Final Project - Comprehensive Classifier Creation

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Abstract

The objective of this final project was to integrate various classification techniques to achieve the best performance on the chosen dataset. This project was a group effort where we explored both supervised and unsupervised classificaiton techniques including MPP (all 3 cases), kNN (with different k's), BPNN (developed), decision tree, and k-means, winner-take-all, and kohonen maps. We also explored two classifier fusion techniques including majority vote fusion and naive Bayes.

Introduction

This project performed for ECE 471 is an exercise using all the classificaiton methods we have used in past projects with the additional exploration of two new fusion methods which we previously had no experience with. The dataset we are using is titled "Poker Hand Dataset," publised by Robert Cattrel et. al., released in January 2007 *link to dataset*. By experimenting with various classification techniques, we learn the best specific methodology to classify this particular dataset.

Overall the project served its purpose and was an opportunity to review and become experts with the classification methods learned during this course. We are proud to announce we did not use any supporting libraries that do heavy-lifting of core computations, i.e. all classification methods were re-written by team members for this project.

We used a github repository to collaborate on this project:
https://github.com/sneyhart/swagteam6

Team Member Contributions

Clark

Mpp
Knn
BPNN
Decision Tree
Report Writing

Sam

Winner-take-all
Kmeans
Kohonen Map
Report writing

Kevin

Normalization
Evaluation
Team organization
Report writing

Dataset

The dataset we chose consists of all possible permutations of five-card poker hands dealt from a standard deck of 52 cards. Each sample is one hand and each card is represented by two features (suit and rank), for a total of 10 predictive attributes plus one class attribute. As previously mentioned, the order of cards is unimportant to its classification, which is why there are 480 possible Royal Flush hands as compared to only 4 in the combination set.

From poker-hand.names

Attribute Information:
1) S1 Suit of card 1
   Ordinal (1-4) representing Hearts, Spades, Diamonds, Clubs
2) C1 Rank of card 1
   Numerical (1-13) representing (Ace, 2, 3, ... , Queen, King)
3) S2 Suit of card 2
   Ordinal (1-4) representing Hearts, Spades, Diamonds, Clubs
4) C2 Rank of card 2
   Numerical (1-13) representing (Ace, 2, 3, ... , Queen, King)
5) S3 Suit of card 3
   Ordinal (1-4) representing Hearts, Spades, Diamonds, Clubs
6) C3 Rank of card 3
   Numerical (1-13) representing (Ace, 2, 3, ... , Queen, King)
7) S4 Suit of card 4
   Ordinal (1-4) representing Hearts, Spades, Diamonds, Clubs
8) C4 Rank of card 4
   Numerical (1-13) representing (Ace, 2, 3, ... , Queen, King)
9) S5 Suit of card 5
   Ordinal (1-4) representing Hearts, Spades, Diamonds, Clubs
10) C5 Rank of card 5
   Numerical (1-13) representing (Ace, 2, 3, ... , Queen, King)
11) CLASS Poker Hand
   Ordinal (0-9)

Class Information:
0: Nothing in hand; not a recognized poker hand
1: One pair; one pair of equal ranks within five cards
2: Two pairs; two pairs of equal ranks within five cards
3: Three of a kind; three equal ranks within five cards
4: Straight; five cards, sequentially ranked with no gaps
5: Flush; five cards with the same suit
6: Full house; pair + different rank three of a kind
7: Four of a kind; four equal ranks within five cards
8: Straight flush; straight + flush
9: Royal flush; Ace, King, Queen, Jack, Ten + flush

N: 25,010 training, 1,000,000 testing

Technical Approach

MPP The mpp.py Python script implements the MPP algorithm using basic Python, the numpy library, and the matplotlib library. It performs MPP parametric-based classification by first calculating the mean and covariance matricies from the dataset. *Bayes/Discriminant Func*

Case 1 The features are statistically independent, and have the same variance. Geometrically, the samples fall in equal-size hyperspherical clusters. Decision boundary: hyperplane of d-1 dimension. This classification technique employs the linear discriminant function and linear machine. Additionally, when prior probabilities are the same, the discriminant function is actually measuring the minimum distance from each feature to each of the c mean vectors.

Case 2 The covariance matrices for all the classes are identical but not a scalar of identity matrix. Geometrically, the samples fall in hyperellipsoidal clusters. Decision boundary: hyperplane of d-1 dimension.

Case 3 No assumption: the covariance matrices are different for each class. Quadratic classifier. Decision boundary: hyperquadratic for 2-D Gaussian.

kNN The knn.py Python script implements the kNN algorithm using basic Python, the numpy library, and the scipy library. It performs kNN classification, or majority voting, using Euclidean distance to assign a random sample according to the majority representation of classes within the enclosing hypersphere of k nearest neighbors. We experiment with different k's and evaluate performance.

BPNN The backprop.py script implements the backpropogation algorithm using basic Python, the numpy library, and the random library. Backpropogation is a type of multilayer feedforward network that calculates the difference between unit output and expected output, "back-propogating" this delta from the output layers back toward the feeding layers. This technique causes the network to "learn" correct classifictions in a supervised architecture. The script uses a network with 2 hidden layes. Each hidden layer has 15 neurons. The input layers change based on if the PCA preprocessing has been done on the input data. The output for the network is one neuron for the classification.

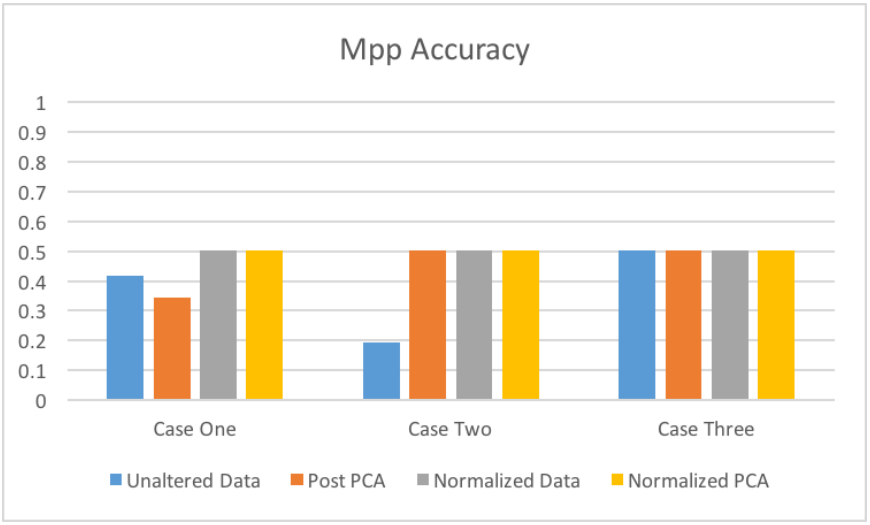
Decision Tree The dtree.py script implements the decision tree architecture using basic Python and the numpy library. The decision tree is structured to decide the various classes in an increasing faction. The highest valued class that is decided is the resulting classification of that hand. This is very efficient because the features of the data set are such that each class is made up of a specific set of cards. Thus each node will test the hand and classify it into that hand.

Kmeans The *kmeans* program was written for this project in C because we believed that python would not be able to perform the kmeans algorithm within an acceptable time span. The files *hand.c* and *hand.h* contain the definition of a hand struct as well some useful functions relating to this struct. Our kmeans program makes use of these two file in order to perform kmeans clustering on our data set. Despite having been written in C, the algorithm can take several minutes large data sets. Because of the the nature of poker hands, clustering on the raw data does not perform particularily well.

