

Data classification using K-nearest neighbor classifier and Bayes classifier with unimodal Gaussian density

Student's Name: Bharat Kumar Course- IC272

Roll Number: B20090 Mobile No: 6299862503

Assignment-4 Branch: CSE

1 a.

	Prediction	n Outcome
Label	93	25
True	19	200

Figure 1 KNN Confusion Matrix for K = 1

	Prediction	Outcome
Label	92	26
True	9	210

Figure 2 KNN Confusion Matrix for K = 3



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	Prediction	Outcome
Label	92	26
True	10	209

Figure 3 KNN Confusion Matrix for K = 5

b.

Table 1 KNN Classification Accuracy for K = 1, 3 and 5

	Classification
K	Accuracy (in %)
1	86.94
3	89.61
4	89.32

Inferences:

- 1. The highest classification accuracy is obtained with K =.3
- 2. Infer whether increasing the value of K increases the prediction accuracy to some value after that it decreases.
- 3. Since we select class based on the distances that we get from k datapoints. So, if k is more then it will give more accurate result.
- 4. No. of diagonal elements increases with increase in accuracy.
- 5. No. of off-diagonal elements decreases with increase in accuracy.
- 6. Off-diagonal elements decreases because they are wrongly classified datapoints.
- 2 a.

Prediction Outcome



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Label	111	7
True Label	6	213

Figure 4 KNN Confusion Matrix for K = 1 post data normalization

	Prediction	Outcome
Label	112	6
True	4	215

Figure 5 KNN Confusion Matrix for K = 3 post data normalization

	Prediction	Outcome
Label	112	6
True	3	216

Figure 6 KNN Confusion Matrix for K = 5 post data normalization

b.



Data classification using K-nearest neighbor classifier and Bayes classifier with unimodal Gaussian density

Table 2 KNN Classification Accuracy for K = 1, 3 and 5 post data normalization

К	Classification Accuracy (in %)
1	96.14
3	97.03
5	97.33

Inferences:

- 1. Data normalization increases classification accuracy.
- 2. The reason for increase in classification accuracy after data normalization is that now the distance calculated is more realistic.
- 3. The highest classification accuracy is obtained with K =.5.
- 4. Increasing the value of K increases the prediction accuracy.
- 5. Since we select class based on the distances that we get from k datapoints. So, if k is more then it will give more accurate result.
- 6. No. of diagonal elements increases with increase in accuracy.
- 7. No. of off-diagonal elements decreases with increase in accuracy.
- 8. Off-diagonal elements decreases because they are wrongly classified datapoints.

3

	Prediction	Outcome
Label	101	7
True	12	216

Figure 7 Confusion Matrix obtained from Bayes Classifier

The classification accuracy obtained from Bayes Classifier is 94.35 %.



Data classification using K-nearest neighbor classifier and Bayes classifier with unimodal Gaussian density

	0	1
X_Maximum	0.164714	0.434183
Y_Maximum	0.147408	0.124446
Pixels_Areas	0.047598	0.003809
X_Perimeter	0.033848	0.004804
Y_Perimeter	0.011358	0.002320
Sum_of_Luminosity	0.069740	0.005289
Minimum_of_Luminosity	0.272463	0.483694
Maximum_of_Luminosity	0.457679	0.431407
Length_of_Conveyer	0.129623	0.402173
Steel_Plate_Thickness	0.000951	0.232438
Edges_Index	0.127057	0.390740
Empty_Index	0.476330	0.443525
Square_Index	0.589849	0.506224
Outside_X_Index	0.121995	0.020990
Edges_X_Index	0.559508	0.620130
Edges_Y_Index	0.500517	0.829175
Outside_Global_Index	0.268551	0.611000
LogOfAreas	0.675562	0.402095
Log_X_Index	0.629985	0.329262
Log_Y_Index	0.428535	0.305139
Orientation_Index	0.334356	0.566372
Luminosity_Index	0.559709	0.551181
SigmoidOfAreas	0.904506	0.463138



Data classification using K-nearest neighbor classifier and Bayes classifier with unimodal Gaussian density

In Fig. 8 and 9 representing covariance matrices for class 1 and class 0 respectively the column numbers and row numbers correspond to attribute with serial number as in Table 3

