ProjectStartUp1_NeuralNetwork-M5

December 12, 2020

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```python
[1]: from scipy.io import loadmat
     import numpy as np

     #SETUP
     X = loadmat("RawData.mat")['X']
     y = loadmat("RawData.mat")['y']
     Xones = np.ones((len(X),1))

     #Single threshold for classification
     thresh = 1500
     for i in range(len(X)):
         if(y[i] <= thresh):
             y[i] = 0
         if(y[i] > thresh):
             y[i] = 1

     #print(np.mean(y))

     #Optional: Eliminate high values
     #for i in range(110):
     #    X = np.delete(X, np.argmax(y), 0)
     #    y = np.delete(y, np.argmax(y), 0)
     #    X = np.delete(X, np.argmin(y), 0)
     #    y = np.delete(y, np.argmin(y), 0)

     TwoNormCol = np.zeros((len(X.T),1))

     #Remove keyword columns (poorly treated data)
     X = np.delete(X, 17, 1)
     X = np.delete(X, 17, 1)
     X = np.delete(X, 17, 1)
     X = np.delete(X, 17, 1)
     X = np.delete(X, 17, 1)
     X = np.delete(X, 17, 1)
     X = np.delete(X, 17, 1)
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```python
X = np.delete(X, 17, 1)
X = np.delete(X, 17, 1)

#Normalize columns to 2-norm
for i in range(len(X.T)):
    TwoNormCol[i] = np.sqrt(X[i,:]@X[i,:])
    X[i,:] = X[i,:]/TwoNormCol[i]
#print(TwoNormCol)
#print(X[0,:])
#print(y)

#Form subsets (indices, first group is full X)
Xsubs = np.
 ↪array([[0,49],[0,5],[5,7],[7,9],[9,11],[11,17],[17,20],[20,26],[28,33],[33,37],[37,45],[45,

#Create and run over 11 sets of 3604 entries from X and y,
#using 1 as a primary test set (when needed for lambda)
setArr = np.array([[0,int(len(X)/11)],[int(len(X)/11),int(2*len(X)/
 ↪11)],[int(2*len(X)/11),int(3*len(X)/11)],\
                  [int(3*len(X)/11),int(4*len(X)/11)],[int(4*len(X)/
 ↪11),int(5*len(X)/11)],\
                  [int(5*len(X)/11),int(6*len(X)/11)],[int(6*len(X)/
 ↪11),int(7*len(X)/11)],\
                  [int(7*len(X)/11),int(8*len(X)/11)],[int(8*len(X)/
 ↪11),int(9*len(X)/11)],\
                  [int(9*len(X)/11),int(10*len(X)/11)],[int(10*len(X)/
 ↪11),int(len(X))]])
#print(setArr)

#Set up network node count
networkCount = 3
networkTest = np.linspace(2, 6, networkCount)
#print(networkCount)

#Error tally storage
errorOrig = np.zeros((110,1))


#############################

#Only looping over full X matrix
Xset = 0

M = 5

errorOrig = np.zeros((12,1))
```

```python
errorNew = np.zeros((12,1))

for Xset in range(len(Xsubs)):
    for i in range(11):
        print("X subset = ",Xset,", i = ",i)
        testTally = 0
        #Set up Training and testing sets
        for k in range(11):
            if i == k:
                XTest1 = X[setArr[i,0]:setArr[i,1],Xsubs[Xset,0]:Xsubs[Xset,1]]
                #print(XTest1)
                yTest1 = y[setArr[i,0]:setArr[i,1]]
                #print(yTest1)
            if k != i:
                if testTally == 0:
                    XTrain = X[setArr[k,0]:setArr[k,1],Xsubs[Xset,0]:
 Xsubs[Xset,1]]

                    yTrain = y[setArr[k,0]:setArr[k,1]]
                    testTally = 1
                else:
                    XTrain = np.concatenate((XTrain, X[setArr[k,0]:
 setArr[k,1],Xsubs[Xset,0]:Xsubs[Xset,1]]),\
                                            axis=0)
                    yTrain = np.concatenate((yTrain, y[setArr[k,0]:
 setArr[k,1]]), axis=0)