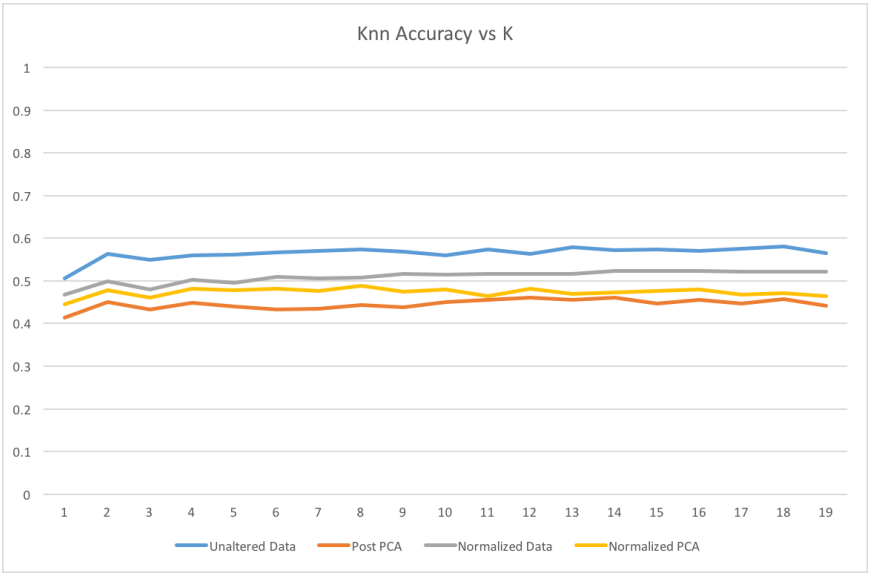
Winner-Take-All In order to perform winner-take-all clustering on our data set the program *wta* was written in C. The general structure of this program is the same as that of the kmeans program. The file input and output sections of code are reused and *wta* also makes use of the hand.c and hand.h files. The main way in which our winner-take-all program differs from our kmeans program is in the loop where the actual algorith is performed. This program is very fast (less than 5 seconds) even for our largest data set (1,000,000 data points).

Kohonen Maps In order to the perform the kohonen map algorithm on our data set the program *kohonen* was written in C. The general structure of this program is the same as that of the kmeans and winner-take-all programs. The file input and output sections of code are reused and *kohonen* also makes use of of the hand.c and hand.h files. Once again all major changes were made in the main loop where the algorithm is performed. The speed of this program is comporable to *wta*.

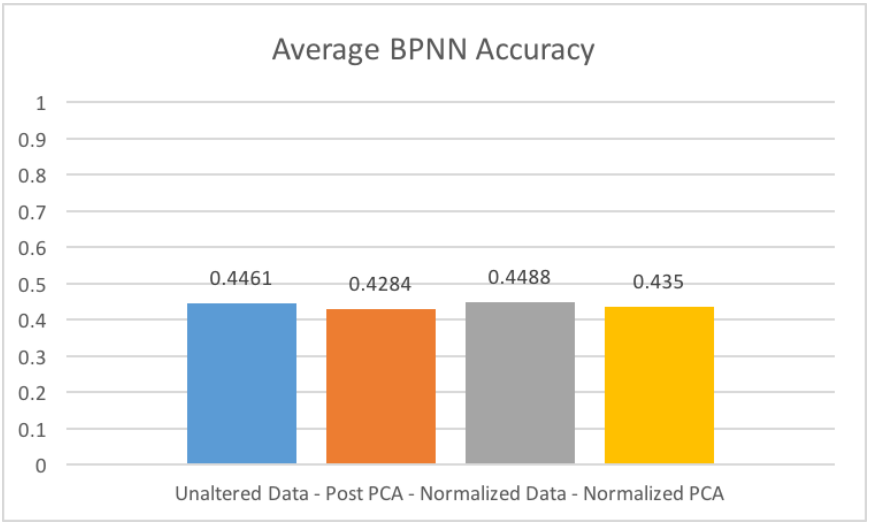
Experiments and Results



MPP

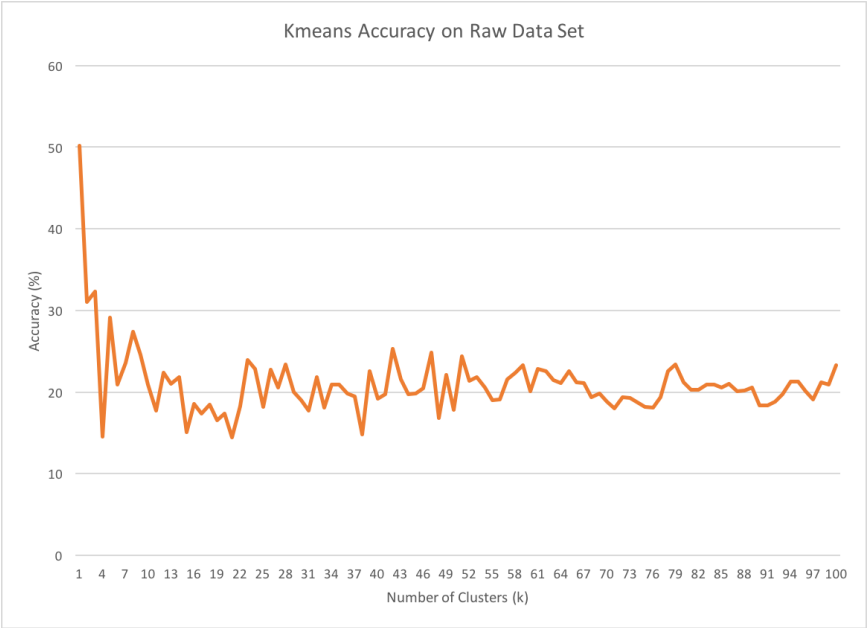


kNN

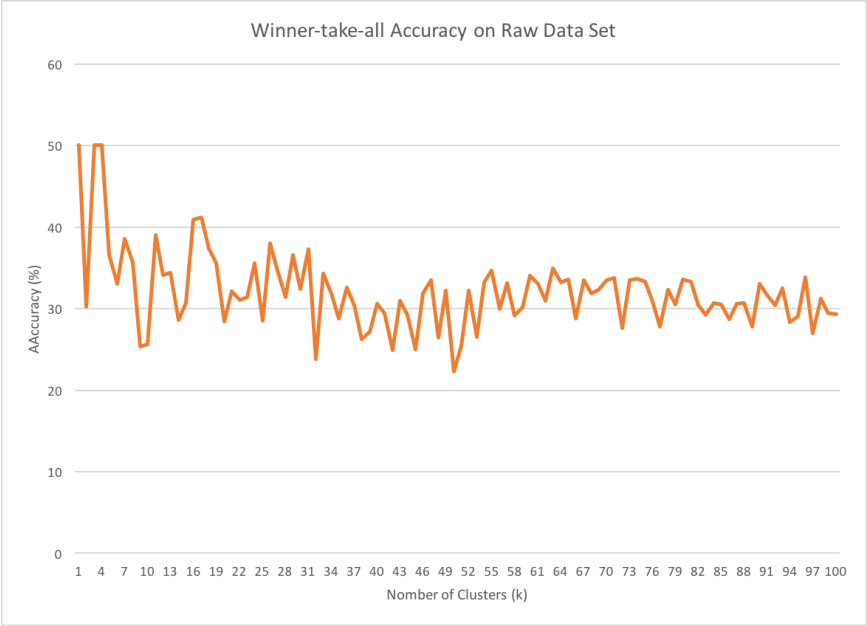


BPNN

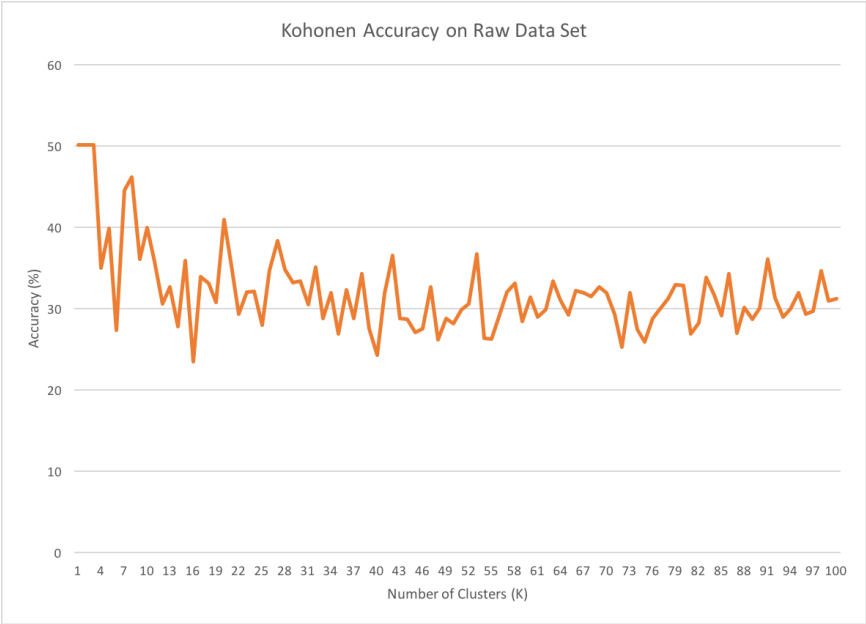
Decision Tree The Decision tree algorithm was actually able to classify with an accuracy of one hundred percent when run on the testing set. The algorithm simply ran through each of the hands and had a node that decided for each of the groups since each group is defined in such a way that is known before hand and has to be a certain combination of the cards. This lead the algorithm to be very fast as well since it only goes through the data set one time to classify each hand.