		-	_			-										~				-			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1	0.088452	0.007506	-7.39E-05	1.46E-05	-6.13E-05	-0.0001	-0.00354	-0.0032	0.018771	-0.00638	0.001994	-0.00153	0.006866	0.000808	0.004985	-0.00254	-0.0059	-0.00185	0.000246	-0.00255	-0.0069	-0.00374	-0.0099
2	0.007506	0.024659	0.000287	0.000241	4.43E-05	0.000395	-0.00158	0.00024	-0.0003	-0.01143	0.003175	-0.00151	-0.00232	0.001804	0.004777	-0.00264	-0.0064	0.001317	0.002804	-0.00058	-0.00509	-0.00076	-0.00027
3	-7.39E-05	0.000287	0.00022	0.000127	4.89E-05	0.000301	-0.00051	8.38E-05	-0.0005	5.83E-05	-0.00025	0.000221	-0.00071	0.000523	-0.00058	-0.00086	0.0002	0.00093	0.000892	0.000528	5.75E-05	-0.00013	0.001674
4	1.46E-05	0.000241	0.000127	9.94E-05	3.04E-05	0.000175	-0.00026	9.04E-05	-0.00053	6.82E-05	-3.58E-05	0.000366	-0.00077	0.000526	-0.00041	-0.00101	-0.00032	0.000745	0.00086	0.000363	-0.00028	-6.13E-05	0.001642
5	-6.13E-05	4.43E-05	4.89E-05	3.04E-05	1.52E-05	6.67E-05	-0.00015	-5.93E-06	-0.00018	6.65E-05	-7.45E-05	0.000152	-0.00036	8.84E-05	-0.00046	-0.00016	0.00035	0.000318	0.000212	0.000255	0.000275	-5.18E-05	0.000767
6	-0.0001	0.000395	0.000301	0.000175	6.67E-05	0.000414	-0.00064	0.000159	-0.00074	4.89E-05	-0.00031	0.000312	-0.00099	0.000732	-0.00078	-0.00123	0.00022	0.001269	0.001234	0.000711	3.86E-05	-0.00013	0.00229
7	-0.00354	-0.00158	-0.00051	-0.00026	-0.00015	-0.00064	0.020176	0.008468	-0.0149	-0.00517	0.006452	0.004133	0.00154	-0.00092	0.001227	-0.00646	-0.01445	-0.00507	-0.00205	-0.00381	-0.00721	0.012657	-0.01104
8	-0.0032	0.00024	8.38E-05	9.04E-05	-5.93E-06	0.000159	0.008468	0.009735	-0.00659	-0.0045	0.003019	-0.00017	-0.00293	0.000837	0.003919	-0.00691	-0.01094	-0.00083	0.002034	-0.0023	-0.00795	0.008486	-0.00373
9	0.018771	-0.0003	-0.0005	-0.00053	-0.00018	-0.00074	-0.0149	-0.00659	0.164573	0.015175	-0.00214	-0.01305	0.013553	-0.00311	0.019056	0.01042	0.001928	-0.00548	-0.00415	-0.00583	-0.00576	-0.00938	-0.02188
10	-0.00638	-0.01143	5.83E-05	6.82E-05	6.65E-05	4.89E-05	-0.00517	-0.0045	0.015175	0.07159	-0.00651	0.002033	-0.00423	-0.00054	-0.00995	0.008803	0.021238	0.00194	-0.0023	0.004121	0.014108	-0.00489	0.007848
11	0.001994	0.003175	-0.00025	-3.58E-05	-7.45E-05	-0.00031	0.006452	0.003019	-0.00214	-0.00651	0.09241	-0.00066	0.007285	0.000334	0.00585	-0.00595	-0.01811	-0.00141	0.002254	-0.00313	-0.01286	0.00381	-0.00084
12	-0.00153	-0.00151	0.000221	0.000366	0.000152	0.000312	0.004133	-0.00017	-0.01305	0.002033	-0.00066	0.021616	-0.00438	0.001228	-0.01372	-0.01168	-0.00834	0.004666	0.00689	0.004704	-0.00147	0.001791	0.025629
13	0.006866	-0.00232	-0.00071	-0.00077	-0.00036	-0.00099	0.00154	-0.00293	0.013553	-0.00423	0.007285	-0.00438	0.080549	-0.00408	0.022105	0.016871	-0.01174	-0.01041	-0.00796	-0.00741	-0.00848	-0.00071	-0.03056
14	0.000808	0.001804	0.000523	0.000526	8.84E-05	0.000732	-0.00092	0.000837	-0.00311	-0.00054	0.000334	0.001228	-0.00408	0.004021	0.002272	-0.0072	-0.00662	0.003201	0.005356	0.000402	-0.00545	-0.00015	0.006402
15	0.004985	0.004777	-0.00058	-0.00041	-0.00046	-0.00078	0.001227	0.003919	0.019056	-0.00995	0.00585	-0.01372	0.022105	0.002272	0.066699	-0.01451	-0.06697	-0.01252	0.004689	-0.01974	-0.05191	0.00234	-0.04862
16	-0.00254	-0.00264	-0.00086	-0.00101	-0.00016	-0.00123	-0.00646	-0.00691	0.01042	0.008803	-0.00595	-0.01168	0.016871	-0.0072	-0.01451	0.05345	0.068831	-0.0058	-0.02174	0.005417	0.045604	-0.00612	-0.01836