        XTest1 = np.hstack((np.ones((len(XTest1),1)), XTest1))
        XTrain = np.hstack((np.ones((len(XTrain),1)), XTrain))

        # Storage for current iteration
        #WNET = np.zeros((len(X.T),networkCount))

        # Loop through different counts
        #for index in range(networkCount):
            #M = networkTest[index]

        V = np.random.randn(M+1, 1);
        W = np.random.randn(len(XTrain.T), M);

        #Step and epoch count
        alpha = 0.5
        L = 10

        def logsig(_x):
            return 1/(1+np.exp(-_x))

        for epoch in range(L):
```

```python
            ind = np.random.permutation(len(XTrain))
            for iii in ind:
                # Forward propagation
                H = logsig(np.hstack((np.ones((1,1)), XTrain[[iii],:]@W)))
                #print(np.hstack((np.ones((1,1)), XTrain[[iii],:]@W)))
                Yhat = logsig(H@V)

                # Back propagation
                delta = (Yhat-yTrain[[iii]])*Yhat*(1-Yhat)
                Vnew = V-alpha*H.T@delta
                gamma = delta@V[1:,:].T*H[:,1:]*(1-H[:,1:])
                Wnew = W - alpha*XTrain[[iii],:].T@gamma
                #print(alpha*XTrain[[iii],:].T@gamma)
                V = Vnew
                W = Wnew
            print(epoch)


        H = logsig(np.hstack((np.ones((len(XTrain),1)), XTrain@W)))
        y_net1 = logsig(H@V)

        errorOrigTemp = 0
        for index in range(len(XTrain)):
            if (yTrain[index] > 0.5 and y_net1[index] < 0.5) or (yTrain[index]␣
↪< 0.5 and y_net1[index] > 0.5):
                errorOrigTemp = errorOrigTemp + 1
        errorOrigTemp = errorOrigTemp/len(XTrain)
        print("Mean error with orig set: ",errorOrigTemp)

        H = logsig(np.hstack((np.ones((len(XTest1),1)), XTest1@W)))
        y_net1 = logsig(H@V)

        errorOrig[Xset] = errorOrig[Xset] + errorOrigTemp

        errorOrigTemp = 0
        for index in range(len(XTest1)):
            if (yTest1[index] > 0.5 and y_net1[index] < 0.5) or (yTest1[index]␣
↪< 0.5 and y_net1[index] > 0.5):
                errorOrigTemp = errorOrigTemp + 1
        errorOrigTemp = errorOrigTemp/len(yTest1)
        print("Mean error with test set: ",errorOrigTemp)

