McGill University

Assignment 2

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1 Generating DS1

The code explains this step clearly. The data is shuffled and then output to DS1_test and DS1_train. The test set contains 1200 examples (600 positive, 600 negative), and the train set contains 2800 examples (1400 positive, 1400 negative).

2 Probabilistic LDA Model

Using the data generated in Question 1, the parameters of the probabilistic LDA model were found and used to calculate the coefficients w_0 and $\mathbf{w}$:

$$w_0 = -27.22691891296201$$

$$\mathbf{w} = \begin{bmatrix} -14.35081404 \\ 8.51556309 \\ 5.75326526 \\ 3.21580021 \\ 9.56280808 \\ 4.26881422 \\ -17.11861584 \\ 23.83916969 \\ 29.0419213 \\ -9.05879699 \\ 13.18260588 \\ 12.4169004 \\ -15.51799165 \\ -12.95808369 \\ 5.72465615 \\ -12.90280764 \\ -29.42539436 \\ 6.57706464 \\ 0.6836093 \\ 4.99936544 \end{bmatrix} \tag{1}$$

These coefficients were used to obtain the following metrics from the test set:

Metric	Score
Accuracy	0.9525
Precision	0.95
Recall	0.95477
F-Measure	0.95238

3 K Nearest Neighbors

Odd k values from 1 to 99 inclusive were tested. KNN performs significantly worse than the linear model for all values of k tested. Here is a plot of K vs the four metrics:

The best k for accuracy and recall was 77. The best k for precision and F-score was 17. It is clear from the plot that certain values of K perform better than others, but all are much worse when compared to the linear model.

The raw scores for all k is shown below, with k=17 and k=77 rows bolded:

K value	Accuracy	Precision	Recall	F-Measure
1	0.52917	0.51333	0.53012	0.52159
3	0.53833	0.53833	0.53833	0.53833
5	0.52000	0.53667	0.51935	0.52787
7	0.54083	0.55667	0.53958	0.54799
9	0.55083	0.55500	0.55041	0.55270
11	0.55167	0.57000	0.54984	0.55974
13	0.56417	0.56667	0.56385	0.56525
15	0.56500	0.56000	0.56566	0.56281
17	0.56417	**0.57833**	0.56240	**0.57025**
19	0.56167	0.56833	0.56086	0.56457
21	0.56333	0.57000	0.56250	0.56623
23	0.55333	0.55833	0.55281	0.55556
25	0.54250	0.53833	0.54286	0.54059
27	0.54667	0.53667	0.54762	0.54209
29	0.55667	0.54667	0.55782	0.55219
31	0.56333	0.55667	0.56419	0.56040
33	0.54917	0.53667	0.55043	0.54346
35	0.55750	0.54167	0.55938	0.55038
37	0.55583	0.53667	0.55806	0.54715
39	0.55083	0.52667	0.55342	0.53971
41	0.55000	0.53167	0.55190	0.54160
43	0.54583	0.52000	0.54833	0.53379
45	0.54750	0.52167	0.55009	0.53550
47	0.54583	0.51667	0.54867	0.53219
49	0.55667	0.52333	0.56071	0.54138
51	0.55167	0.51500	0.55576	0.53460
53	0.55667	0.53000	0.55986	0.54452
55	0.55917	0.53167	0.56261	0.54670
57	0.55583	0.53000	0.55888	0.54405
59	0.55583	0.52833	0.55908	0.54327
61	0.56333	0.53667	0.56690	0.55137
63	0.57500	0.54667	0.57951	0.56261
65	0.57500	0.53833	0.58094	0.55882
67	0.57500	0.54333	0.58007	0.56110
69	0.57750	0.54667	0.58259	0.56406
71	0.57833	0.54667	0.58363	0.56454
73	0.57250	0.53500	0.57838	0.55584
75	0.57000	0.53333	0.57554	0.55363
77	**0.57917**	0.54333	**0.58528**	0.56353
79	0.56250	0.52833	0.56708	0.54702
81	0.56250	0.52667	0.56732	0.54624
83	0.56083	0.52167	0.56600	0.54293
85	0.56333	0.52667	0.56835	0.54671
87	0.56750	0.53333	0.57245	0.55220
89	0.57250	0.53167	0.57895	0.55430
91	0.56750	0.52667	0.57350	0.54909
93	0.57167	0.52667	0.57875	0.55148
95	0.57083	0.52333	0.57827	0.54943
97	0.56250	0.51000	0.56983	0.53826
99	0.56417	0.51000	0.57196	0.53921

4 Generating DS2

The code explains this step clearly. The data is shuffled and then output to DS2_test and DS2_train. The test set contains 1200 examples (600 positive, 600 negative), and the train set contains 2800 examples (1400 positive, 1400 negative).

5 LDA and KNN on DS2

5.1 LDA

Using the data generated in Question 4, the parameters of the probabilistic LDA model were found and used to calculate the coefficients w_0 and $\mathbf{w}$:

$$w_0 = 0.07921153907637934$$

$$\mathbf{w} = \begin{bmatrix} 0.04124253 \\ -0.00244305 \\ -0.01366028 \\ 0.01470345 \\ -0.03887653 \\ -0.03692325 \\ 0.04821048 \\ 0.04070492 \\ -0.03958812 \\ -0.05941566 \\ -0.11504490 \\ 0.03493932 \\ 0.08516702 \\ 0.00812546 \\ -0.00383386 \\ -0.08377713 \\ -0.10174113 \\ -0.02114581 \\ 0.10470002 \\ 0.06721695 \end{bmatrix} \tag{2}$$

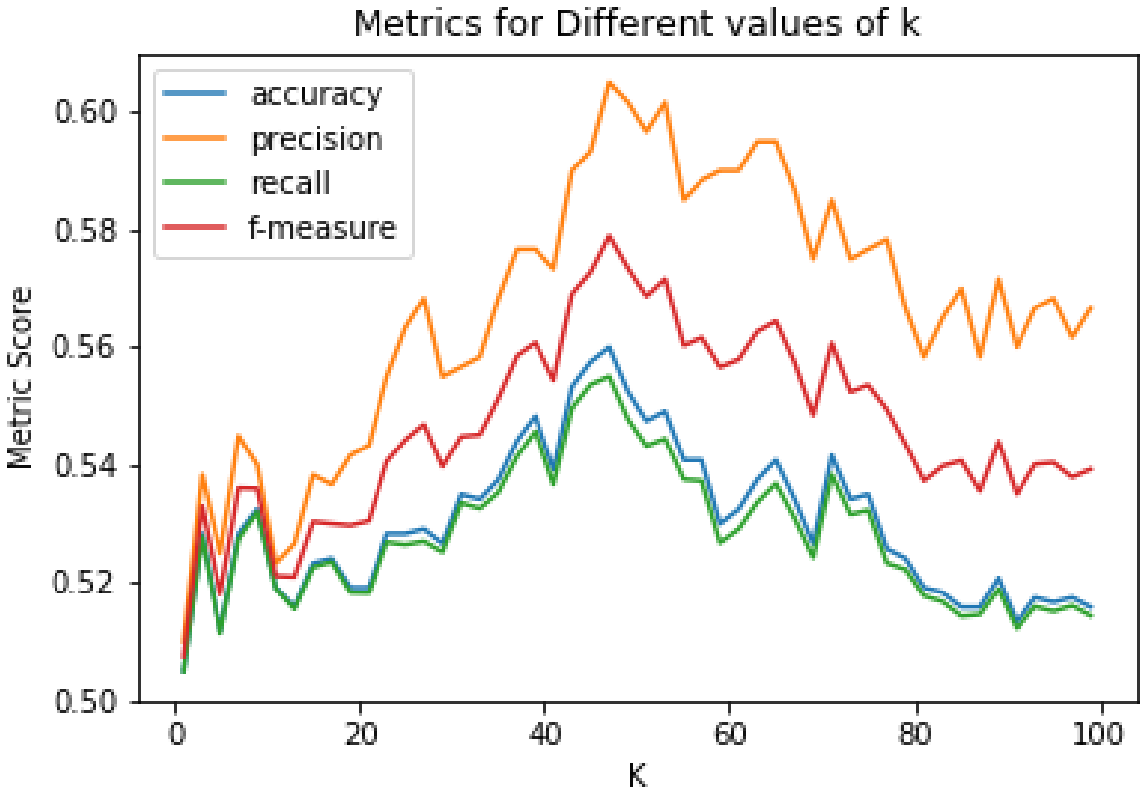
These coefficients were used to obtain the following metrics from the test set:

Metric	**Score**
Accuracy	0.51666
Precision	0.51
Recall	0.51689
F-Measure	0.51342

We notice that when the data is generate by multiple Gaussian distributions, the performance of LDA takes a major hit. Let's look at KNN's performance before further comparison.

5.2 KNN

Here is a plot of K vs the four metrics:



The optimal K value was 47 for all four metrics. The full performance metric for all Ks tested is shown below:

K value	Accuracy	Precision	Recall	F-Measure
1	0.50500	0.51000	0.50495	0.50746
3	0.52833	0.53833	0.52778	0.53300
5	0.51167	0.52500	0.51136	0.51809
7	0.52833	0.54500	0.52742	0.53607
9	0.53250	0.54000	0.53202	0.53598
11	0.51917	0.52333	0.51901	0.52116
13	0.51583	0.52667	0.51550	0.52102
15	0.52333	0.53833	0.52265	0.53038
17	0.52417	0.53667	0.52358	0.53004
19	0.51917	0.54167	0.51834	0.52975
21	0.51917	0.54333	0.51828	0.53051
23	0.52833	0.55500	0.52690	0.54058
25	0.52833	0.56333	0.52648	0.54428
27	0.52917	0.56833	0.52705	0.54691
29	0.52667	0.55500	0.52524	0.53971
31	0.53500	0.55667	0.53355	0.54486
33	0.53417	0.55833	0.53259	0.54516
35	0.53750	0.56833	0.53532	0.55133
37	0.54417	0.57667	0.54147	0.55851
39	0.54833	0.57667	0.54574	0.56078
41	0.53917	0.57333	0.53666	0.55439
43	0.55333	0.59000	0.54969	0.56913
45	0.55750	0.59333	0.55365	0.57281
47	**0.56000**	**0.60500**	**0.55505**	**0.57895**
49	0.55250	0.60167	0.54780	0.57347
51	0.54750	0.59667	0.54325	0.56871
53	0.54917	0.60167	0.54449	0.57165
55	0.54083	0.58500	0.53752	0.56026
57	0.54083	0.58833	0.53729	0.56165
59	0.53000	0.59000	0.52679	0.55660
61	0.53250	0.59000	0.52915	0.55792
63	0.53750	0.59500	0.53363	0.56265
65	0.54083	0.59500	0.53684	0.56443
67	0.53417	0.58667	0.53092	0.55740
69	0.52667	0.57500	0.52432	0.54849
71	0.54167	0.58500	0.53834	0.56070
73	0.53417	0.57500	0.53159	0.55244
75	0.53500	0.57667	0.53231	0.55360
77	0.52583	0.57833	0.52338	0.54949
79	0.52417	0.56667	0.52227	0.54357
81	0.51917	0.55833	0.51777	0.53729
83	0.51833	0.56500	0.51677	0.53981
85	0.51583	0.57000	0.51429	0.54071
87	0.51583	0.55833	0.51459	0.53557
89	0.52083	0.57167	0.51891	0.54401
91	0.51333	0.56000	0.51220	0.53503
93	0.51750	0.56667	0.51593	0.54011
95	0.51667	0.56833	0.51511	0.54041
97	0.51750	0.56167	0.51608	0.53791
99	0.51583	0.56667	0.51437	0.53925

6 Comparing performance of LDA and KNN on DS1 and DS2

We can see that KNN actually beats LDA for DS2 (only slightly)! In fact, the performances of LDA and KNN for DS2 are quite similar to each other. When comparing the results to those of DS1, We see that KNN performs similarly for DS2, whereas LDA performs much worse for DS2 than DS1. This experiment provides evidence that KNN is less affected when the dataset is generated from a mixture of Gaussian distribution. LDA performs worse because the in-class variances are bigger for DS2 as compared to DS1 due to multiple different Gaussian distributions being used instead of just one.

References

[1] The following stackoverflow post was used to help in Q4 when dealing with multiple gaussians: https://stackoverflow.com/questions/39677967/python-sampling-from-different-distributions-with-different-probability