17	-0.0059	-0.0064	0.0002	-0.00032	0.00035	0.00022	-0.01445	-0.01094	0.001928	0.021238	-0.01811	-0.00834	-0.01174	-0.00662	-0.06697	0.068831	0.226632	0.008666	-0.02706	0.025942	0.116333	-0.01148	0.023359
18	-0.00185	0.001317	0.00093	0.000745	0.000318	0.001269	-0.00507	-0.00083	-0.00548	0.00194	-0.00141	0.004666	-0.01041	0.003201	-0.01252	-0.0058	0.008666	0.010941	0.008448	0.007875	0.006437	-0.00242	0.032609
19	0.000246	0.002804	0.000892	0.00086	0.000212	0.001234	-0.00205	0.002034	-0.00415	-0.0023	0.002254	0.00689	-0.00796	0.005356	0.004689	-0.02174	-0.02706	0.008448	0.015111	0.001128	-0.01886	0.000168	0.024891
20	-0.00255	-0.00058	0.000528	0.000363	0.000255	0.000711	-0.00381	-0.0023	-0.00583	0.004121	-0.00313	0.004704	-0.00741	0.000402	-0.01974	0.005417	0.025942	0.007875	0.001128	0.009118	0.019294	-0.00259	0.025709
21	-0.0069	-0.00509	5.75E-05	-0.00028	0.000275	3.86E-05	-0.00721	-0.00795	-0.00576	0.014108	-0.01286	-0.00147	-0.00848	-0.00545	-0.05191	0.045604	0.116333	0.006437	-0.01886	0.019294	0.076833	-0.00679	0.022105
22	-0.00374	-0.00076	-0.00013	-6.13E-05	-5.18E-05	-0.00013	0.012657	0.008486	-0.00938	-0.00489	0.00381	0.001791	-0.00071	-0.00015	0.00234	-0.00612	-0.01148	-0.00242	0.000168	-0.00259	-0.00679	0.010291	-0.00607
23	-0.0099	-0.00027	0.001674	0.001642	0.000767	0.00229	-0.01104	-0.00373	-0.02188	0.007848	-0.00084	0.025629	-0.03056	0.006402	-0.04862	-0.01836	0.023359	0.032609	0.024891	0.025709	0.022105	-0.00607	0.125992
	1	1 2		. 4	5	6	7	, 8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1	0.01974								9			12 -0.00605	13	14 -0.00149	15 0.01215	16 0.01723	17 0.02028	18 -0.01052	19 -0.01182	20	21 0.00965	0.00713	23
	0.01974	-0.00439	-0.00134	-0.00087	-0.00026	-0.00192	0.01268	0.006	0.004	0.00046	0.0154	-0.00605	0.00451	-0.00149	0.01215	0.01723	0.02028	-0.01052	-0.01182	-0.00488	0.00965	0.00713	-0.02224
2	-0.00439	-0.00439 0.0197	-0.00134	-0.00087 -0.00032	-0.00026 -0.00014	-0.00192 -0.00073	0.01268		0.004 -0.00244	0.00046	0.0154 -0.00483	-0.00605 0.00133	0.00451 -0.00817	-0.00149	0.01215 0.00059	0.01723 -0.00351	0.02028	-0.01052 0.00324	-0.01182 0.0043		0.00965 -0.00616	0.00713 -0.0031	-0.02224
3	0.01974 -0.00439 -0.00134	-0.00439 0.0197	-0.00134 -0.00043 0.00122	-0.00087 3 -0.00087	-0.00026 -0.00014 0.00031	-0.00192 -0.00073 0.00191	0.01268 -0.00206 -0.00435	0.006	0.004 -0.00244 0.00052	0.00046 -0.00011 -3.99E-06	0.0154 -0.00483 -0.00314	-0.00605 0.00133 0.00256	0.00451 -0.00817 0.0035	-0.00149 0.00032 0.00171	0.01215 0.00059 -0.00619	0.01723 -0.00351 -0.0045	0.02028 -0.01155 0.0019	-0.01052 0.00324	-0.01182 0.0043 0.00343	-0.00488 0.00094 0.00259	0.00965 -0.00616 0.00123	0.00713 -0.0031	-0.02224 0.00937
3	0.01974 -0.00439 -0.00134 -0.00087	0.0197 0.0197 0.00043 0.00043	-0.00134 -0.00043 0.00122 0.00087	-0.00087 8 -0.00032 2 0.00087 7 0.00068	-0.00026 -0.00014 0.00031 0.00024	-0.00192 -0.00073 0.00191 0.00138	0.01268 -0.00206 -0.00435 -0.00299	0.006 -0.00322 -0.00013	0.004 -0.00244 0.00052 0.00054	0.00046 -0.00011 -3.99E-06 5.05E-07	0.0154 -0.00483 -0.00314 -0.00217	-0.00605 0.00133 0.00256 0.00226	0.00451 -0.00817 0.0035 0.00318	-0.00149 0.00032 0.00171 0.00127	0.01215 0.00059 -0.00619 -0.00506	0.01723 -0.00351 -0.0045 -0.00339	0.02028 -0.01155 0.0019 0.00219	-0.01052 0.00324 0.00378	-0.01182 0.0043 0.00343 0.0024	-0.00488 0.00094 0.00259	0.00965 -0.00616 0.00123 0.0013	0.00713 -0.0031 -0.00065 -0.00035	-0.02224 0.00937 0.0045