        errorNew[Xset] = errorNew[Xset] + errorOrigTemp



GlobalMeanOrigError = np.zeros((11,1))
```

```
GlobalMeanNewError = np.zeros((11,1))
for index in range(11):
    GlobalMeanOrigError[index] = errorOrig[index]/11
    GlobalMeanNewError[index] = errorNew[index]/11
    print("Mean Error for training set, X subset ",(index+1)," =␣
 ↪",GlobalMeanOrigError[index])
    print("Mean Error for test set, X subset ",(index+1)," =␣
 ↪",GlobalMeanNewError[index])
```

X subset = 0 , i = 0

/opt/conda/lib/python3.7/site-packages/ipykernel_launcher.py:117:
RuntimeWarning: overflow encountered in exp

0
1
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9
Mean error with orig set: 0.5443118756936737
Mean error with test set: 0.4961154273029967
X subset = 0 , i = 1
0
1
2
3
4
5
6
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9
Mean error with orig set: 0.45030521642619314
Mean error with test set: 0.5441176470588235
X subset = 0 , i = 2
0
1
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5

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9
Mean error with orig set:  0.4642896781354051
Mean error with test set:  0.40316315205327413
X subset =  0 , i =  3
0
1
2
3
4
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Mean error with orig set:  0.5349889012208657
Mean error with test set:  0.5857380688124306
X subset =  0 , i =  4
0
1
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Mean error with orig set:  0.45957269700332964
Mean error with test set:  0.46476137624861263
X subset =  0 , i =  5
0
1
2
3
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6
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9
Mean error with orig set:  0.5444783573806882
Mean error with test set:  0.4938956714761376
X subset =  0 , i =  6
0
1
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4
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Mean error with orig set: 0.4558546059933407
Mean error with test set: 0.4983351831298557
X subset = 0 , i = 7
0
1
2
3
4
5
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7
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9
Mean error with orig set: 0.5189789123196449
Mean error with test set: 0.5127635960044395
X subset = 0 , i = 8
0
1
2
3
4
5
6
7
8
9
Mean error with orig set: 0.4609322974472808
Mean error with test set: 0.4514428412874584
X subset = 0 , i = 9
0
1
2
3
4
5
6
7
8
9
Mean error with orig set: 0.4634295227524972

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Mean error with test set:  0.41509433962264153
X subset =  0 , i =  10
0
1
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6
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9
Mean error with orig set:  0.4655937846836848
Mean error with test set:  0.40427302996670367
X subset =  1 , i =  0
0
1
2
3
4
5
6
7
8
9
Mean error with orig set:  0.4556881243063263
Mean error with test set:  0.5038845726970034
X subset =  1 , i =  1
0
1
2
3
4
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6
7
8
9
Mean error with orig set:  0.5482241953385127
Mean error with test set:  0.45366259711431745
X subset =  1 , i =  2
0
1
2
3
4
5
6
```

7
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9
Mean error with orig set: 0.5338512763596004
Mean error with test set: 0.5971143174250833
X subset = 1 , i = 3
0
1
2
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4
5
6
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9
Mean error with orig set: 0.4630410654827969
Mean error with test set: 0.4164816870144284
X subset = 1 , i = 4
0
1
2
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4
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Mean error with orig set: 0.45810210876803553
Mean error with test set: 0.46614872364039955
X subset = 1 , i = 5
0
1
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9
Mean error with orig set: 0.4554661487236404
Mean error with test set: 0.5061043285238623
X subset = 1 , i = 6
0
1
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Mean error with orig set: 0.45507769145394006
Mean error with test set: 0.49639289678135406
X subset = 1 , i = 7
0
1
2
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5
6
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9
Mean error with orig set: 0.4596004439511654
Mean error with test set: 0.46448390677025525
X subset = 1 , i = 8
0
1
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9
Mean error with orig set: 0.4609322974472808
Mean error with test set: 0.4514428412874584
X subset = 1 , i = 9
0
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9
Mean error with orig set: 0.4656492785793563
Mean error with test set: 0.40427302996670367

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X subset =  1 , i =  10
0
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9
Mean error with orig set:  0.4655937846836848
Mean error with test set:  0.39039955604883464
X subset =  2 , i =  0
0
1
2
3
4
5
6
7
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9
Mean error with orig set:  0.5082408435072142
Mean error with test set:  0.4911209766925638
X subset =  2 , i =  1
0
1
2
3
4
5
6
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9
Mean error with orig set:  0.4514428412874584
Mean error with test set:  0.5463374028856826
X subset =  2 , i =  2
0
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9
Mean error with orig set: 0.5145671476137624
Mean error with test set: 0.5776914539400666
X subset = 2 , i = 3
0
1
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5
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8
9
Mean error with orig set: 0.4646503884572697
Mean error with test set: 0.4142619311875694
X subset = 2 , i = 4
0
1
2
3
4
5
6
7
8
9
Mean error with orig set: 0.4596281908990011
Mean error with test set: 0.46448390677025525
X subset = 2 , i = 5
0
1
2
3
4
5
6
7
8
9
Mean error with orig set: 0.536126526082131
Mean error with test set: 0.4972253052164262
X subset = 2 , i = 6
0
1
2
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4
5
6
7
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9
Mean error with orig set: 0.5259433962264151
Mean error with test set: 0.4936182019977802
X subset = 2 , i = 7
0
1
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Mean error with orig set: 0.4596281908990011
Mean error with test set: 0.46448390677025525
X subset = 2 , i = 8
0
1
2
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4
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8
9
Mean error with orig set: 0.5329633740288569
Mean error with test set: 0.5288568257491676
X subset = 2 , i = 9
0
1
2
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Mean error with orig set: 0.4656492785793563
Mean error with test set: 0.40427302996670367
X subset = 2 , i = 10

