6COM1044-0105
Machine Learning and Neural Computing:
Data Classification Coursework

Task 1 – Data Exploration

Code can be found in Appendix

Figure 1

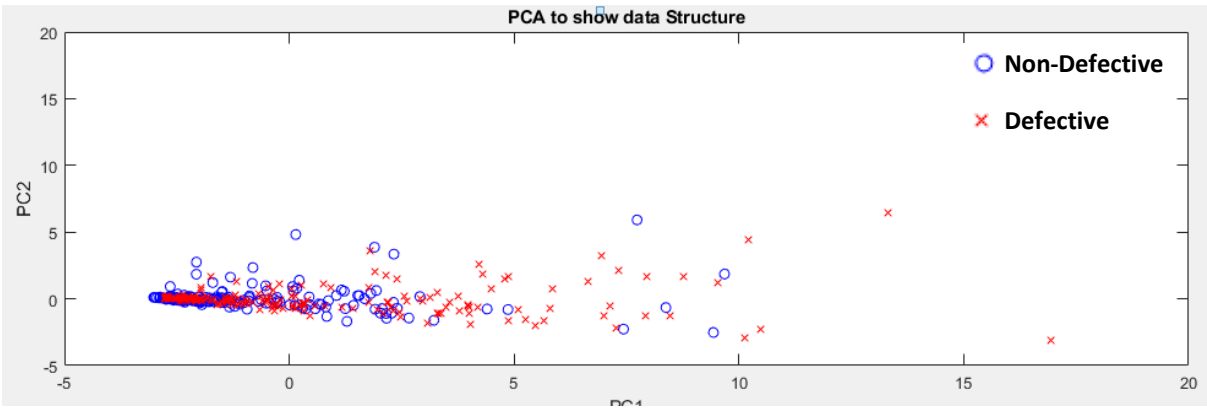
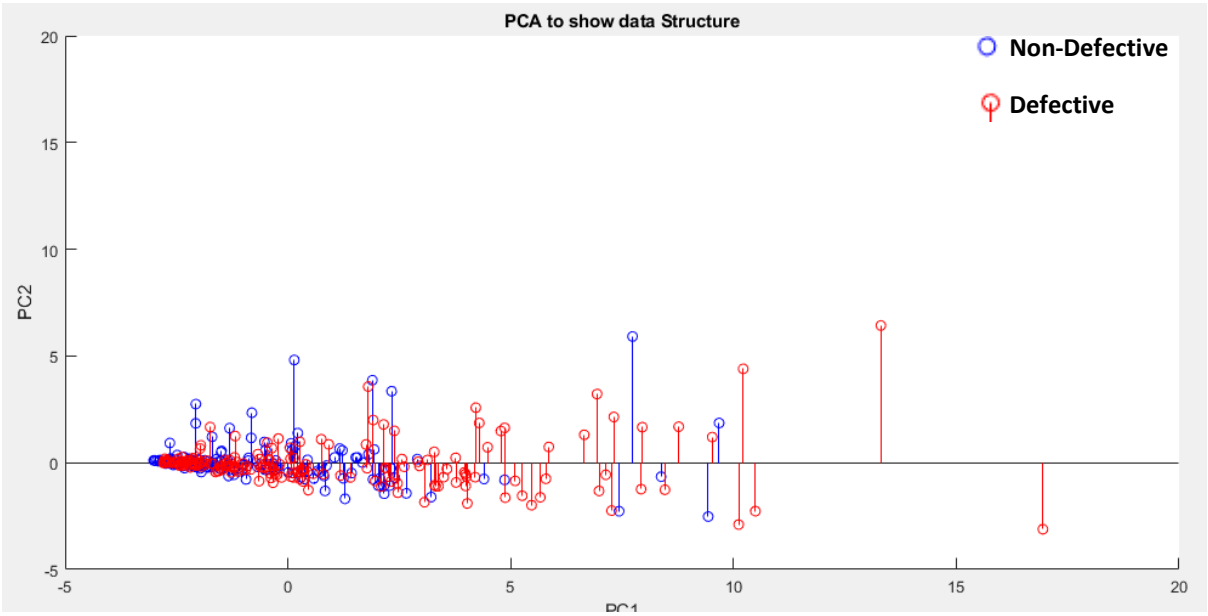


Figure 2



Critical Analysis

In Figure 1, we can observe that a big majority of the data of both classes is concentrated in a single area. Subsequently this would make it difficult for a trained model to predict and may not be always accurate. Further, it appears that the defective data is further spread out in comparison to the non-defective data and also holds both extremes for the X and Y axis which would suggest a higher variance in the defective data.

Task 2 - Normalisation

To normalise (scale) the data, I used the function svm-scale included in LibSVM as seen below in Figure 3:

Figure 3

```
C:\Docs\libsvm-3.23\windows>svm-scale -l 0 -u 1 -s range1 trainingSet.dat > NormalisedTrainingSet
C:\Docs\libsvm-3.23\windows>svm-scale -r range1 testingSet.dat > NormalisedTestingSet
```