2 3 4 5	0.01974 -0.00439 -0.00134 -0.00087 -0.00026	4 -0.00439 9 0.0197 4 -0.00043 7 -0.00032 5 -0.00014	-0.00134 7 -0.00043 8 0.00122 9 0.00083 0.00031	-0.00087 8 -0.00032 2 0.00087 7 0.00068	-0.00026 -0.00014 0.00031 0.00024 8.68E-05	-0.00192 -0.00073 0.00191 0.00138 0.00049	0.01268 -0.00206 -0.00435 -0.00299 -0.00101	0.006 -0.00322 -0.00013 2.00E-05	0.004 -0.00244 0.00052 0.00054 0.00022	0.00046 -0.00011 -3.99E-06 5.05E-07 -9.77E-07	0.0154 -0.00483 -0.00314 -0.00217 -0.00069	-0.00605 0.00133 0.00256 0.00226 0.00078	0.00451 -0.00817 0.0035 0.00318 0.00124	-0.00149 0.00032 0.00171 0.00127 0.00042	0.01215 0.00059 -0.00619 -0.00506 -0.00182	0.01723 -0.00351 -0.0045 -0.00339 -0.00113	0.02028 -0.01155 0.0019 0.00219 0.00105	-0.01052 0.00324 0.00378 0.00266	-0.01182 0.0043 0.00343 0.0024 0.00078	-0.00488 0.00094 0.00259 0.00194 0.00068	0.00965 -0.00616 0.00123 0.0013	0.00713 -0.0031 -0.00065 -0.00035 -8.10E-05	-0.02224 0.00937 0.0045 0.00313 0.00103
2 3 4 5 6	0.01974 -0.00439 -0.00134 -0.00087 -0.00026	4 -0.00439 0.0197 4 -0.00043 7 -0.00032 5 -0.00014 2 -0.00073	-0.00134 -0.00043 0.00122 0.00083 0.00031 0.00191	-0.00087 3 -0.00032 0.00087 7 0.00068 1 0.00024 1 0.00138	-0.00026 -0.00014 0.00031 0.00024 8.68E-05 0.00049	-0.00192 -0.00073 0.00191 0.00138 0.00049 0.003	0.01268 -0.00206 -0.00435 -0.00299 -0.00101 -0.00646	0.006 -0.00322 -0.00013 2.00E-05 4.74E-05	0.004 -0.00244 0.00052 0.00054 0.00022 0.00084	0.00046 -0.00011 -3.99E-06 5.05E-07 -9.77E-07 -1.29E-05	0.0154 -0.00483 -0.00314 -0.00217 -0.00069 -0.00463	-0.00605 0.00133 0.00256 0.00226 0.00078 0.00398	0.00451 -0.00817 0.0035 0.00318 0.00124 0.00604	-0.00149 0.00032 0.00171 0.00127 0.00042 0.00257	0.01215 0.00059 -0.00619 -0.00506 -0.00182 -0.00983	0.01723 -0.00351 -0.0045 -0.00339 -0.00113 -0.00678	0.02028 -0.01155 0.0019 0.00219 0.00105	-0.01052 0.00324 0.00378 0.00266 0.0009 0.00568	-0.01182 0.0043 0.00343 0.0024 0.00078 0.00506	-0.00488 0.00094 0.00259 0.00194 0.00068	0.00965 -0.00616 0.00123 0.0013 0.00058 0.00237	0.00713 -0.0031 -0.00065 -0.00035 -8.10E-05 -0.00077	-0.02224 0.00937 0.0045 0.00313 0.00103 0.00656
2 3 4 5 6	0.01974 -0.00439 -0.00134 -0.00087 -0.00026 -0.00192 0.01268	4 -0.00439 9 0.0197 4 -0.00043 7 -0.00032 5 -0.00014 2 -0.00073 3 -0.00206	-0.00134 -0.00043 0.00122 0.00083 0.00093 0.00193 0.00435	-0.00087 3 -0.00032 0.00087 7 0.00068 1 0.00024 1 0.00138	-0.00026 -0.00014 0.00031 0.00024 8.68E-05 0.00049	-0.00192 -0.00073 0.00191 0.00138 0.00049 0.003	0.01268 -0.00206 -0.00435 -0.00299 -0.00101 -0.00646 0.03737	0.006 -0.00322 -0.00013 2.00E-05 4.74E-05 4.10E-06 0.01073	0.004 -0.00244 0.00052 0.00054 0.00022 0.00084 -0.00192	0.00046 -0.00011 -3.99E-06 5.05E-07 -9.77E-07 -1.29E-05 -5.28E-05	0.0154 -0.00483 -0.00314 -0.00217 -0.00069 -0.00463 0.02128	-0.00605 0.00133 0.00256 0.00226 0.00078 0.00398	0.00451 -0.00817 0.0035 0.00318 0.00124 0.00604 0.00572	-0.00149 0.00032 0.00171 0.00127 0.00042 0.00257 -0.0088	0.01215 0.00059 -0.00619 -0.00506 -0.00182 -0.00983 0.02183	0.01723 -0.00351 -0.0045 -0.00339 -0.00113 -0.00678 0.02587	0.02028 -0.01155 0.0019 0.00219 0.00105 0.00385 0.01686	-0.01052 0.00324 0.00378 0.00266 0.0009 0.00568 -0.0241	-0.01182 0.0043 0.00343 0.0024 0.00078 0.00506 -0.02445	-0.00488 0.00094 0.00259 0.00194 0.00068 0.004 -0.01355	0.00965 -0.00616 0.00123 0.0013 0.00058 0.00237 0.00771	0.00713 -0.0031 -0.00065 -0.00035 -8.10E-05 -0.00077	-0.02224 0.00937 0.0045 0.00313 0.00103 0.00656 -0.04141