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Mean error with orig set:  0.5115149833518313
Mean error with test set:  0.5588235294117647
X subset =  3 , i =  0
0
1
2
3
4
5
6
7
8
9
Mean error with orig set:  0.4347114317425083
Mean error with test set:  0.48640399556048836
X subset =  3 , i =  1
0
1
2
3
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5
6
7
8
9
Mean error with orig set:  0.5485571587125416
Mean error with test set:  0.45366259711431745
X subset =  3 , i =  2
0
1
2
3
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5
6
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9
Mean error with orig set: 0.44084350721420645
Mean error with test set: 0.40455049944506105
X subset = 3 , i = 3
0
1
2
3
4
5
6
7
8
9
Mean error with orig set: 0.4388179800221976
Mean error with test set: 0.43146503884572696
X subset = 3 , i = 4
0
1
2
3
4
5
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9
Mean error with orig set: 0.4596281908990011
Mean error with test set: 0.46448390677025525
X subset = 3 , i = 5
0
1
2
3
4
5
6
7
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Mean error with orig set: 0.4554661487236404
Mean error with test set: 0.5061043285238623
X subset = 3 , i = 6
0
1
2
3
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6
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9
Mean error with orig set:  0.4562430632630411
Mean error with test set:  0.4983351831298557
X subset =  3 , i =  7
0
1
2
3
4
5
6
7
8
9
Mean error with orig set:  0.4596281908990011
Mean error with test set:  0.46448390677025525
X subset =  3 , i =  8
0
1
2
3
4
5
6
7
8
9
Mean error with orig set:  0.4609322974472808
Mean error with test set:  0.4514428412874584
X subset =  3 , i =  9
0
1
2
3
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Mean error with orig set:  0.4656492785793563
Mean error with test set:  0.40427302996670367
X subset =  3 , i =  10
0
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Mean error with orig set:  0.471503884572697
Mean error with test set:  0.4880688124306326
X subset =  4 , i =  0
0
1
2
3
4
5
6
7
8
9
Mean error with orig set:  0.4556881243063263
Mean error with test set:  0.5038845726970034
X subset =  4 , i =  1
0
1
2
3
4
5
6
7
8
9
Mean error with orig set:  0.4514428412874584
Mean error with test set:  0.5463374028856826
X subset =  4 , i =  2
0
1
2
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4
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6
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```
Mean error with orig set:  0.465788013318535
Mean error with test set:  0.40288568257491675
X subset =  4 , i =  3
0
1
2
3
4
5
6
7
8
9
Mean error with orig set:  0.4902885682574917
Mean error with test set:  0.5477247502774695
X subset =  4 , i =  4
0
1
2
3
4
5
6
7
8
9
Mean error with orig set:  0.5403718091009989
Mean error with test set:  0.5355160932297447
X subset =  4 , i =  5
0
1
2
3
4
5
6
7
8
9
Mean error with orig set:  0.4554661487236404
Mean error with test set:  0.5061043285238623
X subset =  4 , i =  6
0
1
2
3
4
5
```

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6
7
8
9
Mean error with orig set:  0.45507769145394006
Mean error with test set:  0.4961154273029967
X subset =  4 , i =  7
0
1
2
3
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6
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8
9
Mean error with orig set:  0.4596281908990011
Mean error with test set:  0.46448390677025525
X subset =  4 , i =  8
0
1
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6
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9
Mean error with orig set:  0.4609322974472808
Mean error with test set:  0.4514428412874584
X subset =  4 , i =  9
0
1
2
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6
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8
9
Mean error with orig set:  0.4656492785793563
Mean error with test set:  0.40427302996670367
X subset =  4 , i =  10
0
1
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2
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9
Mean error with orig set: 0.4656492785793563
Mean error with test set: 0.40427302996670367
X subset = 5 , i = 0
0
1
2
3
4
5
6
7
8
9
Mean error with orig set: 0.41012763596004437
Mean error with test set: 0.4667036625971143
X subset = 5 , i = 1
0
1
2
3
4
5
6
7
8
9
Mean error with orig set: 0.40682574916759157
Mean error with test set: 0.4098224195338513
X subset = 5 , i = 2
0
1
2
3
4
5
6
7
8
9
Mean error with orig set: 0.4177302996670366