K-means



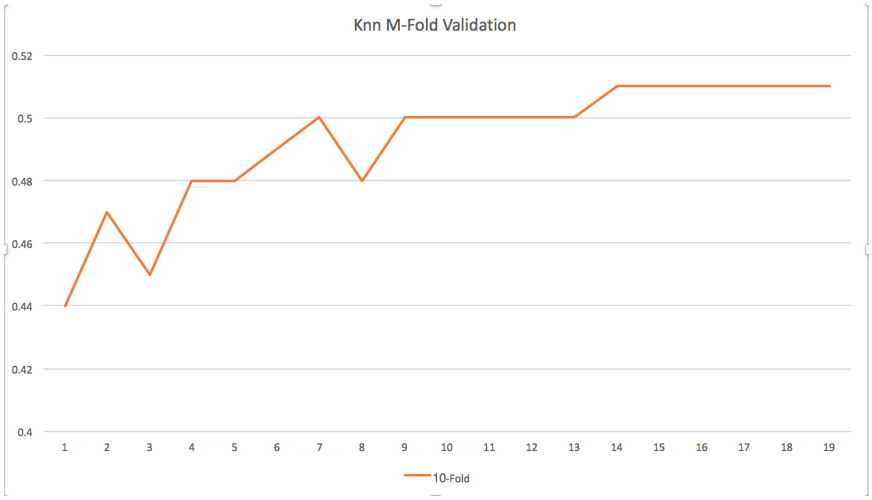
Winner-Take-All



Kohonen Maps

Evaluation

Evalution was performed using 10-fold cross-validation for the kNN classifier. Evaluation is performed in evaluation.py using standard Python language, with the support of the math, random, numpy, and subprocess libraries. This script performes the m-fold cross-validation algorithm by dividing the dataset into m disjoint sets and iterates over them using the 'leave-one-out' methodology, where one set is preserved as the testing (or validaiton) set and the remaining m-1 sets are combined to become the new training set. Normalization is performed anew on each of the m iterations for the training and testing sets separately.



kNN with 10-fold validation has a similar profile to the previous kNN trials performed with generally lower accuracy due to near complete mitigation of training/testing cycle bias.

Discussion

This project was very interesting to perform. Employing all of the classifiers that the course has covered proved to be a difficult yet enjoyable exercise. Using python was a good choice for most of the programs because of the simplicity of programming in Python as well as the ever useful libraries provided in the language. The clustering programs were written in c because of the size of the data set. C performed much faster than Python would have thus the group was able to run more tesst to glean a reasonable understanding of how well the programs performed. This was a very rewarding project to work on for the team.

Appendix

normalize.py

```
1  # Normalizaiton
2  # Input/Output file names defined in main funciton
3  # Running simply normalizes data and writes to output file
4  # Handy data separation techniques used
5
6  import math
7  import numpy as np
8  from numpy import linalg as LA
9
10 DEBUG = 0
11
12 def getInputSeparated(fname):
13         #fname = 'poker-hand-training-true.data'
14         file = open(fname, 'r')                          # read file
15         #with open(fname) as f:
16                 #lines = f.read().splitlines
17         lines = file.readlines()
18         file.close()
19         classData = []
20         class0Data = []                                  # can probably do this n
21         class1Data = []
22         class2Data = []
23         class3Data = []
24         class4Data = []
25         class5Data = []
26         class6Data = []
27         class7Data = []
28         class8Data = []
29         class9Data = []
30         for line in lines:                                       # read elements
31                 line = line.strip()
32                 splitLine = line.split(',')
33                 classIndex = len(splitLine)-1   # max index of splitLine
34                 #print splitLine
35                 #print 'Class Index: {}'.format(classIndex)
36                 #print splitLine[classIndex]
37                 sampleData = []
38                 #sampleData.append(int(splitLine[:lenIndexSplitLine]))
39                 for j in range(classIndex):
40                         #print j
41                         sampleData.append(float(splitLine[j]))
42                 # Separate by classes
```

```
43                  if (splitLine[classIndex] == '0'):
44                          #print 'appending 0'
45                          class0Data.append(sampleData)
46                  elif(splitLine[classIndex] == '1'):
47                          class1Data.append(sampleData)
48                  elif(splitLine[classIndex] == '2'):
49                          class2Data.append(sampleData)
50                  elif(splitLine[classIndex] == '3'):
51                          class3Data.append(sampleData)
52                  elif(splitLine[classIndex] == '4'):
53                          class4Data.append(sampleData)
54                  elif(splitLine[classIndex] == '5'):
55                          class5Data.append(sampleData)
56                  elif(splitLine[classIndex] == '6'):
57                          class6Data.append(sampleData)
58                  elif(splitLine[classIndex] == '7'):
59                          class7Data.append(sampleData)
60                  elif(splitLine[classIndex] == '8'):
61                          class8Data.append(sampleData)
62                  elif(splitLine[classIndex] == '9'):
63                          class9Data.append(sampleData)
64          classData.append(np.asarray(class0Data))
65          classData.append(np.asarray(class1Data))
66          classData.append(np.asarray(class2Data))
67          classData.append(np.asarray(class3Data))
68          classData.append(np.asarray(class4Data))
69          classData.append(np.asarray(class5Data))
70          classData.append(np.asarray(class6Data))
71          classData.append(np.asarray(class7Data))
72          classData.append(np.asarray(class8Data))
73          classData.append(np.asarray(class9Data))
74          return np.asarray(classData)
75
76  def test_getInputSeparated():
77          print 'Entered test_getInputSeparated()'
78          classData = getInputSeparated('poker-hand-training-true.txt')
79          i = -1
80          for classSamples in classData:
81                  i += 1
82                  print 'Class {} data:'.format(i)
83                  for classSample in classSamples:
84                          print classSample
85
86  def test_getInputSeparated2():
87          print 'Entered test_getInputSeparated2()'
88          classData = getInputSeparated('poker-hand-training-true.txt')
```

```
89          print classData
90
91  def weave(classData):
92          weaved = []
93          largestClassSampCount = 0
94          # find the length of the longest list (the number of samples in the larg
95          for classSamples in classData:
96                  numClassSamples = len(classSamples)
97                  if numClassSamples > largestClassSampCount:
98                          largestClassSampCount = numClassSamples
99          # weave samples across all classes
100         # Kevin - I can explain this, just ask me
101         for i in range(largestClassSampCount):
102                 for classSamples in classData:
103                         if (i < len(classSamples)):
104                                 weaved.append(classSamples[i])
105         return weaved
106
107 def test_weave():
108         fName_tr = 'poker-hand-training-true.data'
109         # Get training data
110         X0 = getInputSeparated(fName_tr)
111         X = weave(X0)
112         for samp in X:
113                 print samp
114
115 def getColumnMeans(X):
116         return np.mean(X, axis=0)
117
118 def getColumnStddevs(X):
119         return np.std(X, axis=0)
120
121 def getColMeansSeparated(_XS):
122         colMeansSep = []
123         for classSamples in _XS:
124                 colMeansSep.append(getColumnMeans(classSamples))
125         return np.asarray(colMeansSep)
126
127 def getColumnStddevsSeparated(_XS):
128         colMeansSep = []
129         for classSamples in _XS:
130                 colMeansSep.append(getColumnStddevs(classSamples))
131         return np.asarray(colMeansSep)
132
133 def normalize(X, colMeans, colStddevs):
134         nX = []
```

```
135         for sample in X:
136                 nRow = sample
137                 for i in range(len(nRow)):
138                         nRow[i] = (sample[i] - colMeans[i])/colStddevs[i]
139                 nX.append(nRow)
140         return np.asarray(nX)
141
142 def normalizeSep(XS, colMeans_all_tr, colStddevs_all_tr):
143         nXS = []
144         for classSamples in XS:
145                 nXClass = normalize(classSamples, colMeans_all_tr, colStddevs_al
146                 nXS.append(nXClass)
147         return np.asarray(nXS)
148
149 def rebuild(nXS, fname):
150         nOriginalData = open(fname, 'w')
151         i = -1
152         for nClassSamples in nXS:
153                 i += 1
154                 for nSamp in nClassSamples:
155                         nSampString = ''
156                         for feature in nSamp:
157                                 nSampString += str(feature) + ', '
158                         nSampString += str(i) + '\n'
159                         nOriginalData.write(nSampString)
160                         #print nSampString
161         nOriginalData.close()
162
163 def main():
164         if DEBUG: print 'Entered main()'
165         #fName_IN = 'poker-hand-training-true.data'
166         fName_IN = 'poker-hand-testing.data'
167         #fName_OUT = 'poker-hand-training-true-normalized.data'
168         fName_OUT = 'poker-hand-testing-normalized.data'
169
170         # 'X' denotes original dataset
171         # 'XS' denotes original dataset separated by class (hand type)
172         XS = getInputSeparated(fName_IN)
173         #if DEBUG: print 'XS: \n{}'.format(XS)
174         X = weave(XS)
175
176         if DEBUG: print 'X:\n{}\n\n\n'.format(X)
177         if DEBUG: print 'XS:\n{}\n\n\n'.format(XS)
178
179         # Compute un-normalized training mu & sigma for normalization
180         colMeans_all_tr = getColumnMeans(X)
```

```
181             colStddevs_all_tr = getColumnStddevs(X)
182
183             # 'nX' denotes original dataset - normalized
184             # 'nXS' denotes original dataset, separated - normalized
185             nXS = normalizeSep(XS, colMeans_all_tr, colStddevs_all_tr)
186             nX = weave(nXS)                                    # nX is both classes com
187
188             if DEBUG: print 'nX:\n{}\n\n\n'.format(nX)
189             #if DEBUG:
190             print 'nXS:\n{}'.format(nXS)
191
192             rebuild(nXS, fName_OUT)
193
194
195     main()
```