2 3 4 5 6	0.01974 -0.00439 -0.00134 -0.00087 -0.00026 -0.00192 0.01268 0.006	4 -0.00439 9 0.0197 4 -0.00043 7 -0.00032 5 -0.00014 2 -0.00073 3 -0.00206 5 -0.00322	0.00134 0.00122 0.00083 0.00191 0.00033 0.00191 0.00435 0.00013	-0.00087 3 -0.00032 2 0.00087 7 0.00068 1 0.00024 1 0.00138 5 -0.00299 3 2.00E-05	-0.00026 -0.00014 0.00031 0.00024 8.68E-05 0.00049 -0.00101 4.74E-05	-0.00192 -0.00073 0.00191 0.00138 0.00049 -0.00646 4.10E-06	0.01268 -0.00206 -0.00435 -0.00299 -0.00101 -0.00646 0.03737 0.01073	0.006 -0.00322 -0.00013 2.00E-05 4.74E-05 4.10E-06 0.01073	0.004 -0.00244 0.00052 0.00054 0.00022 0.00084 -0.00192 -9.37E-05	0.00046 -0.00011 -3.99E-06 5.05E-07 -9.77E-07 -1.29E-05 -5.28E-05 -0.00013	0.0154 -0.00483 -0.00314 -0.00217 -0.00069 -0.00463 0.02128 0.00911	-0.00605 0.00133 0.00256 0.00226 0.00078 0.00398 -0.01114 -0.00172	0.00451 -0.00817 0.0035 0.00318 0.00124 0.00604 0.00572 0.01071	-0.00149 0.00032 0.00171 0.00127 0.00042 0.00257 -0.0088 -0.00189	0.01215 0.00059 -0.00619 -0.00506 -0.00182 -0.00983 0.02183 -0.00025	0.01723 -0.00351 -0.0045 -0.00339 -0.00113 -0.00678 0.02587	0.02028 -0.01155 0.0019 0.00219 0.00105 0.00385 0.01686 0.01778	-0.01052 0.00324 0.00378 0.00266 0.0009 0.00568 -0.0241 -0.00577	-0.01182 0.0043 0.00343 0.0024 0.00078 0.00506 -0.02445 -0.00742	-0.00488 0.00094 0.00259 0.00194 0.00068 0.004 -0.01355	0.00965 -0.00616 0.00123 0.0013 0.00058 0.00237 0.00771 0.00923	0.00713 -0.0031 -0.00065 -0.00035 -8.10E-05 -0.00077 0.01506	-0.02224 0.00937 0.0045 0.00313 0.00103 0.00656 -0.04141 -0.01529
2 3 4 5 6 7 8	0.01974 -0.00435 -0.00134 -0.00087 -0.00026 -0.00192 0.01268 0.006	4 -0.00439 9 0.0197 4 -0.00043 7 -0.00032 5 -0.00014 2 -0.00073 3 -0.00206 5 -0.00322 4 -0.00244	9 -0.00134 7 -0.00043 8 0.00122 9 0.00083 9 0.00031 9 0.00193 6 -0.00435 9 0.00052	4 -0.00087 3 -0.00032 2 0.00087 7 0.00068 0.00024 0.00138 5 -0.00299 3 2.00E-05	-0.00026 -0.00014 0.00031 0.00024 8.68E-05 0.00049 -0.00101 4.74E-05	-0.00192 -0.00073 0.00191 0.00138 0.00049 0.003 -0.00646 4.10E-06	0.01268 -0.00206 -0.00435 -0.00299 -0.00101 -0.00646 0.03737 0.01073 -0.00192	0.006 -0.00322 -0.00013 2.00E-05 4.74E-05 4.10E-06 0.01073 0.0077	0.004 -0.00244 0.00052 0.00054 0.00022 0.00084 -0.00192 -9.37E-05 0.01706	0.00046 -0.00011 -3.99E-06 5.05E-07 -9.77E-07 -1.29E-05 -5.28E-05 -0.00013 0.00041	0.0154 -0.00483 -0.00314 -0.00217 -0.00069 -0.00463 0.02128 0.00911 0.00286	-0.00605 0.00133 0.00256 0.00226 0.00078 0.00398 -0.01114 -0.00172 0.00112	0.00451 -0.00817 0.0035 0.00318 0.00124 0.00604 0.00572 0.01071 0.0103	-0.00149 0.00032 0.00171 0.00127 0.00042 0.00257 -0.0088 -0.00189 -0.00087	0.01215 0.00059 -0.00619 -0.00506 -0.00182 -0.00983 0.02183 -0.00025 -0.00695	0.01723 -0.00351 -0.0045 -0.00339 -0.00113 -0.00678 0.02587 0.00761 0.00019	0.02028 -0.01155 0.0019 0.00219 0.00105 0.00385 0.01686 0.01778 0.01303	-0.01052 0.00324 0.00378 0.00266 0.0009 0.00568 -0.0241 -0.00577 0.0006	-0.01182 0.0043 0.00343 0.0024 0.00078 0.00506 -0.02445 -0.00742 -0.00089	-0.00488 0.00094 0.00259 0.00194 0.00068 0.004 -0.01355 -0.00194 0.00152	0.00965 -0.00616 0.00123 0.0013 0.00058 0.00237 0.00771 0.00923 0.0068	0.00713 -0.0031 -0.00065 -0.00035 -8.10E-05 -0.00077 0.01506 0.00859 -0.00078	-0.02224 0.00937 0.0045 0.00313 0.00103 0.00656 -0.04141 -0.01529 0.00024