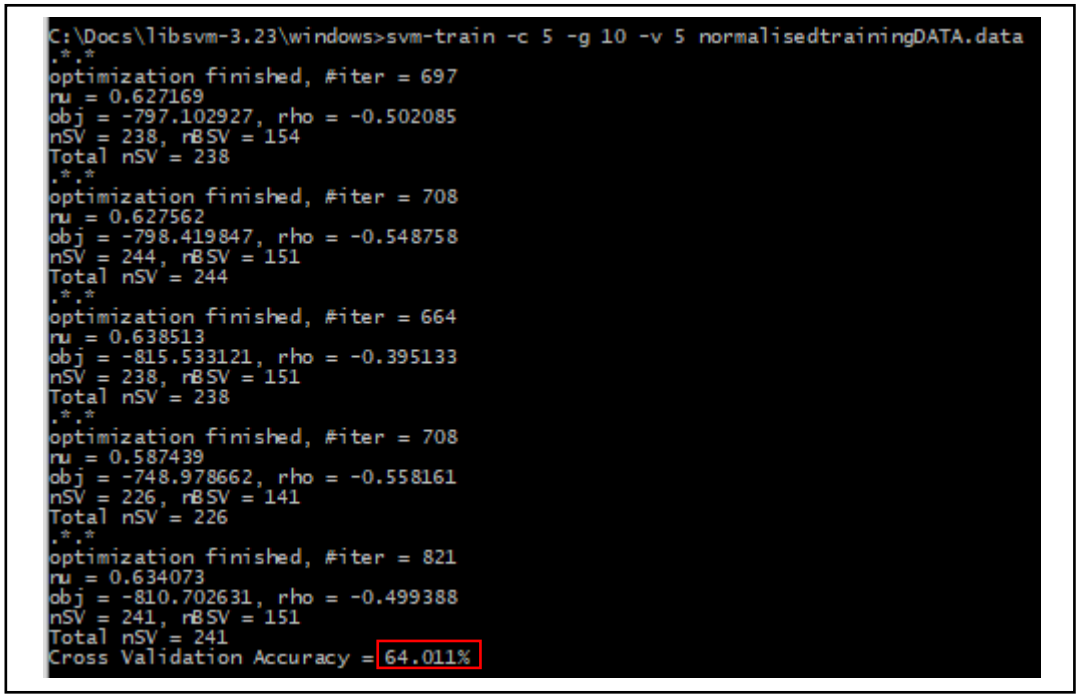
Task 3 – Cross Validation

Given parameters

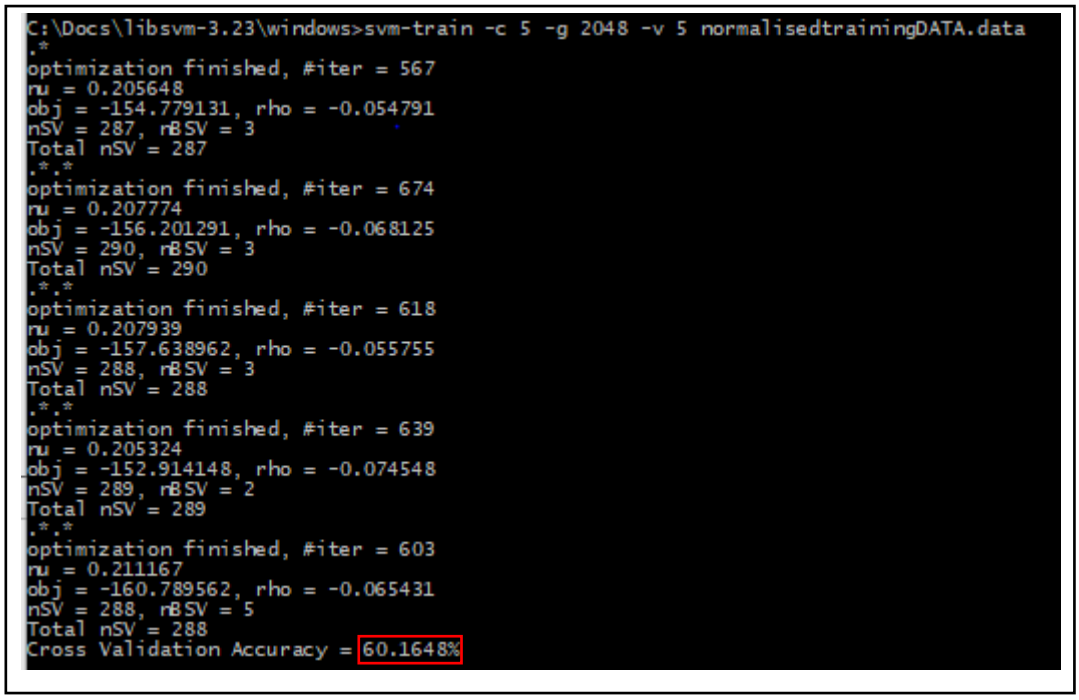
C = 5 G = 0.01 => Cross Validation Accuracy = 62.6374%

```
C:\Docs\libsvm-3.23\windows>svm-train -c 5 -g 0.01 -v 5 normalisedtrainingDATA.data
*
optimization finished, #iter = 148
nu = 0.914131
obj = -1271.290936, rho = 0.221471
nSV = 268, nBSV = 266
Total nSV = 268
*
optimization finished, #iter = 142
nu = 0.894147
obj = -1246.397824, rho = 0.131891
nSV = 262, nBSV = 260
Total nSV = 262
*
optimization finished, #iter = 147
nu = 0.931607
obj = -1289.788835, rho = 0.363748
nSV = 272, nBSV = 269
Total nSV = 272
*
optimization finished, #iter = 139
nu = 0.902791
obj = -1243.683663, rho = 0.256575
nSV = 264, nBSV = 262
Total nSV = 264
*
optimization finished, #iter = 143
nu = 0.909895
obj = -1255.701502, rho = 0.306781
nSV = 264, nBSV = 262
Total nSV = 264
Cross Validation Accuracy = 62.6374%
```