mpp.py

```
1  ##################
2  # Jon Clark Freeman, Sam Neyhart, Kevin Sayarath
3  # mpp.py classifies using the three cases of mpp
4  ##################
5
6  import matplotlib.pyplot as plt
7  import numpy as np
8
9  #function that returns the likelihood for a given [x, y], mean, and covariance n
10 def cmv(x,mean,cov,prior):
11     pre_top = 1;
12     pre_bottom = (2 * np.pi) * np.sqrt(np.linalg.det(cov))
13     post_matrix_mult = np.dot(np.dot(np.transpose(np.subtract(np.array(x), mean)
14     post_scalar = -1.0/2.0
15     return (pre_top/pre_bottom) * np.exp(post_scalar * post_matrix_mult) * prior
16
17 #function that returns Case 1 Discriminant
18 def case_1(x, mean,covariance,prior):
19     return -np.dot(np.subtract(np.array(x), mean),np.transpose(np.subtract(np.ar
20
21 #function that returns Case 2 Discriminant
22 def case_2(x, mean, cov, prior):
23     return -np.dot(np.dot(np.transpose(np.subtract(np.array(x), mean)), np.linalg
24
25 #initialization of priors and glasses
26 priors = [0.501177,0.422569,0.047539,0.021128,0.003925,0.001965,0.001441,0.00024
27 classes = [[] for i in range(0,10)]
28
29 # Handle file manipulation
30 lines = [np.array((file_line.rstrip('\n').split(','))).astype(float) for file_lin
31 lines = np.array(lines)
32
33 #handle getting covariance matrix and means
34 cov_lines = np.delete(lines.T, lines.T.shape[0] - 1,0)
35 for line in lines:
36     classes[int(line[-1])].append(np.delete(line,(line.shape[0]-1),0))
37 classes = np.array([np.array(classer) for classer in classes])
38 means = [np.mean(row) for row in classes]
39 covariance = np.cov(cov_lines)
40
41 testing_lines = [np.array((file_line.rstrip('\n').split(','))).astype(float) for
42 testing_lines = np.array(testing_lines)
43 tests = np.delete(testing_lines.T, testing_lines.T.shape[0] - 1,0).T
44 actual_classes = testing_lines.T[-1]
```

```
45
46 choices = []
47
48 for t,test in enumerate(tests):
49     max_disc = -1
50     max_val = -1000000
51     for i in range(0,len(means)):
52         res = cmv(test, means[i],covariance,priors[i])
53         if res > max_val:
54             max_disc = i
55             max_val = res
56     choices.append(max_disc)
57
58 corrects = 0
59 total = 0
60 for i in range(0, len(choices)):
61     if choices[i] == int(actual_classes[i]):
62         corrects = corrects + 1
63     total = total + 1
64 fusout = open("fusion-files-majority/mpp.data",'w')
65 for choice in choices:
66     fusout.write("{}\n".format(int(choice)))
```

knn.py

```
1  import numpy as np
2  from scipy import spatial as sp
3
4  #Preprocessing
5  lines = []
6  tlines = []
7  data = []
8  groups = []
9  classes = []
10 dtp = []
11 knn_res = []
12 corrects = [0] * 20
13 #file IO
14
15 lines = [np.array((file_line.rstrip('\n').split(','))).astype(float) for file_li
16 lines = np.array(lines)
17 training = np.delete(lines.T, lines.T.shape[0] - 1,0).T
18 res = lines.T[-1]
19
20 testing_lines = [np.array((file_line.rstrip('\n').split(','))).astype(float) for
21 testing_lines = np.array(testing_lines)
22 tests = np.delete(testing_lines.T, testing_lines.T.shape[0] - 1,0).T
23 actual_classes = testing_lines.T[-1]
24
25
26 #testing each unit in the testing set
27 fusout = open("fusion-files-majority/knn_un.data",'w')
28 for u,unit in enumerate(tests):
29     if u % 150 == 0:
30         print "{}%".format(u/150*10)
31     dis = []
32     cords = unit
33     actual = actual_classes[u]
34     for point in training:
35         dis.append(np.linalg.norm(point - cords))
36     idx = np.argsort(dis, axis=0)
37     dis = np.array(dis)[idx]
38     results = np.array(res)[idx]
39     counts = [0,0,0,0,0,0,0,0,0,0]
40
41 #going through each k value after each distance is calculated
42     for k in range(1,20):
43         mmax = -1
44         mindex = -1
```

```
45          counts[int(results[k-1])] = counts[int(results[k-1])] + 1
46
47          for ind,count in enumerate(counts):
48              if mmax < count:
49                  mmax = count
50                  mindex = ind
51          if k == 17:
52              fusout.write("{}\n".format(mindex))
53          if(actual == mindex):
54              corrects[k] += 1
55  # counting the correct guesses per each k value
56  corrects = [(correct * 1.0)/len(tests) for correct in corrects]
57  knn_res.append(corrects)
58  knn_res_tp = np.transpose(knn_res)
59  knn_res_tp = [np.mean(col) for col in knn_res_tp]
60  knn_res = np.transpose(knn_res_tp)
61  #print out the results for each k value up to the max k value
62  for i, k in enumerate(knn_res):
63      print "{},{}".format(i, k)
```

