  m = x_tr.size
                  self.mean = x_tr.mean()
                  self.std = x_tr.std()
```

```
                x_tr = (x_tr - self.mean)/self.std
                for c in range(self.classes):
                    y_tr_c = (y_tr==c).astype(int)
                    theta = np.random.rand(len(x_tr.iloc[0])+1)
                    past_costs = []
                    past_thetas = [theta]
                    x = np.c_[np.ones(len(x_tr.iloc[:,0])),x_tr]
                    for i in range(self.iterations):
                        prediction = self.sigmoid(np.dot(x, theta.T))
                        #prediction[prediction>=0.5] = 1
                        #prediction[prediction<0.5] = 0
                        #print(len(prediction) == len(x_tr))
                        error = prediction - y_tr_c
                        #print(error)
                        cost = - 1/(m) * (np.dot(y_tr.T, error) + np.dot(1-y_tr,1-error))
                        past_costs.append(cost)
                        theta = theta - (self.alpha * (1/m) * np.dot(x.T, error))
                        past_thetas.append(theta)
                    self.theta_c.append(theta)
                #print(self.theta_c)
                return past_thetas, past_costs
            def predict(self, x_val):
                ans = []
                x_val = (x_val - self.mean)/self.std
                #print(self.theta_c)
                for c in range(self.classes):
                    x = np.c_[np.ones(len(x_val.iloc[:,0])),x_val]
                    #print(self.theta_c[c])
                    #print()
                    prediction = self.sigmoid(np.dot(x, self.theta_c[c].T))
                    #print(prediction.shape)
                    ans.append(prediction)
                    #print(prediction.shape)
                ans = np.array(ans).T
                #print(ans)
                return np.argmax(ans,axis=1)
            def sigmoid(self,x):
                return (np.exp(x)/(1+np.exp(x)))
            #past_thetas, past_costs = gradient_descent(X_train_4, Y_train_4, theta, iteration
            #theta = past_thetas[-1]
```

```
In [382]: clf_me = logistic_regressionOVA(classes = 10)
```

```
In [383]: _,_ = clf_me.fit(X_train,Y_train)
```

```
In [384]: from sklearn.linear_model import LogisticRegression
          from sklearn.multiclass import OneVsRestClassifier
          clf_sk = OneVsRestClassifier(LogisticRegression(random_state=0, solver = 'lbfgs', max_
```

```
/home/neil/.local/lib/python3.6/site-packages/sklearn/linear_model/logistic.py:757: ConvergenceW
  "of iterations.", ConvergenceWarning)
```

```
In [385]: y_pred_me = clf_me.predict(X_val)
          acc_me = accuracy_score(y_pred_me,Y_val)
```

```
In [386]: y_pred_sk = clf_sk.predict(X_val)
          acc_sk = accuracy_score(y_pred_sk,Y_val)
```

```
In [387]: print("                            My One vs All Classifier         Sklearn One vs All
          print("accuracy score:              {0}                  {1}".format(acc_me, acc_sk))
```

```
                            My One vs All Classifier         Sklearn One vs All Classifier
accuracy score:               0.5340136054421769               0.536281179138322
```

```
In [460]: train_df = pd.read_csv('wine-quality/data.csv', delimiter=';')
```

```
In [461]: from sklearn.model_selection import train_test_split
          X_train, X_val, Y_train, Y_val = train_test_split(train_df.drop('quality', axis=1),tra
```

```
In [462]: # One Vs One with all classes available in dataset i.e. 3,4,5,6,7,8,9
          class logistic_regressionOVO:
              def __init__(self, alpha=0.1, iteration=10000, classes=2, threshold=0.5):
                  self.alpha = alpha
                  self.iterations = iteration
                  self.classes = classes
                  self.mean = 0
                  self.std = 0
                  self.theta = []
                  self.threshold = threshold
                  self.theta_c = {}
                  self.mp = {}
              def fit(self,x_tr, y_tr):
                  m = x_tr.size
                  self.mean = x_tr.mean()
                  self.std = x_tr.std()
                  x_tr = (x_tr - self.mean)/self.std
                  for i,x in zip(range(len(y_tr.unique().tolist())),y_tr.unique().tolist()):
                      self.mp[i]=x
                  self.classes = len(y_tr.unique().tolist())
                  for c1 in range(self.classes):
                      for c2 in range(c1+1,self.classes):
                          #print([y_tr.unique().tolist()[c1],y_tr.unique().tolist()[c2]])
                          x_tr_c = x_tr[list(x_tr.columns.values)][y_tr.isin([y_tr.unique().toli
                          y_tr_c12 = y_tr[:][y_tr.isin([y_tr.unique().tolist()[c1],y_tr.unique()
                          y_tr_c = (y_tr_c12==y_tr.unique().tolist()[c1]).astype(int)
                          #print(y_tr_c)
```