```
Mean error with test set:  0.390677025527192
X subset =  5 , i =  3
0
1
2
3
4
5
6
7
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9
Mean error with orig set:  0.3891509433962264
Mean error with test set:  0.41148723640399554
X subset =  5 , i =  4
0
1
2
3
4
5
6
7
8
9
Mean error with orig set:  0.3892341842397336
Mean error with test set:  0.41065482796892344
X subset =  5 , i =  5
0
1
2
3
4
5
6
7
8
9
Mean error with orig set:  0.38898446170921197
Mean error with test set:  0.41315205327413984
X subset =  5 , i =  6
0
1
2
3
4
5
6
```

7
8
9
Mean error with orig set: 0.3924250832408435
Mean error with test set: 0.3787458379578246
X subset = 5 , i = 7
0
1
2
3
4
5
6
7
8
9
Mean error with orig set: 0.39719755826859043
Mean error with test set: 0.37597114317425084
X subset = 5 , i = 8
0
1
2
3
4
5
6
7
8
9
Mean error with orig set: 0.43951165371809103
Mean error with test set: 0.4397891231964484
X subset = 5 , i = 9
0
1
2
3
4
5
6
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9
Mean error with orig set: 0.41145948945615984
Mean error with test set: 0.3634850166481687
X subset = 5 , i = 10
0
1
2

3
4
5
6
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9
Mean error with orig set: 0.44320199778024416
Mean error with test set: 0.40288568257491675
X subset = 6 , i = 0
0
1
2
3
4
5
6
7
8
9
Mean error with orig set: 0.5206437291897891
Mean error with test set: 0.5097114317425083
X subset = 6 , i = 1
0
1
2
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6
7
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9
Mean error with orig set: 0.4514428412874584
Mean error with test set: 0.5463374028856826
X subset = 6 , i = 2
0
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9
Mean error with orig set: 0.465788013318535
Mean error with test set: 0.40288568257491675