C = 5 G = 10 => Cross Validation Accuracy = 64.011%



C = 5 G =2048 => Cross Validation Accuracy = 60.1648%



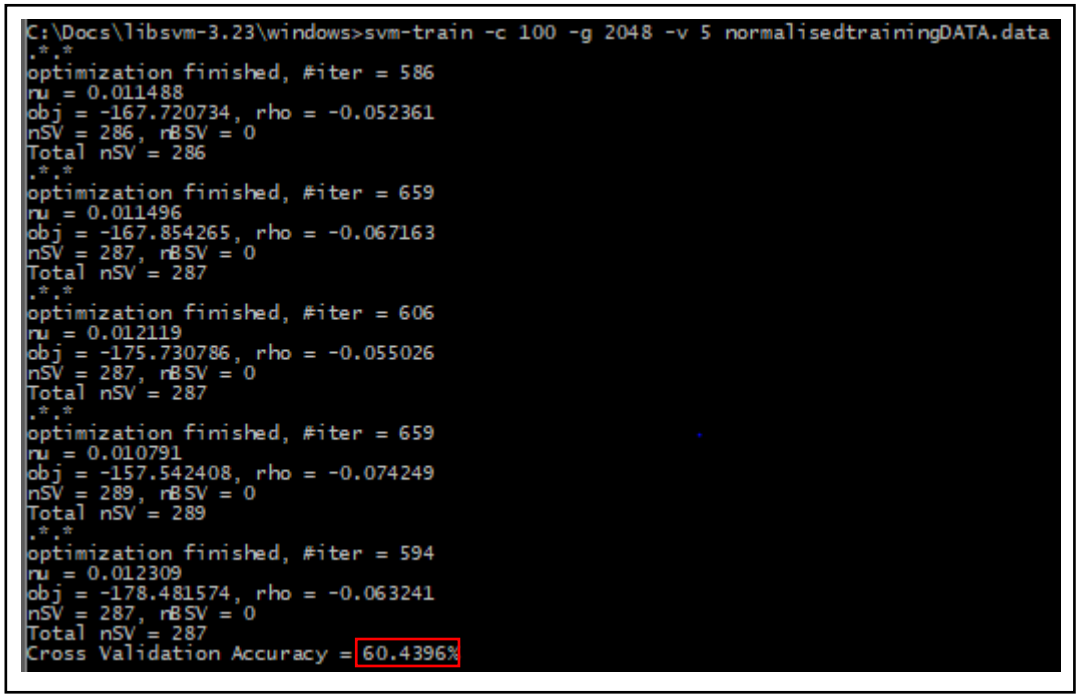
C = 100 G = 0.01 => Cross Validation Accuracy = 64.2857%

```
C:\Docs\libsvm-3.23\windows>svm-train -c 100  -g 0.01 -v 5 normalisedtrainingDATA.data
*
optimization finished, #iter = 218
nu = 0.803972
obj = -22895.294480, rho = 0.603546
nSV = 238, nBSV = 231
Total nSV = 238
*
optimization finished, #iter = 198
nu = 0.791186
obj = -22485.924287, rho = -0.204390
nSV = 233, nBSV = 228
Total nSV = 233
*
optimization finished, #iter = 208
nu = 0.816497
obj = -23027.205490, rho = 2.061166
nSV = 239, nBSV = 233
Total nSV = 239
*
optimization finished, #iter = 233
nu = 0.778597
obj = -22140.455243, rho = 2.245228
nSV = 231, nBSV = 225
Total nSV = 231
*
optimization finished, #iter = 251
nu = 0.792939
obj = -22351.516901, rho = 2.503308
nSV = 233, nBSV = 227
Total nSV = 233
Cross Validation Accuracy = 64.2857%
```

C = 100 G = 10 => Cross Validation Accuracy = 67.3077% ← Highest

```
C:\Docs\libsvm-3.23\windows>svm-train -c 100 -g 10 -v 5 normalisedtrainingDATA.data
.........*......*
optimization finished, #iter = 4103
nu = 0.400049
obj = -9903.400993, rho = -0.604524
nSV = 208, nBSV = 87
Total nSV = 208
..........*...*
optimization finished, #iter = 3977
nu = 0.383740
obj = -9374.389996, rho = -1.497119
nSV = 180, nBSV = 86
Total nSV = 180
.......*......*
optimization finished, #iter = 3794
nu = 0.429211
obj = -10487.609370, rho = -0.523273
nSV = 219, nBSV = 95
Total nSV = 219
.........*...*
optimization finished, #iter = 3739
nu = 0.379931
obj = -9455.428929, rho = -0.808721
nSV = 203, nBSV = 83
Total nSV = 203
............*......*
optimization finished, #iter = 5290
nu = 0.402891
obj = -9783.711943, rho = -1.059495
nSV = 204, nBSV = 88
Total nSV = 204
Cross Validation Accuracy = 67.3077%
```

C = 100 G = 2048 => Cross Validation Accuracy = 60.4396%



Own Parameters

Screenshots for this will be added in appendix at end of the report.

The value of G=10 gave the most accurate reading, for that reason I started experimenting with it first, keeping C at a value of 100 as that gave the most accurate reading beforehand.

. C = 100 G = 20 => Cross Validation Accuracy = 66.7582%

Outcome was lower than when G was 10 so lowered it to G = 0

C = 100 G = 0 => Cross Validation Accuracy = 65.9341%

This was even lower so decided to keep the G value in between 10 and 20 since they were the best results

C = 100 G = 15 => Cross Validation Accuracy = 67.5824%

This was the highest accuracy so far. Decided to take G = 14

C = 100 G = 14 => Cross Validation Accuracy = 66.7582%

As the accuracy for this was lower than G=15, I tried G=16 next

C = 100 G = 16 => Cross Validation Accuracy = ***67.8571%***

As this increased even more next was G=17

C = 100 G = 17 => Cross Validation Accuracy = 66.7582%

As this now decreased the most optimal value of G found was 16

Now I will be training with different C values and G being 16.