```
                theta = np.random.rand(len(x_tr.iloc[0])+1)
                past_costs = []
                past_thetas = [theta]
                x = np.c_[np.ones(len(x_tr_c.iloc[:,0])),x_tr_c]
                if len(x_tr_c)>0:
                    for i in range(self.iterations):
                        prediction = self.sigmoid(np.dot(x, theta.T))
                        #prediction[prediction>=0.5] = 1
                        #prediction[prediction<0.5] = 0
                        #print(len(prediction) == len(x_tr))
                        error = prediction - y_tr_c
                        #print(error)
                        cost = -1/(m) * (np.dot(y_tr_c.T, error) + np.dot(1-y_tr_c,1-e
                        past_costs.append(cost)
                        theta = theta - (self.alpha * (1/m) * np.dot(x.T, error))
                        past_thetas.append(theta)
                self.theta_c[(c1,c2)] = theta
        #print(self.theta_c)
        #print()
        #print(self.mp)
        return past_thetas, past_costs
    def predict(self, x_val):
        ans = []
        #print(self.theta_c)
        x_val = (x_val - self.mean)/self.std
        for c1 in range(self.classes):
            for c2 in range(c1+1,self.classes):
                x = np.c_[np.ones(len(x_val.iloc[:,0])),x_val]
                #print(self.theta_c[(c1,c2)])
                #print()
                prediction = np.dot(x, self.theta_c[(c1,c2)].T)
                #print(prediction.shape)
                #ans.append(prediction)
                #print(prediction.shape)
                prediction[prediction>=self.threshold] = self.mp[c1]
                prediction[prediction<self.threshold] = self.mp[c2]
                #print(prediction)
                ans.append(prediction)
                #print(ans)
        ans = np.array(ans).T
        pred = []
        for i in range(len(ans)):
            pred.append(Counter(ans[i]).most_common(1)[0][0])
        return pred
    def sigmoid(self,x):
        return (np.exp(x)/(1+np.exp(x)))
#past_thetas, past_costs = gradient_descent(X_train_4, Y_train_4, theta, iteration
#theta = past_thetas[-1]
```

```
In [463]: clf_me = logistic_regressionOVO(classes = 10)

In [464]: _,_ = clf_me.fit(X_train,Y_train)

In [465]: from sklearn.linear_model import LogisticRegression
          from sklearn.multiclass import OneVsOneClassifier
          clf_sk = OneVsOneClassifier(LogisticRegression(random_state=0, solver='lbfgs', max_ite

/home/neil/.local/lib/python3.6/site-packages/sklearn/linear_model/logistic.py:757: ConvergenceW
  "of iterations.", ConvergenceWarning)


In [466]: y_pred_me = clf_me.predict(X_val)
          acc_me = accuracy_score(y_pred_me,Y_val)

In [467]: y_pred_sk = clf_sk.predict(X_val)
          acc_sk = accuracy_score(y_pred_sk,Y_val)

In [468]: print("                            My One vs One Classifier         Sklearn One vs One
          print("accuracy score:                {0}                   {1}".format(acc_me, acc_sk))

                            My One vs One Classifier         Sklearn One vs One Classifier
accuracy score:               0.4954648526077097               0.5113378684807256


In [476]: train_df = pd.read_csv('wine-quality/data.csv', delimiter=';')

In [477]: from sklearn.model_selection import train_test_split
          X_train, X_val, Y_train, Y_val = train_test_split(train_df.drop('quality', axis=1),tra

In [484]: # One Vs One with all possible classes 0-10
          class logistic_regressionOVO:
              def __init__(self, alpha=0.1, iteration=10000, classes=2, threshold=0.5):
                  self.alpha = alpha
                  self.iterations = iteration
                  self.classes = classes
                  self.mean = 0
                  self.std = 0
                  self.theta = []
                  self.threshold = threshold
                  self.theta_c = {}
                  self.mp = {}
              def fit(self,x_tr, y_tr):
                  m = x_tr.size
                  self.mean = x_tr.mean()
                  self.std = x_tr.std()
                  x_tr = (x_tr - self.mean)/self.std
                  for i,x in zip(range(len(y_tr.unique().tolist())),y_tr.unique().tolist()):
                      self.mp[i]=x
```

```
        #self.classes = len(y_tr.unique().tolist())
        for c1 in range(self.classes):
            for c2 in range(c1+1,self.classes):
                #print([y_tr.unique().tolist()[c1],y_tr.unique().tolist()[c2]])
                x_tr_c = x_tr[list(x_tr.columns.values)][y_tr.isin([c1,c2])]
                y_tr_c12 = y_tr[:][y_tr.isin([c1,c2])]
                y_tr_c = (y_tr_c12==c1).astype(int)
                #print(y_tr_c)
                theta = np.random.rand(len(x_tr.iloc[0])+1)
                past_costs = []
                past_thetas = [theta]
                x = np.c_[np.ones(len(x_tr_c.iloc[:,0])),x_tr_c]
                if len(x_tr_c)>0:
                    for i in range(self.iterations):
                        prediction = self.sigmoid(np.dot(x, theta.T))
                        #prediction[prediction>=0.5] = 1
                        #prediction[prediction<0.5] = 0
                        #print(len(prediction) == len(x_tr))
                        error = prediction - y_tr_c
                        #print(error)
                        cost = - 1/(m) * (np.dot(y_tr_c.T, error) + np.dot(1-y_tr_c,1-
                        past_costs.append(cost)
                        theta = theta - (self.alpha * (1/m) * np.dot(x.T, error))
                        past_thetas.append(theta)
                self.theta_c[(c1,c2)] = theta
        #print(self.theta_c)
        #print()
        #print(self.mp)
        return past_thetas, past_costs
    def predict(self, x_val):
        ans = []
        #print(self.theta_c)
        x_val = (x_val - self.mean)/self.std
        for c1 in range(self.classes):
            for c2 in range(c1+1,self.classes):
                x = np.c_[np.ones(len(x_val.iloc[:,0])),x_val]
                #print(self.theta_c[(c1,c2)])
                #print()
                prediction = np.dot(x, self.theta_c[(c1,c2)].T)
                #print(prediction.shape)
                #ans.append(prediction)
                #print(prediction.shape)
                prediction[prediction>=self.threshold] = c1
                prediction[prediction<self.threshold] = c2
                #print(prediction)
                ans.append(prediction)
                #print(ans)
        ans = np.array(ans).T
```

```python
            pred = []
            for i in range(len(ans)):
                pred.append(Counter(ans[i]).most_common(1)[0][0])
            #print(pred)
            return pred
        def sigmoid(self,x):
            return (np.exp(x)/(1+np.exp(x)))
        #past_thetas, past_costs = gradient_descent(X_train_4, Y_train_4, theta, iteration
        #theta = past_thetas[-1]
```

In [485]:
```python
clf_me = logistic_regressionOVO(classes = 10)
```

In [486]:
```python
from sklearn.linear_model import LogisticRegression
from sklearn.multiclass import OneVsOneClassifier
clf_sk = OneVsOneClassifier(LogisticRegression(random_state=0, solver='lbfgs', max_ite
```

In [487]:
```python
_,_ = clf_me.fit(X_train,Y_train)
```

In [488]:
```python
np.set_printoptions(threshold=np.nan)
y_pred_me = clf_me.predict(X_val)
acc_me = accuracy_score(y_pred_me,Y_val)
```

In [489]:
```python
y_pred_sk = clf_sk.predict(X_val)
acc_sk = accuracy_score(y_pred_sk,Y_val)
```

In [490]:
```python
print("                              My One vs One Classifier         Sklearn One vs One
print("accuracy score:                 {0}                  {1}".format(acc_me, acc_sk))
```

```
                            My One vs One Classifier        Sklearn One vs One Classifier
accuracy score:               0.5136054421768708               0.5294784580498866
```

In [ ]: