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EE 573 Pattern Recognition - Project 5 Report

Introduction

For both part 1 and 2, one-against-one method with voting is used. Only the positive samples are considered.

PART 1: Ho-Kashyap Procedure

In this part, optimal hyperplane parameters a and b are given in Appendix. The equation of the resulting hyperplanes can be constructed using each column of table 'a' as follows:

$$a_0 + \sum_{i=1}^{8} a_i x_i = 0$$

where each x_i corresponds to features.

The resulting metrics without normalizing the patterns by using 'Basic' Ho-Kashyap procedure taking $b_{min} = 0.1$ and $\eta = 1$ as follows:

```
metrics.ho_kashyap

ans =

   4×4 table

     tp_plus_fp     tp_plus_fn     recall      precision
_____________    _____________    ________    _________

          58               59       0.98305           1
           6                6             1           1
          46               42             1     0.91304
          13               16        0.8125           1
```

Then, after normalizing the positive samples and by using 'Basic' Ho-Kashyap procedure with $b_{min} = 10$ and $\eta = 1$, the performance metrics are as follows:

```
metrics.ho_kashyap
ans =
  4×4 table
    tp_plus_fp     tp_plus_fn       recall       precision
    ___________    ___________    ___________    ___________
    6.1000e+01     5.9000e+01     1.0000e+00     9.6721e-01
    5.0000e+00     6.0000e+00     8.3333e-01     1.0000e+00
    4.3000e+01     4.2000e+01     9.7619e-01     9.5349e-01
    1.4000e+01     1.6000e+01     8.7500e-01     1.0000e+00
```

PART 2: SVM Procedure

In this part, one-against-one method with voting is used as well.

The resulting metrics by using 'Gaussian' kernel of size 10 and a 'Perceptron' solver of slack 0.1 is as follows:

```
metrics.svm_one_ag_one

ans =
   4×4 table

     tp_plus_fp     tp_plus_fn     recall      precision
_____________    _____________    ________    _________

          62               59             1      0.95161
          16                6       0.83333       0.3125
          32               42        0.7381      0.96875
          13               16         0.625      0.76923
```

After normalizing the data and by using 'Gaussian' kernel of size 0.1 and a 'Perceptron' solver of slack 0.01 is as follows:

```
metrics.svm_one_ag_one
ans =
    4×4 table
      tp_plus_fp     tp_plus_fn       recall       precision
      ___________    ___________    ____________    ____________

      5.9000e+01     5.9000e+01     1.0000e+00      1.0000e+00
      5.0000e+00     6.0000e+00     8.3333e-01      1.0000e+00
      4.2000e+01     4.2000e+01     9.7619e-01      9.7619e-01
      1.7000e+01     1.6000e+01     1.0000e+00      9.4118e-01
```

Comparison of the two approaches

Without normalizing the patterns, Ho-Kashyap performed better than SVM. After normalizing, it is the opposite. Overall, both algorithms perform well. It is weird that for each class pair SVM algorithm finds all the sample vectors to be support vector. However, SVM performs well with an accuracy of 0.98. This fact seems like a red flag, but our voting approach may be compensating this weakness.

References

SVM.m, Ho_Kashyap.m and process_params.m functions in DHS toolbox are used in this project.

Appendix

```
>> a

a =

  9×6 table
```

w_i=2 w_j=1	w_i=3 w_j=1	w_i=3 w_j=2	w_i=4 w_j=1	w_i=4 w_j=2	w_i=4 w_j=3
-2.7690e+00	-7.3598e+01	-1.1093e+01	-1.6033e+01	-1.1994e+01	-9.2042e+00
3.2861e-01	2.7041e-01	-1.0673e-01	1.2004e-01	-3.9549e-02	3.8316e-01
-4.9182e-03	2.2870e-02	1.8351e-03	5.6941e-04	3.3449e-03	3.2441e-03
-7.4484e-03	-2.7639e-03	7.2106e-04	1.6058e-03	7.1163e-03	7.6739e-04
1.1927e-03	8.0185e-03	9.1825e-04	-8.9624e-04	1.6852e-03	8.5241e-05
-5.6348e-03	7.8413e-03	2.0801e-03	1.7247e-03	7.4676e-04	-2.1685e-03
-6.9973e-02	-2.6177e-01	3.3043e-02	6.3057e-04	1.6540e-02	-1.6732e-02
2.7955e-02	9.8156e-02	1.4169e-03	-3.2377e-02	-1.7976e-03	-1.7560e-02
-8.9421e-01	4.1864e+00	8.2192e-01	1.1248e-02	-3.3624e-01	-3.3482e+00

```
>> displayWholeObj(b)

b =

  76×6 table
```

w_i=2 w_j=1	w_i=3 w_j=1	w_i=3 w_j=2	w_i=4 w_j=1	w_i=4 w_j=2	w_i=4 w_j=3
2.2012e+00	1.0000e+00	2.0178e+00	1.0000e+00	1.7512e+00	2.8827e+00
4.1262e+00	4.6218e+00	1.3560e+00	1.5565e+00	1.1591e+00	3.1166e+00
4.3910e+00	1.1299e+01	1.6995e+00	3.4652e+00	1.3840e+00	1.0652e+00
4.2532e+00	1.0833e+01	1.3061e+00	3.3643e+00	1.4330e+00	1.0898e+00
3.9754e+00	7.9145e+00	1.0000e+00	2.0707e+00	1.0000e+00	1.3600e+00
3.3217e+00	1.1151e+01	1.1602e+00	2.4258e+00	1.0000e+00	1.3461e+00
4.5489e+00	1.1427e+01	1.5832e+00	3.0224e+00	1.5156e+00	1.3482e+00
1.8785e+00	2.9888e+00	2.0851e+00	1.1872e+00	1.4141e+00	1.7661e+00
1.0000e+00	3.2961e+00	1.2189e+00	1.1274e+00	1.1479e+00	1.6748e+00
2.4217e+00	3.8326e+00	1.7966e+00	1.3336e+00	1.5104e+00	2.4981e+00
1.8368e+00	4.0967e+00	1.3114e+00	1.2991e+00	1.3137e+00	1.6727e+00

2.4363e+00	2.3708e+00	1.0428e+00	1.0435e+00	1.0000e+00	1.8590e+00
1.8207e+00	6.9466e+00	1.0162e+00	1.9987e+00	1.0000e+00	1.8590e+00
2.7522e+00	4.7666e+00	1.1038e+00	1.6293e+00	1.3354e+00	2.0853e+00
3.6631e+00	1.9819e+00	1.5787e+00	1.0819e+00	1.1715e+00	1.9054e+00
2.3229e+00	6.6420e+00	1.0000e+00	1.9435e+00	2.0127e+00	1.9054e+00
1.2660e+00	5.5087e+00	1.1337e+00	2.2730e+00	1.0000e+00	1.1263e+00
2.5382e+00	4.3696e+00	1.1691e+00	1.4788e+00	1.0000e+00	1.0000e+00
1.6668e+00	4.2354e+00	1.5454e+00	1.6261e+00	1.0126e+00	1.0000e+00
2.7047e+00	6.2258e+00	1.5740e+00	1.7768e+00	1.2044e+00	1.1776e+00
1.7922e+00	6.8768e+00	1.3071e+00	1.9330e+00	1.8034e+00	1.6508e+00
1.3342e+00	3.8840e+00	1.2184e+00	1.2538e+00	1.8355e+00	1.1337e+00
1.8374e+00	1.8143e+00	1.9774e+00	1.1206e+00	1.2323e+00	1.5904e+00
1.9924e+00	4.5030e+00	1.2269e+00	1.5171e+00	1.4970e+00	1.0193e+00
2.0276e+00	8.6321e+00	1.3004e+00	2.1003e+00	1.0520e+00	1.4463e+00
2.6895e+00	3.5649e+00	1.3004e+00	1.5032e+00	NaN	1.6047e+00
2.2774e+00	1.0000e+00	1.4430e+00	1.6320e+00	NaN	2.1361e+00
1.3549e+00	3.4826e+00	1.7780e+00	1.0000e+00	NaN	1.0000e+00
1.0000e+00	1.0196e+01	1.7780e+00	2.8124e+00	NaN	1.1075e+00
1.4690e+00	7.0699e+00	1.3436e+00	1.5872e+00	NaN	2.9169e+00
1.0000e+00	1.0000e+00	1.0000e+00	1.5940e+00	NaN	1.0000e+00
1.2984e+00	3.4019e+00	1.0968e+00	1.1908e+00	NaN	2.4884e+00
1.4690e+00	7.0699e+00	1.1551e+00	1.5872e+00	NaN	1.7603e+00
1.4690e+00	7.0699e+00	1.0895e+00	1.5872e+00	NaN	2.2137e+00
1.0000e+00	1.0000e+00	1.0000e+00	1.5940e+00	NaN	1.4122e+00
1.2984e+00	3.4019e+00	1.0499e+00	1.1908e+00	NaN	NaN
1.0000e+00	1.0000e+00	NaN	1.5940e+00	NaN	NaN
1.2984e+00	3.4019e+00	NaN	1.1908e+00	NaN	NaN
1.7010e+00	4.3460e+00	NaN	1.3611e+00	NaN	NaN
1.1787e+00	3.2662e+00	NaN	1.3943e+00	NaN	NaN
2.1042e+00	4.7237e+00	NaN	1.6544e+00	NaN	NaN
2.7488e+00	7.8666e+00	NaN	2.1425e+00	NaN	NaN
2.9130e+00	1.0000e+00	NaN	1.0535e+00	NaN	NaN
1.5352e+00	1.0788e+00	NaN	1.0000e+00	NaN	NaN
1.5638e+00	2.1516e+00	NaN	1.0458e+00	NaN	NaN
4.0242e+00	1.0711e+01	NaN	3.0407e+00	NaN	NaN
2.3806e+00	2.7657e+00	NaN	1.3378e+00	NaN	NaN
1.1733e+00	3.3264e+00	NaN	1.5267e+00	NaN	NaN
1.1733e+00	3.3264e+00	NaN	1.5267e+00	NaN	NaN
1.1733e+00	3.3264e+00	NaN	1.5267e+00	NaN	NaN

1.0000e+00	4.3935e+00	NaN	1.7348e+00	NaN	NaN
1.0000e+00	4.3935e+00	NaN	1.7348e+00	NaN	NaN
4.1777e+00	5.1601e+00	NaN	1.3169e+00	NaN	NaN
1.0000e+00	1.0000e+00	NaN	1.0000e+00	NaN	NaN
3.0140e+00	1.0000e+00	NaN	1.0663e+00	NaN	NaN
1.7863e+00	5.0268e+00	NaN	1.9244e+00	NaN	NaN
4.4228e+00	6.1028e+00	NaN	1.7959e+00	NaN	NaN
1.0000e+00	5.7441e+00	NaN	1.0000e+00	NaN	NaN
1.4546e+00	5.9371e+00	NaN	1.0035e+00	NaN	NaN
2.2791e+00	5.3373e+00	NaN	1.5867e+00	NaN	NaN
2.2769e+00	3.5297e+00	NaN	1.0000e+00	NaN	NaN
1.4066e+00	5.8558e+00	NaN	1.0208e+00	NaN	NaN
1.5272e+00	1.3149e+00	NaN	1.4650e+00	NaN	NaN
1.0000e+00	4.5254e+00	NaN	1.3248e+00	NaN	NaN
1.1428e+00	2.7042e+00	NaN	1.0346e+00	NaN	NaN
1.3768e+00	2.7042e+00	NaN	NaN	NaN	NaN
NaN	4.6592e+00	NaN	NaN	NaN	NaN
NaN	2.6460e+00	NaN	NaN	NaN	NaN
NaN	2.6460e+00	NaN	NaN	NaN	NaN
NaN	4.0270e+00	NaN	NaN	NaN	NaN
NaN	4.7542e+00	NaN	NaN	NaN	NaN
NaN	4.2085e+00	NaN	NaN	NaN	NaN
NaN	5.2877e+00	NaN	NaN	NaN	NaN
NaN	5.0724e+00	NaN	NaN	NaN	NaN
NaN	7.1363e+00	NaN	NaN	NaN	NaN
NaN	4.1569e+00	NaN	NaN	NaN	NaN