C = 150 G = 16 => Cross Validation Accuracy = 66.2088%

Lower accuracy so now attempting C =50

C = 50 G = 16 => Cross Validation Accuracy = 67.8571%

Same as C = 100 so attempted C = 25

C = 25 G = 16 => Cross Validation Accuracy = 65.6593%

Lower accuracy therefor attempting C = 75

C = 75 G = 16 => Cross Validation Accuracy = 67.5824%%

Slightly lower than C = 100 or C=50 so attempting C = 80

*C = 80 G = 16 => Cross Validation Accuracy = **68.1319%***

New highest accuracy value found all other values tested were the same or lower

Optimal Values C = 80 G = 16

Task 4 – Non-linear Classification

```
C:\Docs\libsvm-3.23\windows>svm-train -c 80 -g 16 normalisedTrainingSet normalisedTrainingModel1
.....*.....*
optimization finished, #iter = 4012
nu = 0.354629
obj = -8663.326105, rho = -0.807594
nSV = 268, nBSV = 95
Total nSV = 268
```

```
C:\Docs\libsvm-3.23\windows>svm-predict normalisedTestingSet normalisedTrainingModel1 predict
Accuracy = 57.3529% (78/136) (classification)

C:\Docs\libsvm-3.23\windows>
```

Task 5 – Classification Analysis

Code:

falsenegativeScript.m

```
testingSet = csvread('testingSet.csv',1,13,[1,13,136,13]);
load predict;

correctCount = sum([predict == testingSet]);
accuracy_rate = (correctCount / size(testingSet,1))*100;
errorPositions = find ((predict ~= testingSet)==1);

falseNeg = find ((predict == -1) & (testingSet == 1))
```

Total errors: 58

3, 7, 8, 10, 13, 14, 15, 18, 22, 24, 25, 26, 28, 31, 33, 38, 39, 40, 43, 45, 52, 53, 54, 59, 60, 61, 63, 64, 69, 72, 73, 75, 78, 83, 86, 88, 90, 91, 95, 97, 98, 103, 106, 108, 109, 114, 115, 117, 118, 121, 124, 125, 126, 128, 130, 132, 133, 135

False negatives: 37

3, 10, 13, 14, 15, 18, 22, 25, 28, 31, 38, 39, 40, 43, 45, 52, 53, 60, 61, 63, 64, 69, 72, 73, 91, 95, 97, 98, 106, 108, 109, 114, 117, 124, 125, 126, 128

Critical Analysis

Looking at the figures from Task 1 and the positions of the errors, we can see that a big majority of non-defective data were correctly classified around the large cloud of data and the defective data was correctly classified outside of it. This suggests there is a link between variance and being misclassified. Most non-defective data that was misclassified had a low variance and was mostly concentrated around the main data cloud. Defective data with high variance was mostly misclassified on the outside of the main data.

Task 6 – Linear Classification

```
C:\Docs\libsvm-3.23\windows>svm-train -t 0 -c 5 normalisedTrainingSet C5LinearModel
*
optimization finished, #iter = 319
nu = 0.773347
obj = -1379.113699, rho = 1.471498
nSV = 286, nBSV = 280
Total nSV = 286

C:\Docs\libsvm-3.23\windows>svm-train -t 0 -c 10 normalisedTrainingSet C10LinearModel
.
WARNING: using -h 0 may be faster
*
optimization finished, #iter = 597
nu = 0.764125
obj = -2714.685946, rho = 1.478319
nSV = 281, nBSV = 272
Total nSV = 281

C:\Docs\libsvm-3.23\windows>svm-train -t 0 -c 100 normalisedTrainingSet C100LinearModel
.......*...*....*
optimization finished, #iter = 5107
nu = 0.719874
obj = -25770.188339, rho = 1.380064
nSV = 266, nBSV = 255
Total nSV = 266
```

```
C:\Docs\libsvm-3.23\windows>svm-predict normalisedTestingSet C5LinearModel C5Predict
Accuracy = 61.7647% (84/136) (classification)

C:\Docs\libsvm-3.23\windows>svm-predict normalisedTestingSet C10LinearModel C10Predict
Accuracy = 60.2941% (82/136) (classification)

C:\Docs\libsvm-3.23\windows>svm-predict normalisedTestingSet C100LinearModel C100Predict
Accuracy = 61.7647% (84/136) (classification)

C:\Docs\libsvm-3.23\windows>
```

Cost = 5

Accuracy rate = 61.7646

Total Errors: 52

1,3,10,13,14,16,18,21,22,23,25,28,31,32,35,37,39,43,44,45,47,49,52,53,61,63,64,65,69,72,73,78,80,84,86,88,91,95,97,98,99,108,109,112,115,117,119,120,121,123,125,128

Total False Negatives: 44

1,3,10,13,14,16,18,21,22,23,25,28,31,32,35,37,39,43,44,45,47,49,52,53,61,63,64,65,69,72,73,80,84,91,95,97,98,99,108,109,117,120,125,128

Cost = 10

Accuracy rate = 60.2941

Total Errors: 54

1,3,10,13,14,16,18,21,22,23,25,28,31,32,35,37,39,43,44,45,47,49,52,53,60,61,63,64,65,69,72,73,78,80,84,86,88,91,95,97,98,99,108,109,112,115,117,119,120,121,123,125,127,128

Total False Negatives: 46

1,3,10,13,14,16,18,21,22,23,25,28,31,32,35,37,39,43,44,45,47,49,52,53,60,61,63,64,65,69,72,73,80,84,91,95,97,98,99,108,109,117,120,125,127,128

Cost = 100

Accuracy rate = 61.7647

Total Errors: 52

1,3,10,13,14,15,16,18,21,22,23,25,28,31,32,35,37,39,43,44,45,47,49,52,53,60,61,63,64,65,69,72,73,78,80,84,86,88,91,97,98,99,108,109,112,115,117,121,123,125,127,128

Total False Negatives: 45

1,3,10,13,14,15,16,18,21,22,23,25,28,31,32,35,37,39,43,44,45,47,49,52,53,60,61,63,64,65,69,72,73,80,84,91,97,98,99,108,109,117,125,127,128

Critical Analysis

From the 3 models above, we can see that the parameters C = 5 and C = 100 resulted in the best accuracy % and both resulted in the same amount of errors. As C = 5 produced one less False Negative and thus I would use it over the others as false negatives make up the majority of the errors and having less would make it more balanced.