2 3 4 5 6 7 8	0.01974 -0.00439 -0.00134 -0.00087 -0.00026 -0.00192 0.01268 0.006 0.0046	4 -0.00439 9 0.0197 4 -0.00043 7 -0.00032 5 -0.00014 2 -0.00073 3 -0.00206 5 -0.00322 4 -0.00244 5 -0.00011	9 -0.00134 7 -0.00043 8 0.00122 9 0.00083 9 0.00031 9 0.00193 9 -0.0043 9 -0.00052 1 -3.99E-06	3 -0.00087 3 -0.00032 2 0.00087 7 0.00068 1 0.00024 1 0.00138 3 -0.00299 3 2.00E-05 2 0.00054 5 5.05E-07	-0.00026 -0.00014 0.00031 0.00024 8.68E-05 0.00049 -0.00101 4.74E-05 0.00022	-0.00192 -0.00073 0.00191 0.00138 0.00049 0.003 -0.00646 4.10E-06 0.00084 -1.29E-05	0.01268 -0.00206 -0.00435 -0.00299 -0.00101 -0.00646 0.03737 0.01073 -0.00192 -5.28E-05	0.006 0.00322 0.00013 0.00E-05 4.74E-05 4.10E-06 0.01073 0.0077 0.937E-05	0.004 -0.00244 0.00052 0.00054 0.00022 0.00084 -0.00192 -9.37E-05 0.01706 0.00041	0.00046 -0.00011 -3.99E-06 5.05E-07 -9.77E-07 -1.29E-05 -5.28E-05 -0.00013 0.00041 9.88E-05	0.0154 -0.00483 -0.00314 -0.00217 -0.00069 -0.00463 0.02128 0.00911 0.00286 -8.84E-05	-0.00605 0.00133 0.00256 0.00226 0.00078 0.00398 -0.01114 -0.00172 0.00112 -7.47E-05	0.00451 -0.00817 0.0035 0.00318 0.00124 0.00604 0.00572 0.01071 0.0103 -1.29E-06	-0.00149 0.00032 0.00171 0.00127 0.00042 0.00257 -0.0088 -0.00189 -0.00087 3.10E-05	0.01215 0.00059 -0.00619 -0.00506 -0.00182 -0.00983 0.02183 -0.00025 -0.00695 6.05E-05	0.01723 -0.00351 -0.0045 -0.00339 -0.00113 -0.00678 0.02587 0.00761 0.00019 0.00017	0.02028 -0.01155 0.0019 0.00219 0.00105 0.00385 0.01686 0.01778 0.01303 0.00029	-0.01052 0.00324 0.00378 0.00266 0.0009 0.00568 -0.0241 -0.00577 0.0006 -4.03E-05	-0.01182 0.0043 0.00343 0.0024 0.00078 0.00506 -0.02445 -0.00742 -0.00089 -6.03E-05	-0.00488 0.00094 0.00259 0.00194 0.00068 0.004 -0.01355 -0.00194 0.00152 -1.06E-05	0.00965 -0.00616 0.00123 0.0013 0.00058 0.00237 0.00771 0.00923 0.0068 0.00012	0.00713 -0.0031 -0.00065 -0.00035 -8.10E-05 -0.00077 0.01506 0.00859 -0.00078 -0.00013	-0.02224 0.00937 0.0045 0.00313 0.00103 0.00656 -0.04141 -0.01529 0.00024 7.17E-05
2 3 4 5 6 7 8 9 10 11	0.01974 -0.00439 -0.00134 -0.00087 -0.00026 -0.00192 0.01268 0.006 0.0046 0.0154 -0.00609	4 -0.00439 9 0.0197 4 -0.00043 7 -0.00032 5 -0.00014 2 -0.00073 3 -0.00206 5 -0.00322 4 -0.00244 5 -0.00013 4 -0.00483 5 0.00133	0.00134 0.00043 0.00031 0.00031 0.00031 0.00043 0.00043 0.00052 0.00052 0.00053 0.00052	4 -0.00087 3 -0.00032 2 0.00087 7 0.00068 1 0.00024 2 0.00138 3 -0.00299 3 2.00E-05 2 0.00054 5 5.05E-07 4 -0.00217 5 0.00226	-0.00026 -0.00014 0.00031 0.00024 8.68E-05 0.00049 -0.00101 4.74E-05 0.00022 -9.77E-07 -0.00069 0.00078	-0.00192 -0.00073 0.00191 0.00138 0.00049 0.003 -0.00646 4.10E-06 0.00084 -1.29E-05 -0.00463 0.00398	0.01268 -0.00206 -0.00435 -0.00299 -0.00101 -0.00646 0.03737 -0.00192 -5.28E-05 0.02128 -0.01114	3 0.006 5 -0.00322 6 -0.00013 9 2.00E-05 4.74E-05 5 4.10E-06 7 0.01073 0.0077 2 -9.37E-05 6 -0.00013 0.00911 1 -0.00172	0.004 -0.00244 0.00052 0.00054 0.00022 0.00084 -0.00192 -9.37E-05 0.01706 0.00041 0.00286 0.00112	0.00046 -0.00011 -3.99E-06 5.05E-07 -9.77E-07 -1.29E-05 -5.28E-05 -0.00013 0.00041 9.88E-05 -8.84E-05 -7.47E-05	0.0154 -0.00483 -0.00314 -0.00217 -0.00069 -0.00463 0.02128 0.00911 0.00286 -8.84E-05 0.03168 -0.01139	-0.00605 0.00133 0.00256 0.00226 0.00078 0.00398 -0.01114 -0.00172 0.00112 -7.47E-05 -0.01139 0.01782	0.00451 -0.00817 0.0035 0.00318 0.00124 0.00604 0.00572 0.01071 0.0103 -1.29E-06 0.00855 0.00338	-0.00149 0.00032 0.00171 0.00127 0.00042 0.00257 -0.0088 -0.00189 -0.00087 3.10E-05 -0.00749 0.00713	0.01215 0.00059 -0.00619 -0.00506 -0.00182 -0.00983 0.02183 -0.00025 -0.00695 6.05E-05 0.01727 -0.01845	0.01723 -0.00351 -0.0045 -0.00339 -0.00113 -0.00678 0.02587 0.00761 0.00019 0.00017 0.02615 -0.01659	0.02028 -0.01155 0.0019 0.00219 0.00105 0.00385 0.01686 0.01778 0.01303 0.00029 0.02523 -0.00164	-0.01052 0.00324 0.00378 0.00266 0.0009 0.00568 -0.0241 -0.00577 0.0006 -4.03E-05 -0.01841 0.01197	-0.01182 0.0043 0.00343 0.0024 0.00078 0.00506 -0.02445 -0.00742 -0.00089 -6.03E-05 -0.02074 0.01344	-0.00488 0.00094 0.00259 0.00194 0.00068 0.004 -0.01355 -0.00194 0.00152 -1.06E-05 -0.00947 0.00857	0.00965 -0.00616 0.00123 0.0013 0.00058 0.00237 0.00771 0.00923 0.0068 0.00012 0.01254 -0.00033	0.00713 -0.0031 -0.00065 -0.00035 -8.10E-05 -0.00077 0.01506 0.00859 -0.00078 -0.00013 0.01084 -0.00298	-0.02224 0.00937 0.0045 0.00313 0.00103 0.00656 -0.04141 -0.01529 0.00024 7.17E-05 -0.03457 0.02042
2 3 4 5 6 7 8 9 10 11 12	0.01974 -0.00439 -0.00134 -0.00087 -0.00026 -0.00192 0.01268 0.0004 0.00046 -0.00609 0.00451	4 -0.00439 9 0.0197 4 -0.00043 7 -0.00032 5 -0.00014 2 -0.00033 3 -0.00204 4 -0.0044 5 -0.0011 4 -0.00483 5 0.00133 1 -0.00817	0.00134 0.00122 0.00083 0.00123 0.00033 0.00193 0.000193 0.000193 0.000052 0.000053 0.00053 0.00054 0.00056	4 -0.00087 3 -0.00032 2 0.00087 7 0.00068 1 0.00024 1 0.00138 5 -0.00299 2 0.00054 5 5.05E-07 4 -0.00217 5 0.00226 5 0.00318	-0.00026 -0.00014 0.00031 0.00024 8.68E-05 0.00049 -0.00101 4.74E-05 0.00022 -9.77E-07 -0.00069 0.00078	-0.00192 -0.00073 0.00191 0.00138 0.00049 0.003 -0.00646 0.00084 -1.29E-05 -0.00463 0.00398	0.01268 -0.00206 -0.00435 -0.00299 -0.00101 -0.00646 0.03737 -0.00192 -5.28E-05 0.02128 -0.01114 0.00572	3 0.006 5 -0.00322 6 -0.00013 2 .00E-05 4 .74E-05 5 4.10E-06 7 0.01073 1 -0.0077 2 -9.37E-05 6 -0.00013 1 0.00911 1 -0.00172 1 0.01071	0.004 -0.00244 0.00052 0.00054 0.00022 0.00084 -0.00192 -9.37E-05 0.01706 0.00041 0.00286 0.00112 0.0103	0.00046 -0.00011 -3.99E-06 5.05E-07 -9.77E-07 -1.29E-05 -0.00013 0.00041 9.88E-05 -8.84E-05 -7.47E-05 -1.29E-06	0.0154 -0.00483 -0.00314 -0.00217 -0.00069 -0.00463 0.02128 0.00911 0.00286 -8.84E-05 0.03168 -0.01139	-0.00605 0.00133 0.00256 0.00226 0.00078 0.00398 -0.01114 -0.00172 -7.47E-05 -0.01139 0.01782 0.00338	0.00451 -0.00817 0.0035 0.00318 0.00124 0.00604 0.00572 0.01071 0.0103 -1.29E-06 0.00855 0.00338 0.06603	-0.00149 0.00032 0.00171 0.00127 0.00042 0.00257 -0.0088 -0.00189 -0.00087 3.10E-05 -0.00749 0.00713 -0.00532	0.01215 0.00059 -0.00619 -0.00506 -0.00182 -0.00983 0.02183 -0.00025 -0.00695 6.05E-05 0.01727 -0.01845 -0.03764	0.01723 -0.00351 -0.0045 -0.00339 -0.00113 -0.00678 0.02587 0.00761 0.00019 0.00017 0.02615 -0.01659 0.00168	0.02028 -0.01155 0.0019 0.00219 0.00105 0.00385 0.01686 0.01778 0.01303 0.00029 0.02523 -0.00164 0.07073	-0.01052 0.00324 0.00378 0.00266 0.0009 0.00568 -0.0241 -0.00577 0.0006 -4.03E-05 -0.01841 0.01197 -0.00042	-0.01182 0.0043 0.00343 0.0024 0.00506 -0.02445 -0.00742 -0.00089 -6.03E-05 -0.02074 0.01344 -0.00882	-0.00488 0.00094 0.00259 0.00194 0.00068 0.004 -0.01355 -0.00194 0.00152 -1.06E-05 -0.00947 0.00857 0.00575	0.00965 -0.00616 0.00123 0.0013 0.00058 0.00237 0.00771 0.00923 0.0068 0.00012 0.01254 -0.00033 0.03688	0.00713 -0.0031 -0.00065 -0.00035 -8.10E-05 -0.00077 0.01506 0.00859 -0.00078 -0.00013 0.01084 -0.00298 0.01028	-0.02224 0.00937 0.0045 0.00313 0.00103 0.00656 -0.04141 -0.01529 0.00024 7.17E-05 -0.03457 0.02042 -0.01541
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Inferences:

- 1. The accuracy of Bayes Classifier is 94.35 % and it is lesser than the previous classifier because it is linear but not the previous one.
- 2. Diagonal elements are variance of different attributes which signifies the spread of that attribute.
- 3. Off-diagonal elements are pairwise covariance between different attributes.
- 4. The off-diagonal elements are symmetric about diagonal.
- 5. Minimum covariance for class 0 (Y_Maximum, Sum of Luminocsity), Maximum is for (X_Maximum, Y_Maximum).
- 6. Minimum covariance for class 1 (Steel_plate_thickness, Y_Maximum), Maximum is for (Y_Maximum, Sum of Luminocsity).



Data classification using K-nearest neighbor classifier and Bayes classifier with unimodal Gaussian density

Table 4 Comparison between classifiers based upon classification accuracy

S. No.	Classifier	Accuracy (in %)
1.	KNN(max)	89.61
2.	KNN on normalized data(max)	97.33
3.	Bayes	94.35

Inferences:

- 1. The classifier with highest and lowest accuracy are KNN on normalized data with k=5 and KNN on normal data with k=1.
- 2. Arrange the classifiers in ascending order of classification accuracy. Classifier 1 < Classifier 3 < Classifier 2.
- 3. The reason behind Inference 1 and 2 is normalization of data.
- 4. Even Baye's Classifier on normal data gives very less accuracy.
- 5. In general Bayes classifier is less accurate compared to KNN because it is a linear classifier.