```
X subset =  6 , i =  3
0
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9
Mean error with orig set:  0.4646503884572697
Mean error with test set:  0.4142619311875694
X subset =  6 , i =  4
0
1
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6
7
8
9
Mean error with orig set:  0.4596281908990011
Mean error with test set:  0.46448390677025525
X subset =  6 , i =  5
0
1
2
3
4
5
6
7
8
9
Mean error with orig set:  0.45543840177580464
Mean error with test set:  0.5061043285238623
X subset =  6 , i =  6
0
1
2
3
4
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6
7
```

8
9
Mean error with orig set: 0.45621531631520534
Mean error with test set: 0.4983351831298557
X subset = 6 , i = 7
0
1
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6
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8
9
Mean error with orig set: 0.4596004439511654
Mean error with test set: 0.46448390677025525
X subset = 6 , i = 8
0
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8
9
Mean error with orig set: 0.4609322974472808
Mean error with test set: 0.4514428412874584
X subset = 6 , i = 9
0
1
2
3
4
5
6
7
8
9
Mean error with orig set: 0.4656492785793563
Mean error with test set: 0.40427302996670367
X subset = 6 , i = 10
0
1
2
3

4
5
6
7
8
9
Mean error with orig set: 0.5343507214206438
Mean error with test set: 0.5957269700332963
X subset = 7 , i = 0
0
1
2
3
4
5
6
7
8
9
Mean error with orig set: 0.4222253052164262
Mean error with test set: 0.4542175360710322
X subset = 7 , i = 1
0
1
2
3
4
5
6
7
8
9
Mean error with orig set: 0.41897891231964485
Mean error with test set: 0.48668146503884574
X subset = 7 , i = 2
0
1
2
3
4
5
6
7
8
9
Mean error with orig set: 0.42938401775804663
Mean error with test set: 0.38263041065482795
X subset = 7 , i = 3

```
0
1
2
3
4
5
6
7
8
9
Mean error with orig set:  0.4271920088790233
Mean error with test set:  0.40455049944506105
X subset =  7 , i =  4
0
1
2
3
4
5
6
7
8
9
Mean error with orig set:  0.4353218645948946
Mean error with test set:  0.43118756936736957
X subset =  7 , i =  5
0
1
2
3
4
5
6
7
8
9
Mean error with orig set:  0.42139289678135405
Mean error with test set:  0.4625416204217536
X subset =  7 , i =  6
0
1
2
3
4
5
6
7
8
```

9
Mean error with orig set: 0.42333518312985574
Mean error with test set: 0.44311875693673697
X subset = 7 , i = 7
0
1
2
3
4
5
6
7
8
9
Mean error with orig set: 0.42602663706992233
Mean error with test set: 0.416204217536071
X subset = 7 , i = 8
0
1
2
3
4
5
6
7
8
9
Mean error with orig set: 0.4331853496115427
Mean error with test set: 0.4525527192008879
X subset = 7 , i = 9
0
1
2
3
4
5
6
7
8
9
Mean error with orig set: 0.42852386237513873
Mean error with test set: 0.3912319644839068
X subset = 7 , i = 10
0
1
2
3
4

5
6
7
8
9
Mean error with orig set: 0.45729744728079913
Mean error with test set: 0.44339622641509435
X subset = 8 , i = 0
0
1
2
3
4
5
6
7
8
9
Mean error with orig set: 0.41775804661487237
Mean error with test set: 0.46198668146503885
X subset = 8 , i = 1
0
1
2
3
4
5
6
7
8
9
Mean error with orig set: 0.4193673695893452
Mean error with test set: 0.45338512763596006
X subset = 8 , i = 2
0
1
2
3
4
5
6
7
8
9
Mean error with orig set: 0.4204772475027747
Mean error with test set: 0.459211986681465
X subset = 8 , i = 3
0

```
1
2
3
4
5
6
7
8
9
Mean error with orig set:  0.42125416204217536
Mean error with test set:  0.46004439511653716
X subset =  8 , i =  4
0
1
2
3
4
5
6
7
8
9
Mean error with orig set:  0.42597114317425083
Mean error with test set:  0.4447835738068812
X subset =  8 , i =  5
0
1
2
3
4
5
6
7
8
9
Mean error with orig set:  0.4352108768035516
Mean error with test set:  0.4306326304106548
X subset =  8 , i =  6
0
1
2
3
4
5
6
7
8
9
```