Surprisingly, all 3 linear models resulted in higher accuracy rates in comparison to the Gaussian model in task 4. All linear models also had fewer overall errors 52 and 54 in comparison to the Gaussian model with 58. The Gaussian model had more of a balance between false negatives and false positives as the linear models all had a high concentration of the errors being false negatives.

As Gaussian models usually result in higher accuracy %, these results suggest that the C and γ values used in task 4 were not optimal.

Appendix:

Task 1 Code:

COURSEWORK.m | falsenegativeScript.m

```
training = csvread('trainingSet.csv',1,0,[1,0,364,12]);
dataLabels = csvread('trainingset.csv',1,13,[1,13,364,13]);
label_name = {'LOC_BLANK','BRANCH_COUNT','LOC_CODE_AND_COMMENT','LOC_COMMENTS','CYCLOMATIC_COMPLEXITY','DESIGN_COMPLEXITY',
testingLabels = csvread('testingLabels.csv')
normData = zscore(training);
testing = xlsread('testingSet.csv');
[pcvectors, pcScores, pcEigenValues] = pca(normData) ;

figure(1)
hold on
h1 = plot(pcScores(dataLabels == -1,1), pcScores(dataLabels == -1,2), 'bo');
h2 = plot(pcScores(dataLabels == 1,1), pcScores(dataLabels == 1,2), 'rx');
set(gca, 'Box','on')


figure(2)
hold on
h1 = stem(pcScores(dataLabels == -1,1), pcScores(dataLabels == -1,2), 'bo');
h2 = stem(pcScores(dataLabels == 1,1), pcScores(dataLabels == 1,2), 'ro');

normData2 = zscore(testing);

[pcvectors2, pcScores2, pcEigenValues2] = pca(normData2) ;
errors = find((predict~=testingLabels)==1);
```

Task 3 Screenshots Below

```
C:\Docs\libsvm-3.23\windows>svm-train -c 100 -g 20 -v 5 normalisedtrainingDATA.data
..........*...*
optimization finished, #iter = 4014
nu = 0.308351
obj = -7254.314027, rho = -0.865168
nSV = 219, nBSV = 62
Total nSV = 219
........*.......*
optimization finished, #iter = 4461
nu = 0.292114
obj = -6892.502813, rho = -0.908920
nSV = 213, nBSV = 58
Total nSV = 213
.......*...*
optimization finished, #iter = 2986
nu = 0.319208
obj = -7495.939126, rho = -0.613225
nSV = 224, nBSV = 64
Total nSV = 224
.........*....*
optimization finished, #iter = 3806
nu = 0.286218
obj = -6733.531214, rho = -0.780822
nSV = 219, nBSV = 54
Total nSV = 219
........*....*
optimization finished, #iter = 3504
nu = 0.306804
obj = -7061.940343, rho = -0.910246
nSV = 216, nBSV = 59
Total nSV = 216
Cross Validation Accuracy = 66.7582%

C:\Docs\libsvm-3.23\windows>svm-train -c 100 -g 0 -v 5 normalisedtrainingDATA.data
.
WARNING: using -h 0 may be faster
*
optimization finished, #iter = 466
nu = 0.767532
obj = -21507.344196, rho = 0.449159
nSV = 230, nBSV = 218
Total nSV = 230
.
WARNING: using -h 0 may be faster
*
optimization finished, #iter = 543
nu = 0.743246
obj = -20827.607953, rho = -3.957476
nSV = 223, nBSV = 211
Total nSV = 223
.*.*
optimization finished, #iter = 650
nu = 0.774409
obj = -21661.799901, rho = -2.878544
nSV = 230, nBSV = 217
Total nSV = 230
.*.*
optimization finished, #iter = 603
nu = 0.738413
obj = -20790.693680, rho = -2.922256
nSV = 225, nBSV = 209
Total nSV = 225
.*
optimization finished, #iter = 397
nu = 0.750643
obj = -21137.126399, rho = -3.153576
nSV = 224, nBSV = 215
Total nSV = 224
Cross Validation Accuracy = 65.9341%

C:\Docs\libsvm-3.23\windows>svm-train -c 100 -g 1 -v 5 normalisedtrainingDATA.data
```

```
C:\Docs\libsvm-3.23\windows>svm-train -c 100 -g 1 -v 5 normalisedtrainingDATA.data
.....*...*
optimization finished, #iter = 2521
nu = 0.632479
obj = -17376.812381, rho = -1.483210
nSV = 213, nBSV = 167
Total nSV = 213
....*.*
optimization finished, #iter = 1708
nu = 0.613096
obj = -16813.402377, rho = -1.021613
nSV = 200, nBSV = 165
Total nSV = 200
....*...*
optimization finished, #iter = 2310
nu = 0.644669
obj = -17648.576638, rho = -3.573698
nSV = 211, nBSV = 170
Total nSV = 211
....*..*
optimization finished, #iter = 1962
nu = 0.608987
obj = -16580.813826, rho = -3.278438
nSV = 206, nBSV = 161
Total nSV = 206
.....*.*
optimization finished, #iter = 1824
nu = 0.648452
obj = -17635.628038, rho = -4.447456
nSV = 212, nBSV = 173
Total nSV = 212
Cross Validation Accuracy = 64.011%

C:\Docs\libsvm-3.23\windows>svm-train -c 100 -g 15 -v 5 normalisedtrainingDATA.data
.........*.......*
optimization finished, #iter = 4921
nu = 0.345004
obj = -8333.801211, rho = -0.802866
nSV = 208, nBSV = 68
Total nSV = 208
.......*....*
optimization finished, #iter = 3455
nu = 0.329954
obj = -7919.753065, rho = -1.106604
nSV = 186, nBSV = 71
Total nSV = 186
........*.....*
optimization finished, #iter = 3901
nu = 0.359930
obj = -8660.397382, rho = -0.556403
nSV = 222, nBSV = 72
Total nSV = 222
........*....*
optimization finished, #iter = 3596
nu = 0.322225
obj = -7838.596155, rho = -0.785334
nSV = 207, nBSV = 63
Total nSV = 207
.........*.*
optimization finished, #iter = 3162
nu = 0.343376
obj = -8196.329724, rho = -0.938261
nSV = 210, nBSV = 71
Total nSV = 210
Cross Validation Accuracy = 67.5824%

C:\Docs\libsvm-3.23\windows>svm-train -c 100 -g 14 -v 5 normalisedtrainingDATA.data
........*....*
optimization finished, #iter = 3516
nu = 0.353242
obj = -8597.716187, rho = -0.784226
nSV = 205, nBSV = 73
Total nSV = 205
.........*..*
optimization finished, #iter = 3460
nu = 0.337201
obj = -8165.436284, rho = -1.190697
nSV = 183, nBSV = 75
Total nSV = 183
........*....*
optimization finished, #iter = 3726
nu = 0.371018
obj = -8946.241869, rho = -0.548050
nSV = 224, nBSV = 78
Total nSV = 224
.........*.....*
optimization finished, #iter = 4091
nu = 0.332533
obj = -8102.057180, rho = -0.782855
nSV = 204, nBSV = 65
Total nSV = 204
.......*...*
optimization finished, #iter = 2963
nu = 0.352279
obj = -8460.792730, rho = -0.955248
nSV = 208, nBSV = 74
Total nSV = 208
Cross Validation Accuracy = 66.7582%
```

```
C:\Docs\libsvm-3.23\windows>svm-train -c 100 -g 16 -v 5 normalisedtrainingDATA.data
........*....*
optimization finished, #iter = 3714
nu = 0.336303
obj = -8088.950673, rho = -0.824981
nSV = 211, nBSV = 68
Total nSV = 211
.......*.....*
optimization finished, #iter = 3584
nu = 0.322387
obj = -7685.337585, rho = -1.037867
nSV = 192, nBSV = 68
Total nSV = 192
.........*....*
optimization finished, #iter = 3958
nu = 0.350180
obj = -8397.662497, rho = -0.551701
nSV = 223, nBSV = 72
Total nSV = 223
.........*...*
optimization finished, #iter = 3579
nu = 0.314765
obj = -7594.041536, rho = -0.787299
nSV = 207, nBSV = 64
Total nSV = 207
.......*...*
optimization finished, #iter = 2990
nu = 0.335115
obj = -7947.264906, rho = -0.941163
nSV = 209, nBSV = 69
Total nSV = 209
Cross Validation Accuracy = 67.8571%

C:\Docs\libsvm-3.23\windows>svm-train -c 100 -g 17 -v 5 normalisedtrainingDATA.data
...........*...*
optimization finished, #iter = 4153
nu = 0.328807
obj = -7861.066297, rho = -0.849193
nSV = 212, nBSV = 67
Total nSV = 212
........*....*
optimization finished, #iter = 3688
nu = 0.315100
obj = -7464.621070, rho = -0.979626
nSV = 210, nBSV = 66
Total nSV = 210
.......*...*
optimization finished, #iter = 3076
nu = 0.342355
obj = -8150.930664, rho = -0.552451
nSV = 222, nBSV = 69
Total nSV = 222
.........*..........*........*
optimization finished, #iter = 7968
nu = 0.308069
obj = -7358.287105, rho = -0.793929
nSV = 213, nBSV = 60
Total nSV = 213
.......*..*
optimization finished, #iter = 2825
nu = 0.327566
obj = -7710.324323, rho = -0.936519
nSV = 209, nBSV = 65
Total nSV = 209
Cross Validation Accuracy = 66.7582%

C:\Docs\libsvm-3.23\windows>svm-train -c 150 -g 16 -v 5 normalisedtrainingDATA.data
...........*....*
optimization finished, #iter = 4656
nu = 0.310362
obj = -11084.416776, rho = -0.983853
nSV = 206, nBSV = 64
Total nSV = 206
...........*.......*
optimization finished, #iter = 5524
nu = 0.295452
obj = -10504.929868, rho = -1.084119
nSV = 185, nBSV = 59
Total nSV = 185
.........*......*
optimization finished, #iter = 4448
nu = 0.324228
obj = -11541.892592, rho = -0.646706
nSV = 219, nBSV = 63
Total nSV = 219
...........*.....*
optimization finished, #iter = 4900
nu = 0.292247
obj = -10411.984935, rho = -0.872840
nSV = 208, nBSV = 57
Total nSV = 208
.........*.....*
optimization finished, #iter = 4407
nu = 0.309857
obj = -10849.262441, rho = -1.051777
nSV = 193, nBSV = 60
Total nSV = 193
Cross Validation Accuracy = 66.2088%
```

```
C:\Docs\libsvm-3.23\windows>svm-train -c 50 -g 16 -v 5 normalisedtrainingDATA.data
.....*...*
optimization finished, #iter = 2409
nu = 0.382574
obj = -4662.260872, rho = -0.638957
nSV = 219, nBSV = 81
Total nSV = 219
....*..*
optimization finished, #iter = 1932
nu = 0.366134
obj = -4450.343732, rho = -0.894758
nSV = 215, nBSV = 83
Total nSV = 215
.....*....*
optimization finished, #iter = 2810
nu = 0.409950
obj = -4863.030954, rho = -0.506410
nSV = 229, nBSV = 86
Total nSV = 229
.....*..*
optimization finished, #iter = 2256
nu = 0.359125
obj = -4372.441807, rho = -0.678322
nSV = 219, nBSV = 75
Total nSV = 219
......*..*
optimization finished, #iter = 2555
nu = 0.383322
obj = -4605.062824, rho = -0.813200
nSV = 222, nBSV = 79
Total nSV = 222
Cross Validation Accuracy = 67.8571%

C:\Docs\libsvm-3.23\windows>svm-train -c 75 -g 16 -v 5 normalisedtrainingDATA.data
........*..*
optimization finished, #iter = 3154
nu = 0.354856
obj = -6445.729538, rho = -0.741927
nSV = 214, nBSV = 74
Total nSV = 214
.....*....*
optimization finished, #iter = 2731
nu = 0.340188
obj = -6140.019365, rho = -0.989478
nSV = 204, nBSV = 75
Total nSV = 204
......*....*
optimization finished, #iter = 2910
nu = 0.371582
obj = -6687.159314, rho = -0.535970
nSV = 225, nBSV = 76
Total nSV = 225
.......*..*
optimization finished, #iter = 2864
nu = 0.332076
obj = -6041.001473, rho = -0.741691
nSV = 212, nBSV = 64
Total nSV = 212
......*..*
optimization finished, #iter = 2573
nu = 0.354135
obj = -6346.793145, rho = -0.876600
nSV = 216, nBSV = 75
Total nSV = 216
Cross Validation Accuracy = 67.5824%

C:\Docs\libsvm-3.23\windows>svm-train -c 25 -g 16 -v 5 normalisedtrainingDATA.data
...*..*
optimization finished, #iter = 1488
nu = 0.438237
obj = -2672.434168, rho = -0.509453
nSV = 231, nBSV = 96
Total nSV = 231
...*..*
optimization finished, #iter = 1463
nu = 0.431044
obj = -2575.741731, rho = -0.740546
nSV = 226, nBSV = 96
Total nSV = 226
...*.*
optimization finished, #iter = 1208
nu = 0.456013
obj = -2797.552839, rho = -0.429486
nSV = 228, nBSV = 102
Total nSV = 228
....*...*
optimization finished, #iter = 2185
nu = 0.409110
obj = -2507.616075, rho = -0.600032
nSV = 227, nBSV = 86
Total nSV = 227
....*..*
optimization finished, #iter = 1809
nu = 0.446982
obj = -2663.042601, rho = -0.690251
nSV = 227, nBSV = 90
Total nSV = 227
Cross Validation Accuracy = 65.6593%
```

```
C:\Docs\libsvm-3.23\windows>svm-train -c 80 -g 16 -v 5 normalisedtrainingDATA.data
........*..*
optimization finished, #iter = 3155
nu = 0.351138
obj = -6783.946878, rho = -0.756858
nSV = 213, nBSV = 71
Total nSV = 213
......*..*
optimization finished, #iter = 2586
nu = 0.336337
obj = -6459.176321, rho = -1.001576
nSV = 194, nBSV = 73
Total nSV = 194
.......*..*
optimization finished, #iter = 2895
nu = 0.366433
obj = -7037.852634, rho = -0.542012
nSV = 222, nBSV = 76
Total nSV = 222
.......*...*
optimization finished, #iter = 2990
nu = 0.327530
obj = -6359.708625, rho = -0.753798
nSV = 211, nBSV = 64
Total nSV = 211
......*..*
optimization finished, #iter = 2563
nu = 0.350133
obj = -6676.570157, rho = -0.885319
nSV = 215, nBSV = 74
Total nSV = 215
Cross Validation Accuracy = 68.1319%

C:\Docs\libsvm-3.23\windows>svm-train -c 84 -g 16 -v 5 normalisedtrainingDATA.data
.......*......*
optimization finished, #iter = 3805
nu = 0.347842
obj = -7050.663647, rho = -0.768806
nSV = 212, nBSV = 69
Total nSV = 212
.......*..*
optimization finished, #iter = 2778
nu = 0.333402
obj = -6710.518100, rho = -1.008197
nSV = 191, nBSV = 71
Total nSV = 191
........*....*
optimization finished, #iter = 3566
nu = 0.362868
obj = -7315.032319, rho = -0.544153
nSV = 223, nBSV = 74
Total nSV = 223
........*...*
optimization finished, #iter = 3326
nu = 0.324385
obj = -6611.830902, rho = -0.761531
nSV = 211, nBSV = 64
Total nSV = 211
.......*..*
optimization finished, #iter = 2822
nu = 0.346654
obj = -6936.546989, rho = -0.893068
nSV = 215, nBSV = 73
Total nSV = 215
Cross Validation Accuracy = 68.1319%

C:\Docs\libsvm-3.23\windows>svm-train -c 85 -g 16 -v 5 normalisedtrainingDATA.data
.......*....*
optimization finished, #iter = 3480
nu = 0.347054
obj = -7116.870819, rho = -0.771956
nSV = 212, nBSV = 69
Total nSV = 212
.......*...*
optimization finished, #iter = 2934
nu = 0.332665
obj = -6772.839154, rho = -1.010102
nSV = 191, nBSV = 71
Total nSV = 191
........*....*
optimization finished, #iter = 3506
nu = 0.361990
obj = -7383.880956, rho = -0.544367
nSV = 223, nBSV = 73
Total nSV = 223
........*...*
optimization finished, #iter = 3430
nu = 0.323652
obj = -6674.453232, rho = -0.763345
nSV = 211, nBSV = 64
Total nSV = 211
........*..*
optimization finished, #iter = 3146
nu = 0.345820
obj = -7001.079921, rho = -0.895027
nSV = 215, nBSV = 72
Total nSV = 215
Cross Validation Accuracy = 68.1319%
```

```
C:\Docs\libsvm-3.23\windows>svm-train -c 90 -g 16 -v 5 normalisedtrainingDATA.data
.........*.....*
optimization finished, #iter = 3810
nu = 0.343352
obj = -7445.099526, rho = -0.787247
nSV = 213, nBSV = 69
Total nSV = 213
.........*...*
optimization finished, #iter = 3388
nu = 0.329191
obj = -7081.497258, rho = -1.020846
nSV = 192, nBSV = 71
Total nSV = 192
.........*.....*
optimization finished, #iter = 3954
nu = 0.357608
obj = -7725.729989, rho = -0.548463
nSV = 223, nBSV = 72
Total nSV = 223
.........*......*
optimization finished, #iter = 4252
nu = 0.320172
obj = -6985.119672, rho = -0.771967
nSV = 210, nBSV = 63
Total nSV = 210
.......*...*
optimization finished, #iter = 2971
nu = 0.341895
obj = -7321.054707, rho = -0.907859
nSV = 211, nBSV = 71
Total nSV = 211
Cross Validation Accuracy = 68.1319%

C:\Docs\libsvm-3.23\windows>svm-train -c 95 -g 16 -v 5 normalisedtrainingDATA.data
.........*.....*
optimization finished, #iter = 3959
nu = 0.339628
obj = -7769.009914, rho = -0.805150
nSV = 212, nBSV = 67
Total nSV = 212
.........*.....*
optimization finished, #iter = 3530
nu = 0.325677
obj = -7385.481158, rho = -1.028289
nSV = 192, nBSV = 69
Total nSV = 192
.........*...*
optimization finished, #iter = 3603
nu = 0.353680
obj = -8063.667557, rho = -0.550970
nSV = 223, nBSV = 71
Total nSV = 223
.........*.....*
optimization finished, #iter = 3728
nu = 0.317130
obj = -7291.818956, rho = -0.778901
nSV = 209, nBSV = 63
Total nSV = 209
.......*...*
optimization finished, #iter = 3114
nu = 0.338483
obj = -7636.388614, rho = -0.926206
nSV = 210, nBSV = 71
Total nSV = 210
Cross Validation Accuracy = 68.1319%

C:\Docs\libsvm-3.23\windows>svm-train -c 100 -g 16 -v 5 normalisedtrainingDATA.data
.........*.....*
optimization finished, #iter = 3714
nu = 0.336303
obj = -8088.950673, rho = -0.824981
nSV = 211, nBSV = 68
Total nSV = 211
.......*.....*
optimization finished, #iter = 3584
nu = 0.322387
obj = -7685.337585, rho = -1.037867
nSV = 192, nBSV = 68
Total nSV = 192
.........*.....*
optimization finished, #iter = 3958
nu = 0.350180
obj = -8397.662497, rho = -0.551701
nSV = 223, nBSV = 72
Total nSV = 223
.........*...*
optimization finished, #iter = 3579
nu = 0.314765
obj = -7594.041536, rho = -0.787299
nSV = 207, nBSV = 64
Total nSV = 207
.......*...*
optimization finished, #iter = 2990
nu = 0.335115
obj = -7947.264906, rho = -0.941163
nSV = 209, nBSV = 69
Total nSV = 209
Cross Validation Accuracy = 67.8571%
```

```
C:\Docs\libsvm-3.23\windows>svm-train -c 99 -g 16 -v 5 normalisedtrainingDATA.data
.........*....*
optimization finished, #iter = 3946
nu = 0.336909
obj = -8025.288396, rho = -0.820658
nSV = 211, nBSV = 68
Total nSV = 211
.......*....*
optimization finished, #iter = 3417
nu = 0.323029
obj = -7625.689894, rho = -1.035878
nSV = 191, nBSV = 68
Total nSV = 191
........*......*
optimization finished, #iter = 4068
nu = 0.350847
obj = -8331.180341, rho = -0.551658
nSV = 223, nBSV = 71
Total nSV = 223
.........*..*
optimization finished, #iter = 3367
nu = 0.315209
obj = -7533.976579, rho = -0.785596
nSV = 207, nBSV = 64
Total nSV = 207
.......*..*
optimization finished, #iter = 2834
nu = 0.335794
obj = -7885.427116, rho = -0.938119
nSV = 209, nBSV = 70
Total nSV = 209
Cross Validation Accuracy = 67.8571%

C:\Docs\libsvm-3.23\windows>svm-train -c 79 -g 16 -v 5 normalisedtrainingDATA.data
........*...*
optimization finished, #iter = 3451
nu = 0.351976
obj = -6716.784991, rho = -0.754147
nSV = 213, nBSV = 72
Total nSV = 213
.....*..*
optimization finished, #iter = 2295
nu = 0.337055
obj = -6395.793558, rho = -0.999544
nSV = 197, nBSV = 73
Total nSV = 197
.......*....*
optimization finished, #iter = 3293
nu = 0.367337
obj = -6968.070741, rho = -0.541096
nSV = 223, nBSV = 76
Total nSV = 223
........*..*
optimization finished, #iter = 3211
nu = 0.328393
obj = -6296.277452, rho = -0.751358
nSV = 211, nBSV = 64
Total nSV = 211
......*..*
optimization finished, #iter = 2587
nu = 0.350907
obj = -6611.081675, rho = -0.883860
nSV = 215, nBSV = 74
Total nSV = 215
Cross Validation Accuracy = 68.1319%
```