backprop.py

```
1  ### backprop.py
2  ### Jon Clark Freeman
3  ### learns and tests XOR logic
4  import numpy as np
5  import numpy.random as rando
6  import random
7
8  class BPNN:
9      #initialize the network
10     def __init__(self, network):
11         self.weights = []
12
13         #weights for hidden and input
14         for i in range(1, len(network) - 1):
15             self.weights.append(2*rando.random((network[i-1] + 1, network[i] + 1
16
17         self.weights.append(2*rando.random((network[i] + 1, network[i+1])) - 1)
18
19     def activation(self, x):
20         return np.tanh(x)
21
22     def activation_deriv(self, x):
23         return 1.0 - x**2
24
25     def train(self, inp, target,learning_rate=0.01, trials=10000):
26         #Add bias units as a col of ones on the inputs
27         ones = np.atleast_2d(np.ones(inp.shape[0]))
28         x = np.concatenate((ones.T, inp), axis=1)
29         for j in range(trials):
30             #choose a random input to train with
31             i = np.random.randint(inp.shape[0])
32             activations = [x[i]]
33
34             #calculating the activations for each of the layers
35             for k in range(len(self.weights)):
36                 dot_value = np.dot(activations[k], self.weights[k])
37                 act = self.activation(dot_value)
38                 activations.append(act)
39
40             # calculating error from outputs and targets
41             error = target[i] - activations[-1]
42             deltas = [error * self.activation_deriv(activations[-1])]
43
44             # Calculating deltas starting at the hidden layer
```

```
45              for k in range(len(activations) - 2, 0, -1):
46                  deltas.append(deltas[-1].dot(self.weights[k].T)*self.activation_
47              deltas.reverse()
48
49              # updating the weights using the deltas, activations
50              for i in range(len(self.weights)):
51                  layer = np.atleast_2d(activations[i])
52                  delta = np.atleast_2d(deltas[i])
53                  self.weights[i] += learning_rate * layer.T.dot(delta)
54
55      #test on all of the inputs
56      def test(self, inp):
57          retval = np.concatenate((np.ones(1).T, np.array(inp)), axis=1)
58          for i in range(0, len(self.weights)):
59              retval = self.activation(np.dot(retval, self.weights[i]))
60          return retval
61
62  #code to test and train using the class above
63  nn = BPNN([10,15,15,1])
64
65  lines = [np.array((file_line.rstrip('\n').split(','))).astype(float) for file_li
66  lines = np.array(lines)
67  training = np.delete(lines.T, lines.T.shape[0] - 1,0).T
68  res = lines.T[-1]
69
70  testing_lines = [np.array((file_line.rstrip('\n').split(','))).astype(float) for
71  testing_lines = np.array(testing_lines)
72  tests = np.delete(testing_lines.T, testing_lines.T.shape[0] - 1,0).T
73  actual_classes = testing_lines.T[-1]
74
75  nn.train(training, res)
76  corrects = 0.0
77  total = 0.0
78  fusout = open("fusion-files-majority/bpnn.data",'w')
79  for t,inpu in enumerate(tests):
80      total = total + 1
81      fusout.write("{}\n".format(int(round(nn.test(inpu)[0]))))
82      if int(round(nn.test(inpu)[0])) == actual_classes[t]:
83          corrects = corrects + 1
84  print "Accuracy - {}".format(corrects/total)
```

dtree.py

```
'''
dtree.py
decision tree classifier
has 9 nodes to check for each possible hand
'''
#file IO
import numpy as np
testing_lines = [np.array((file_line.rstrip('\n').split(','))).astype(int) for file_line in
testing_lines = np.array(testing_lines)
tests = np.delete(testing_lines.T, testing_lines.T.shape[0] - 1,0).T
actual_classes = testing_lines.T[-1]

#initialize
corrects = 0.0
total = 0.0

#each testing
for t,test in enumerate(tests):
    #get info sorted into suits and ranks
    total = total + 1
    ranks = []
    suits = []
    for i in range(0,10,2):
        suits.append(test[i])
        ranks.append(test[i+1])
    matches = [0]
    idx = np.argsort(ranks, axis=0)
    ranks = np.array(ranks)[idx]
    suits = np.array(suits)[idx]
    ranks = ranks.tolist()
    suits = suits.tolist()

    #is pair?
    ph = 0
    for val in ranks:
        if ranks.count(val) == 2:
            ph = 1
    if ph == 1:
        matches.append(1)

    #is two pair?
    ph = 0
    first = 0
    for val in ranks:
```

```
    if ranks.count(val) == 2:
        if first == 0:
            first = val
        elif first != val:
            ph = 1
if ph == 1:
    matches.append(2)

#is three of a kind?
ph = 0
for val in ranks:
    if ranks.count(val) == 3:
        ph = 1
if ph == 1:
    matches.append(3)

#is straight?
ph = 1
if ranks.count(1) == 1 and ranks[-1] == 13:
    for i,val in enumerate(ranks):
        if i != 0 and i != 1:
            if ranks[i] - ranks[i - 1] != 1:
                ph = 0
else:
    for i,val in enumerate(ranks):
        if i != 0:
            if ranks[i] - ranks[(i - 1)] != 1:
                ph = 0
if ph == 1:
    matches.append(4)


#is flush?
if suits.count(suits[0]) == 5:
    matches.append(5)

#is full house?
if 1 in matches and 3 in matches:
    matches.append(6)

#is four of a kind?
ph = 0
for val in ranks:
    if ranks.count(val) == 4:
        ph = 1
if ph == 1:
```

```
            matches.append(7)

        #is straight flush?
        if 4 in matches and 5 in matches:
            matches.append(8)

        #is royal flush?
        if 8 in matches and ranks[0] == 1 and ranks[-1] == 13:
            matches.append(9)

        #checking result
        result = matches[-1]
        if result == actual_classes[t]:
            corrects = corrects + 1
    print "Accuracy {}".format(corrects/total)
```

kmeans.c

```
1  /*
2   * kmeans.c
3   * Sam Neyhart
4   * This file contains the kmeans program used in the final project of
5   * ECE 471.
6   * USAGE: kmeans filename.data nclusters
7   */
8
9  #include<string.h>
10 #include<time.h>
11 #include<stdio.h>
12 #include<math.h>
13 #include<stdlib.h>
14 #include"hand.h"
15
16
17 static const int ITERATIONS = 1; //How many times to go through data
18 static const int NCLASSES = 10;
19 static const int NCARDS = 10;
20 static int NCLUSTERS;
21 static int NLINES = 0;
22
23 int main(int argc, char ** argv)
24 {
25         //----------File IO----------
26         FILE * in;
27         in = fopen(argv[1],"r");
28         if (argc != 3) return 0;
29         NCLUSTERS = atoi(argv[2]);
30         //Get numLines
31         char buf[255];
32         while(fgets(buf,255,in) != NULL){
33                 NLINES++;
34         }
35         rewind(in);
36         //create arrays
37         hand * data = malloc(NLINES*sizeof(hand));
38         hand * mu = malloc(NCLUSTERS*sizeof(hand));
39         int * clas = malloc(NLINES*sizeof(int));
40         //fill data
41         for(int i = 0; i < NLINES; i++){
42                 char * tmp;
43                 fgets(buf,255,in);
44                 tmp = strtok(buf,",");
```

```
45                  for(int j = 0; j < NCARDS; j++){
46                          data[i].cards[j] = atof(tmp);
47                          tmp = strtok(NULL,",");
48                  }
49                  clas[i]=atoi(tmp);
50          }
51          //randomly fill mu
52          time_t t;
53          srand((unsigned)time(&t));
54          for(int i = 0; i < NCLUSTERS; i++){
55                  int tmp = rand() % NLINES;
56                  for(int j = 0; j < NCARDS; j++){
57                          mu[i].cards[j] = data[tmp].cards[j];
58                  }
59          }
60
61          //---------Perform Kmeans----------
62          int *clus1 = malloc(NLINES*sizeof(int));
63          int *clus2 = malloc(NLINES*sizeof(int));
64          int flip = 0;
65          int done = 0;
66          int it = 0;
67          while (done==0){
68                  //printf("iteration %d\n",it);
69                  if (flip==0){
70                          cluster(data,mu,NLINES,NCLUSTERS,clus1);
71                          avg(mu, data, clus1,NLINES,NCLUSTERS);
72                          flip++;
73                  }else{
74                          cluster(data,mu,NLINES,NCLUSTERS,clus2);
75                          avg(mu, data, clus2,NLINES,NCLUSTERS);
76                          flip--;
77                  }
78                  if (clus_equal(clus1,clus2,NLINES))
79                          done++;
80                  it++;
81          }
82
83          //-----Deterimine Accuracy-----
84          hand *avgclas = calloc(NCLASSES,sizeof(hand));
85          hand *avgclus = calloc(NCLUSTERS,sizeof(hand));
86          avg(avgclas, data, clas, NLINES, NCLASSES);
87          avg(avgclus, data, clus1, NLINES, NCLUSTERS);
88          printf(
89                          "-------------------------------For Number of clusters %d"
90                          "-------------------------------\n",NCLUSTERS);
```

```
91          printf("Number of Iterations for Kmeans: %d\n",it);
92          printf("Avg Clusters:\n");
93          for(int i = 0; i < NCLUSTERS; i++){
94                  for(int j = 0; j < NCARDS; j++){
95                          printf("%lf ",avgclus[i].cards[j]);
96                  }
97                  printf("\n");
98          }
99          printf("\nAvg Classes:\n");
100         for(int i = 0; i < NCLASSES; i++){
101                 for(int j = 0; j < NCARDS; j++){
102                         printf("%lf ",avgclas[i].cards[j]);
103                 }
104                 printf("\n");
105         }
106         double acc;
107         acc = accuracy(NLINES,NCLUSTERS,NCLASSES,clus1,clas,avgclus,avgclas);
108         printf("\nOverall Accuracy is %lf\n\n",acc);
109
110         //---------Cleanup----------
111         free(data);
112         free(mu);
113         free(clas);
114         free(avgclas);
115         free(avgclus);
116         free(clus1);
117         free(clus2);
118         fclose(in);
119 }
```

wta.c

```
1  /*
2   * wta.c
3   * Sam Neyhart
4   * This file contains the wta program used in the final project of
5   * ECE 471.
6   * USAGE: wta filename.data nclusters
7   */
8
9  #include<string.h>
10 #include<time.h>
11 #include<stdio.h>
12 #include<math.h>
13 #include<stdlib.h>
14 #include"hand.h"
15
16
17 static const int ITERATIONS = 20; //How many times to go through data
18 static const int NCLASSES = 10;
19 static const int NCARDS = 10;
20 static int NCLUSTERS;
21 static int NLINES = 0;
22
23 int main(int argc, char ** argv)
24 {
25         //----------File IO----------
26         FILE * in;
27         in = fopen(argv[1],"r");
28         if (argc != 3) return 0;
29         NCLUSTERS = atoi(argv[2]);
30         //Get numLines
31         char buf[255];
32         while(fgets(buf,255,in) != NULL){
33                 NLINES++;
34         }
35         rewind(in);
36         //create arrays
37         hand * data = malloc(NLINES*sizeof(hand));
38         hand * mu = malloc(NCLUSTERS*sizeof(hand));
39         int * clas = malloc(NLINES*sizeof(int));
40         //fill data
41         for(int i = 0; i < NLINES; i++){
42                 char * tmp;
43                 fgets(buf,255,in);
44                 tmp = strtok(buf,",");
```

```
45                  for(int j = 0; j < NCARDS; j++){
46                          data[i].cards[j] = atof(tmp);
47                          tmp = strtok(NULL," ,");
48                  }
49                  clas[i]=atoi(tmp);
50          }
51          //randomly fill mu
52          time_t t;
53          srand((unsigned)time(&t));
54          for(int i = 0; i < NCLUSTERS; i++){
55                  int tmp = rand() % NLINES;
56                  for(int j = 0; j < NCARDS; j++){
57                          mu[i].cards[j] = data[tmp].cards[j];
58                  }
59          }
60
61          //----------Perform WTA----------
62          for(int i = 0; i < ITERATIONS; i++){
63                  for(int j=0; j<NLINES;j++){
64                          update_mu(&data[j],mu,NCLUSTERS);
65                  }
66          }
67
68          //------Deterimine Accuracy------
69          int *clus = malloc(NLINES*sizeof(int));
70          cluster(data,mu,NLINES,NCLUSTERS,clus);
71          hand *avgclas = calloc(NCLASSES,sizeof(hand));
72          hand *avgclus = calloc(NCLUSTERS,sizeof(hand));
73          avg(avgclas, data, clas, NLINES, NCLASSES);
74          avg(avgclus, data, clus, NLINES, NCLUSTERS);
75          printf(
76                          "--------------------------------For Number of clusters %d"
77                          "--------------------------------\n",NCLUSTERS);
78          printf("Avg Clusters:\n");
79          for(int i = 0; i < NCLUSTERS; i++){
80                  for(int j = 0; j < NCARDS; j++){
81                          printf("%lf ",avgclus[i].cards[j]);
82                  }
83                  printf("\n");
84          }
85          printf("\nAvg Classes:\n");
86          for(int i = 0; i < NCLASSES; i++){
87                  for(int j = 0; j < NCARDS; j++){
88                          printf("%lf ",avgclas[i].cards[j]);
89                  }
90                  printf("\n");
```

```
91              }
92              double acc;
93              acc = accuracy(NLINES,NCLUSTERS,NCLASSES,clus,clas,avgclus,avgclas);
94              printf("\nOverall Accuracy is %lf\n\n",acc);
95
96              //---------Cleanup----------
97              free(data);
98              free(mu);
99              free(clas);
100             free(clus);
101             fclose(in);
102     }
```

kohonen.c

```
1  /*
2   * kohonen.c
3   * Sam Neyhart
4   * This file contains the kohonen program used in the final project of
5   * ECE 471.
6   * USAGE: kohonen filename.data nclusters
7   */
8
9  #include<string.h>
10 #include<time.h>
11 #include<stdio.h>
12 #include<math.h>
13 #include<stdlib.h>
14 #include"hand.h"
15
16
17 static const int ITERATIONS = 6000000; //How many times to go through data
18 static const int NCLASSES = 10;
19 static const int NCARDS = 10;
20 static int NCLUSTERS;
21 static int NLINES = 0;
22
23 int main(int argc, char ** argv)
24 {
25         //----------File IO----------
26         FILE * in;
27         in = fopen(argv[1],"r");
28         if (argc != 3) return 0;
29         NCLUSTERS = atoi(argv[2]);
30         //Get numLines
31         char buf[255];
32         while(fgets(buf,255,in) != NULL){
33                 NLINES++;
34         }
35         rewind(in);
36         //create arrays
37         hand * data = malloc(NLINES*sizeof(hand));
38         hand * mu = malloc(NCLUSTERS*sizeof(hand));
39         int * clas = malloc(NLINES*sizeof(int));
40         //fill data
41         for(int i = 0; i < NLINES; i++){
42                 char * tmp;
43                 fgets(buf,255,in);
44                 tmp = strtok(buf,",");
```

```
45                  for(int j = 0; j < NCARDS; j++){
46                          data[i].cards[j] = atof(tmp);
47                          tmp = strtok(NULL,",");
48                  }
49                  clas[i]=atoi(tmp);
50          }
51          //randomly fill mu
52          time_t t;
53          srand((unsigned)time(&t));
54          for(int i = 0; i < NCLUSTERS; i++){
55                  int tmp = rand() % NLINES;
56                  for(int j = 0; j < NCARDS; j++){
57                          mu[i].cards[j] = data[tmp].cards[j];
58                  }
59          }
60
61          //----------Perform Kohonen----------
62          for(int i = 0; i < ITERATIONS; i++){
63                  kohonen_mu(&data[i%NLINES],mu,NCLUSTERS,i,ITERATIONS);
64          }
65
66          //------Deterimine Accuracy------
67          int *clus = malloc(NLINES*sizeof(int));
68          cluster(data,mu,NLINES,NCLUSTERS,clus);
69          hand *avgclas = calloc(NCLASSES,sizeof(hand));
70          hand *avgclus = calloc(NCLUSTERS,sizeof(hand));
71          avg(avgclas, data, clas, NLINES, NCLASSES);
72          avg(avgclus, data, clus, NLINES, NCLUSTERS);
73          printf(
74                          "--------------------------------For Number of clusters %d"
75                          "--------------------------------\n",NCLUSTERS);
76          printf("Avg Clusters:\n");
77          for(int i = 0; i < NCLUSTERS; i++){
78                  for(int j = 0; j < NCARDS; j++){
79                          printf("%lf ",avgclus[i].cards[j]);
80                  }
81                  printf("\n");
82          }
83          printf("\nAvg Classes:\n");
84          for(int i = 0; i < NCLASSES; i++){
85                  for(int j = 0; j < NCARDS; j++){
86                          printf("%lf ",avgclas[i].cards[j]);
87                  }
88                  printf("\n");
89          }
90          double acc;
```

```
91          acc = accuracy(NLINES,NCLUSTERS,NCLASSES, clus , clas , avgclus , avgclas );
92          printf("\nOverall Accuracy is %lf\n\n", acc);
93
94          //---------Cleanup----------
95          free(data);
96          free(mu);
97          free(clas);
98          free(clus);
99          fclose(in);
100 }
```

hand.c

```
1  /*
2   * hand.c
3   * Sam Neyhart
4   * This contains the hand struct and some related functions
5   * used in the final project of ECE 471.
6   */
7
8  #include"hand.h"
9  #include<math.h>
10 #include<stdio.h>
11
12 static const double EPSILON = 0.01;
13 static const double EPSILON_MAX = 0.05;
14
15 int clus_equal(int *c1, int *c2,int NLINES)
16 {
17         for(int i=0; i<NLINES;i++){
18                 if(c1[i]!=c2[i]){
19                         return 0;
20                 }
21         }
22         return 1;
23 }
24
25 void avg(hand *avgc, hand *data, int *c, int nl, int nc)
26 {
27         int count[nc];
28         for(int i=0; i<nc; i++)
29                 count[i]=0;
30         for(int i=0; i<nc; i++){
31                 for(int j=0; j<10; j++){
32                         avgc[i].cards[j] = 0;
33                 }
34         }
35         for(int i=0; i<nl; i++){
36                 count[c[i]]++;
37                 for(int j=0; j<10; j++){
38                         avgc[c[i]].cards[j]+= data[i].cards[j];
39                 }
40         }
41         for(int i=0; i<nc; i++){
42                 for(int j=0; j<10; j++){
43                         avgc[i].cards[j]/=count[i];
44                         if (count[i]==0)
```

```
45                                      avgc[i].cards[j]=-1;
46                      }
47              }
48      }
49
50      double accuracy(int NLINES, int nclu, int nc, int *clus, int *clas, hand *avgclu
51      {
52              int truec[nclu];
53              int count = 0;
54              printf("\n");
55              for(int i=0; i<nclu; i++){
56                      truec[i] = closest(&avgclus[i], avgclas, nc);
57                      printf("Cluster %d is class %d\n",i,truec[i]);
58              }
59              for(int i=0; i<NLINES; i++){
60                      count+=(truec[clus[i]]==clas[i]);
61              }
62              return count/(float)NLINES;
63      }
64
65      void kohonen_mu(hand *h1, hand *mu, int NCLUSTERS, int k, int kmax)
66      {
67              int close = closest(h1, mu, NCLUSTERS);
68              hand win = mu[close];
69              for(int i=0; i<NCLUSTERS; i++){
70                      hand tmp = vdiff(h1,&mu[i]);
71                      double e = EPSILON_MAX * pow(EPSILON/EPSILON_MAX,k/(double)kmax)
72                      double d = exp(-1*dist(&win,&mu[i]));
73                      tmp = scale(&tmp,e*d);
74                      for(int j=0; j < sizeof(tmp.cards)/sizeof(tmp.cards[0]); j++){
75                              mu[i].cards[j]+=tmp.cards[j];
76                      }
77              }
78      }
79
80      void update_mu(hand *h1, hand *mu, int nc)
81      {
82              int close = closest(h1, mu, nc);
83              hand tmp = vdiff(h1, &mu[close]);
84              tmp = scale(&tmp, EPSILON);
85              for(int i = 0; i < sizeof(tmp.cards)/sizeof(tmp.cards[0]); i++)
86                      mu[close].cards[i] += tmp.cards[i];
87      }
88
89      hand vdiff(hand *h1, hand *h2)
90      {
```

```
91          hand out = *h1;
92          for(int i = 0; i < sizeof(out.cards)/sizeof(out.cards[0]); i++)
93                  out.cards[i] = h1->cards[i] - h2->cards[i];
94          return out;
95  }
96
97  hand scale(hand *h1, double s)
98  {
99          hand out = *h1;
100         for(int i = 0; i < sizeof(out.cards)/sizeof(out.cards[0]); i++)
101                 out.cards[i]*=s;
102         return out;
103 }
104
105 double dist(hand *h1, hand *h2)
106 {
107         double dist = 0;
108         for(int i = 0; i<sizeof(h1->cards)/sizeof(h1->cards[0]); i++){
109                 dist += pow(fabs(h1->cards[i]-h2->cards[i]),2);
110         }
111         return sqrt(dist);
112 }
113
114 int closest(hand *h1, hand *mu, int NCLUSTERS)
115 {
116         double small = -1;
117         int closest = -1;
118         for(int i = 0; i < NCLUSTERS; i++){
119                 int tmp = dist(h1, &(mu[i]));
120                 if(small == -1 || small > tmp){
121                         small = tmp;
122                         closest = i;
123                 }
124         }
125         return closest;
126 }
127
128 void cluster(hand *data, hand *mu, int nl, int nc, int *clus)
129 {
130         for(int i=0; i<nl; i++){
131                 clus[i] = closest(&data[i],mu,nc);
132         }
133 }
```

hand.h

```
1  /*
2   * hand.h
3   * Sam Neyhart
4   * This contains the definition of the hand struct
5   * and the declarations of the relevant functions
6   * used in the final project of ECE 471.
7   */
8
9  #ifndef _hand
10 #define _hand
11 typedef struct{
12         double cards[10];
13 }hand;
14
15 hand scale(hand *h1, double s);
16 double dist(hand *h1, hand *h2);
17 hand vdiff(hand *h1, hand *h2);
18 void update_mu(hand *h1, hand *mu, int nc);
19 void kohonen_mu(hand *h1,hand *mu, int NCLUSTERS,int k,int kmax);
20 int closest(hand *h1, hand *mu, int nc);
21 void cluster(hand *data, hand *mu, int nl, int nc, int *cluster);
22 void avg(hand *avgc, hand *data, int *c, int nl, int nc);
23 double accuracy(int NLINES, int nclu, int nc, int *clus, int *clas, hand *avgclu
24 int clus_equal(int *c1, int *c2,int NLINES);
25 #endif
```

evaluation.py

```
1  # Normalizaiton
2  # Input/Output file names defined in main funciton
3  # Running simply normalizes data and writes to output file
4  # Handy data separation techniques used
5
6  import math
7  import random
8  import numpy as np
9  from numpy import linalg as LA
10 from subprocess import call
11
12 DEBUG = 0
13 CLASSINDEX = 10                    # zero-indexed
14
15 def getInputSeparated(fname):
16         #fname = 'poker-hand-training-true.data'
17         file = open(fname, 'r')                              # read file
18         #with open(fname) as f:
19                 #lines = f.read().splitlines
20         lines = file.readlines()
21         file.close()
22         classData = []
23         class0Data = []                                      # can probably d
24         class1Data = []
25         class2Data = []
26         class3Data = []
27         class4Data = []
28         class5Data = []
29         class6Data = []
30         class7Data = []
31         class8Data = []
32         class9Data = []
33         for line in lines:                                   # read elements
34                 line = line.strip()
35                 splitLine = line.split(',')
36                 classIndex = len(splitLine)-1   # max index of splitLine
37                 #print splitLine
38                 #print 'Class Index: {}'.format(classIndex)
39                 #print splitLine[classIndex]
40                 sampleData = []
41                 #sampleData.append(int(splitLine[:lenIndexSplitLine]))
42                 for j in range(classIndex):
43                         #print j
44                         sampleData.append(float(splitLine[j]))
```

```
45                  # Separate by classes
46                  if (splitLine[classIndex] == '0'):
47                          #print 'appending 0'
48                          class0Data.append(sampleData)
49                  elif(splitLine[classIndex] == '1'):
50                          class1Data.append(sampleData)
51                  elif(splitLine[classIndex] == '2'):
52                          class2Data.append(sampleData)
53                  elif(splitLine[classIndex] == '3'):
54                          class3Data.append(sampleData)
55                  elif(splitLine[classIndex] == '4'):
56                          class4Data.append(sampleData)
57                  elif(splitLine[classIndex] == '5'):
58                          class5Data.append(sampleData)
59                  elif(splitLine[classIndex] == '6'):
60                          class6Data.append(sampleData)
61                  elif(splitLine[classIndex] == '7'):
62                          class7Data.append(sampleData)
63                  elif(splitLine[classIndex] == '8'):
64                          class8Data.append(sampleData)
65                  elif(splitLine[classIndex] == '9'):
66                          class9Data.append(sampleData)
67          classData.append(np.asarray(class0Data))
68          classData.append(np.asarray(class1Data))
69          classData.append(np.asarray(class2Data))
70          classData.append(np.asarray(class3Data))
71          classData.append(np.asarray(class4Data))
72          classData.append(np.asarray(class5Data))
73          classData.append(np.asarray(class6Data))
74          classData.append(np.asarray(class7Data))
75          classData.append(np.asarray(class8Data))
76          classData.append(np.asarray(class9Data))
77          return np.asarray(classData)
78
79  def test_getInputSeparated():
80          print 'Entered test_getInputSeparated()'
81          classData = getInputSeparated('poker-hand-training-true.txt')
82          nTotal = 0
83          i = -1
84          for classSamples in classData:
85                  i += 1
86                  print 'Class {} data:'.format(i)
87                  for classSample in classSamples:
88                          print classSample
89
90  def test_getInputSeparated2():
```

```
91          print 'Entered test_getInputSeparated2()'
92          classData = getInputSeparated('poker-hand-training-true.txt')
93          print classData
94
95  # aggregates a 2-D array into a single numpy array
96  def weave(classData, classification=0):
97          weaved = []
98          largestClassSampCount = 0
99          # find the length of the longest list (the number of samples in the larg
100         for classSamples in classData:
101                 numClassSamples = len(classSamples)
102                 if numClassSamples > largestClassSampCount:
103                         largestClassSampCount = numClassSamples
104         # weave samples across all classes
105         # Kevin - I can explain this, just ask me
106         c = 0
107         samp = []
108         for i in range(largestClassSampCount):
109                 c = -1
110                 for j in range(len(classData)):
111                         c += 1
112                         classSamples = classData[j]
113                         if (i < len(classSamples)):
114                                 samp = []
115                                 for feature in classSamples[i]:
116                                         samp.append(feature)
117                                 if (classification): samp.append(c)
118                                 weaved.append(samp)
119         return np.asarray(weaved)
120
121 def test_weave():
122         fName_tr = 'poker-hand-training-true.data'
123         # Get training data
124         X0 = getInputSeparated(fName_tr)
125         X = weave(X0, 1)
126         for samp in X:
127                 print samp
128
129 def getColumnMeans(X):
130         return np.mean(X, axis=0)
131
132 def getColumnStddevs(X):
133         return np.std(X, axis=0)
134
135 def getColMeansSeparated(_XS):
136         colMeansSep = []
```

```
137         for classSamples in _XS:
138                 colMeansSep.append(getColumnMeans(classSamples))
139         return np.asarray(colMeansSep)
140
141 def getColumnStddevsSeparated(_XS):
142         colMeansSep = []
143         for classSamples in _XS:
144                 colMeansSep.append(getColumnStddevs(classSamples))
145         return np.asarray(colMeansSep)
146
147 # Normalize the given dataset
148 def normalize(X, colMeans, colStddevs):
149         nX = []
150         for sample in X:
151                 nRow = sample
152                 for i in range(len(nRow)):
153                         nRow[i] = (sample[i] - colMeans[i])/colStddevs[i]
154                 nX.append(nRow)
155         return np.asarray(nX)
156
157 # Normalize each separate class
158 def normalizeSep(XS, colMeans_all_tr, colStddevs_all_tr):
159         nXS = []
160         for classSamples in XS:
161                 nXClass = normalize(classSamples, colMeans_all_tr, colStddevs_al
162                 nXS.append(nXClass)
163         return np.asarray(nXS)
164
165 # Rebuild original data file with normalized samples (classes are not normalized
166 def rebuild(nXS, fname):
167         nOriginalData = open(fname, 'w')
168         i = -1
169         for nClassSamples in nXS:
170                 i += 1
171                 for nSamp in nClassSamples:
172                         nSampString = ''
173                         for feature in nSamp:
174                                 nSampString += str(feature) + ', '
175                         nSampString += str(i) + '\n'
176                         nOriginalData.write(nSampString)
177                         #print nSampString
178         nOriginalData.close()
179
180 # Verify correct sample classificaiton
181 def verify(sample, classification):
182         if (sample[CLASSINDEX] == classification):
```

```
183                     return 1
184             else:
185                     return 0
186             #return sample[CLASSINDEX] == classification
187
188     # Leave specified set out (stored as an empty list)
189     def combineSetsExcept(sets, exclude):
190             combined = []
191             i = -1
192             for st in sets:
193                     i += 1
194                     if i == exclude:
195                             combined.append([])
196                             continue
197                     combined.append(st)
198             return np.asarray(combined)
199
200     def combineSetsExcept2(sets, exclude):
201             combined = []
202             sampWithClass = []
203             i = -1
204             for st in sets:
205                     i += 1
206                     if i == exclude: continue
207                     for sample in st:
208                             sampWithClass = sample
209                             sampWithClass.append(i)
210                             combined.append(sampWithClass)
211             return np.asarray(combined)
212
213     # Get m randomly assigned sets
214     def getMSets(XS, m):
215             mSets = []
216             for mth in range(m):                                    # init n
217                     mSets.append([])
218             #print 'len(XS):\n{}'.format(len(XS))
219             X = weave(XS, 1)
220             n = len(X)
221
222             # Randomly divide dataset into m sets
223             randIs = random.sample(range(n), n)                     # get random ind
224             numRIs = len(randIs)
225             mMaxSize = (n / m) + n % m                              # max m
226             ri = -1
227             for _ in range(mMaxSize):                               # iterat
228                     for mthSet in range(m):                         # iterat
```

```
229                             if ((ri + 1) >= numRIs):
230                                     break
231                             else:
232                                     ri += 1
233                             mSets[mthSet].append(X[ri])                     # assign
234         return mSets
235
236 def test_getMSets():
237         fName_tr = 'poker-hand-training-true.data'
238         # Get training data
239         XS = getInputSeparated(fName_tr)
240         mSets = getMSets(XS, 10)
241
242         mSetSize = 0
243         mSetSizeCombined = 0
244         i = -1
245         for mthSet in mSets:
246                 i += 1
247                 mSetSize = len(mthSet)
248                 mSetSizeCombined += mSetSize
249                 print '{}th set:\nSize: {}'.format(i, mSetSize)
250                 for samp in mthSet:
251                         print samp
252                 print
253         print 'mSetSizeCombined: {}'.format(mSetSizeCombined)
254
255 # Placeholder for WIP code
256 def mFoldValid_devSup():
257         print '{}th set:'.format(mthSet)
258         for samp in trSet:
259                 print samp
260         print '\n\n'
261
262 # m = n?  See project requirements
263 def mFoldValid(XS, m):
264         print 'Entered mFoldValid()'
265         fName_OUT = 'm-foldValid.txt'
266         mSets = getMSets(XS, 10)
267
268         # go through sets
269         for mthSet in range(len(mSets)):
270                 te = mSets[mthSet]
271                 trS = combineSetsExcept(mSets, mthSet)                  # trS is
272                 tr = weave(trS)
273                 # Normalize tr set
274                 trColMeans = getColumnMeans(tr)
```

```
275                     trColStddevs = getColumnStddevs(tr)
276                     nTr = normalize(tr, trColMeans, trColStddevs)
277                     nTrS = normalizeSep(trS, trColMeans, trColStddevs)
278                     # Normalize te set
279                     teColMeans = getColumnMeans(te)
280                     teColStddevs = getColumnStddevs(te)
281                     nTe = normalize(trSet, teColMeans, teColStddevs)
282                     # CLASSIFY using tr
283                     #rebuild(trS, fName_OUT)
284                     #call(['knn.py'])
285                     # TEST using te
286                     #call(['knn.py'])
287
288 def test_mFoldValid():
289         print 'Entered test_mFoldValid()'
290         fName_tr = 'poker-hand-training-true.data'
291         XS = getInputSeparated(fName_tr)
292         mFoldValid(XS, 10)
293
294 def main():
295         if DEBUG: print 'Entered main()'
296         fName_IN = 'poker-hand-training-true.data'
297         #fName_IN = 'poker-hand-testing.data'
298         fName_OUT = 'poker-hand-training-true-normalized.data'
299         #fName_OUT = 'poker-hand-testing-normalized.data'
300
301         # 'X' denotes original dataset
302         # 'XS' denotes original dataset separated by class (hand type)
303         XS = getInputSeparated(fName_IN)
304         #if DEBUG: print 'XS: \n{}'.format(XS)
305         X = weave(XS)
306
307         if DEBUG: print 'X:\n{}\n\n\n'.format(X)
308         if DEBUG: print 'XS:\n{}\n\n\n'.format(XS)
309
310         # Compute un-normalized training mu & sigma for normalization
311         colMeans_all_tr = getColumnMeans(X)
312         colStddevs_all_tr = getColumnStddevs(X)
313
314         # 'nX' denotes original dataset - normalized
315         # 'nXS' denotes original dataset, separated - normalized
316         nXS = normalizeSep(XS, colMeans_all_tr, colStddevs_all_tr)
317         nX = weave(nXS)                                    # nX is both classes com
318
319         if DEBUG: print 'nX:\n{}\n\n\n'.format(nX)
320         #if DEBUG:
```

```
321             print  'nXS:\n{}'.format(nXS)
322
323             # Create normalized file
324             #rebuild(nXS, fName_OUT)
325
326             # M-fold validation
327             mfoldValid(XS, 10)
328
329
330
331 main()
332 #test_weave()
333 #test_getMSets()
334 #test_mFoldValid()
```