```
Mean error with orig set:  0.4480022197558269
Mean error with test set:  0.47780244173140957
X subset =  8 , i =  7
0
1
2
3
4
5
6
7
8
9
Mean error with orig set:  0.4265260821309656
Mean error with test set:  0.3915094339622642
X subset =  8 , i =  8
0
1
2
3
4
5
6
7
8
9
Mean error with orig set:  0.43066037735849055
Mean error with test set:  0.4064927857935627
X subset =  8 , i =  9
0
1
2
3
4
5
6
7
8
9
Mean error with orig set:  0.42896781354051056
Mean error with test set:  0.38623751387347394
X subset =  8 , i =  10
0
1
2
3
4
5
```

```
6
7
8
9
Mean error with orig set:  0.4287458379578246
Mean error with test set:  0.4017758046614872
X subset =  9 , i =  0
0
1
2
3
4
5
6
7
8
9
Mean error with orig set:  0.48143729189789125
Mean error with test set:  0.48251942286348504
X subset =  9 , i =  1
0
1
2
3
4
5
6
7
8
9
Mean error with orig set:  0.4450332963374029
Mean error with test set:  0.4961154273029967
X subset =  9 , i =  2
0
1
2
3
4
5
6
7
8
9
Mean error with orig set:  0.45754716981132076
Mean error with test set:  0.4039955604883463
X subset =  9 , i =  3
0
1
```

```
2
3
4
5
6
7
8
9
Mean error with orig set:  0.459322974472808
Mean error with test set:  0.42508324084350724
X subset =  9 , i =  4
0
1
2
3
4
5
6
7
8
9
Mean error with orig set:  0.44983351831298557
Mean error with test set:  0.46004439511653716
X subset =  9 , i =  5
0
1
2
3
4
5
6
7
8
9
Mean error with orig set:  0.44603218645948944
Mean error with test set:  0.4711431742508324
X subset =  9 , i =  6
0
1
2
3
4
5
6
7
8
9
Mean error with orig set:  0.4532741398446171
```

```
Mean error with test set:  0.49528301886792453
X subset =  9 , i =  7
0
1
2
3
4
5
6
7
8
9
Mean error with orig set:  0.4998612652608213
Mean error with test set:  0.4900110987791343
X subset =  9 , i =  8
0
1
2
3
4
5
6
7
8
9
Mean error with orig set:  0.47605438401775807
Mean error with test set:  0.46420643729189787
X subset =  9 , i =  9
0
1
2
3
4
5
6
7
8
9
Mean error with orig set:  0.4598779134295228
Mean error with test set:  0.4056603773584906
X subset =  9 , i =  10
0
1
2
3
4
5
6
```

7
8
9
Mean error with orig set: 0.4590177580466149
Mean error with test set: 0.40843507214206437
X subset =   10 , i =   0
0
1
2
3
4
5
6
7
8
9
Mean error with orig set: 0.4556881243063263
Mean error with test set: 0.5038845726970034
X subset =   10 , i =   1
0
1
2
3
4
5
6
7
8
9
Mean error with orig set: 0.4449778024417314
Mean error with test set: 0.537180910099889
X subset =   10 , i =   2
0
1
2
3
4
5
6
7
8
9
Mean error with orig set: 0.46476137624861263
Mean error with test set: 0.4034406215316315
X subset =   10 , i =   3
0
1
2

3
4
5
6
7
8
9
Mean error with orig set: 0.4646503884572697
Mean error with test set: 0.4142619311875694
X subset = 10 , i = 4
0
1
2
3
4
5
6
7
8
9
Mean error with orig set: 0.457519422863485
Mean error with test set: 0.46448390677025525
X subset = 10 , i = 5
0
1
2
3
4
5
6
7
8
9
Mean error with orig set: 0.4554661487236404
Mean error with test set: 0.5061043285238623
X subset = 10 , i = 6
0
1
2
3
4
5
6
7
8
9
Mean error with orig set: 0.45621531631520534
Mean error with test set: 0.4983351831298557

```
X subset =  10 , i =  7
0
1
2
3
4
5
6
7
8
9
Mean error with orig set:  0.4593507214206437
Mean error with test set:  0.46448390677025525
X subset =  10 , i =  8
0
1
2
3
4
5
6
7
8
9
Mean error with orig set:  0.4596836847946726
Mean error with test set:  0.4508879023307436
X subset =  10 , i =  9
0
1
2
3
4
5
6
7
8
9
Mean error with orig set:  0.4656492785793563
Mean error with test set:  0.40427302996670367
X subset =  10 , i =  10
0
1
2
3
4
5
6
7
```

```
8
9
Mean error with orig set:  0.4650943396226415
Mean error with test set:  0.40316315205327413
X subset =  11 , i =   0
0
1
2
3
4
5
6
7
8
9
Mean error with orig set:  0.4521087680355161
Mean error with test set:  0.4869589345172031
X subset =  11 , i =   1
0
1
2
3
4
5
6
7
8
9
Mean error with orig set:  0.44864039955604884
Mean error with test set:  0.5443951165371809
X subset =  11 , i =   2
0
1
2
3
4
5
6
7
8
9
Mean error with orig set:  0.4578523862375139
Mean error with test set:  0.4117647058823529
X subset =  11 , i =   3
0
1
2
3
```

4
5
6
7
8
9
Mean error with orig set: 0.4548279689234184
Mean error with test set: 0.413984461709212
X subset = 11 , i = 4
0
1
2
3
4
5
6
7
8
9
Mean error with orig set: 0.4596281908990011
Mean error with test set: 0.46448390677025525
X subset = 11 , i = 5
0
1
2
3
4
5
6
7
8
9
Mean error with orig set: 0.45097114317425085
Mean error with test set: 0.4875138734739179
X subset = 11 , i = 6
0
1
2
3
4
5
6
7
8
9
Mean error with orig set: 0.448834628190899
Mean error with test set: 0.49084350721420644
X subset = 11 , i = 7

```
0
1
2
3
4
5
6
7
8
9
Mean error with orig set:  0.45038845726970034
Mean error with test set:  0.46059933407325193
X subset =  11 , i =  8
0
1
2
3
4
5
6
7
8
9
Mean error with orig set:  0.5146226415094339
Mean error with test set:  0.5330188679245284
X subset =  11 , i =  9
0
1
2
3
4
5
6
7
8
9
Mean error with orig set:  0.46526082130965596
Mean error with test set:  0.419811320754717
X subset =  11 , i =  10
0
1
2
3
4
5
6
7
8
```

```
9
Mean error with orig set:  0.4566315205327414
Mean error with test set:  0.4195338512763596
Mean Error for training set, X subset  1  =  [0.48752144]
Mean Error for test set, X subset  1  =  [0.47906367]
Mean Error for training set, X subset  2  =  [0.47465695]
Mean Error for test set, X subset  2  =  [0.46821713]
Mean Error for training set, X subset  3  =  [0.49366865]
Mean Error for test set, X subset  3  =  [0.49465241]
Mean Error for training set, X subset  4  =  [0.46290738]
Mean Error for test set, X subset  4  =  [0.45938856]
Mean Error for training set, X subset  5  =  [0.46963475]
Mean Error for test set, X subset  5  =  [0.47845828]
Mean Error for training set, X subset  6  =  [0.40780446]
Mean Error for test set, X subset  6  =  [0.40576128]
Mean Error for training set, X subset  7  =  [0.47221269]
Mean Error for test set, X subset  7  =  [0.47800424]
Mean Error for training set, X subset  8  =  [0.42935123]
Mean Error for test set, X subset  8  =  [0.433483]
Mean Error for training set, X subset  9  =  [0.42754011]
Mean Error for test set, X subset  9  =  [0.43398749]
Mean Error for training set, X subset  10  =  [0.46248108]
Mean Error for test set, X subset  10  =  [0.45477248]
Mean Error for training set, X subset  11  =  [0.45900515]
Mean Error for test set, X subset  11  =  [0.45913631]
```

[ ]: