Project Based - Toward a Data Mining Portfolio EXTRA CREDIT

Diane Hoang

2024-03-19

```
#load the mlbench package which has the BreastCancer data set

library(mlbench)


# if you don't have any required package, use the install.packages() command
# load the data set
data(BreastCancer)
str(BreastCancer)
```

```
## 'data.frame':    699 obs. of  11 variables:
##  $ Id             : chr  "1000025" "1002945" "1015425" "1016277" ...
##  $ Cl.thickness   : Ord.factor w/ 10 levels "1"<"2"<"3"<"4"<..: 5 5 3 6 4 8 1 2 2 4 ...
##  $ Cell.size      : Ord.factor w/ 10 levels "1"<"2"<"3"<"4"<..: 1 4 1 8 1 10 1 1 1 2 ...
##  $ Cell.shape     : Ord.factor w/ 10 levels "1"<"2"<"3"<"4"<..: 1 4 1 8 1 10 1 2 1 1 ...
##  $ Marg.adhesion  : Ord.factor w/ 10 levels "1"<"2"<"3"<"4"<..: 1 5 1 1 3 8 1 1 1 1 ...
##  $ Epith.c.size   : Ord.factor w/ 10 levels "1"<"2"<"3"<"4"<..: 2 7 2 3 2 7 2 2 2 2 ...
##  $ Bare.nuclei    : Factor w/ 10 levels "1","2","3","4",..: 1 10 2 4 1 10 10 1 1 1 ...
##  $ Bl.cromatin    : Factor w/ 10 levels "1","2","3","4",..: 3 3 3 3 3 9 3 3 1 2 ...
##  $ Normal.nucleoli: Factor w/ 10 levels "1","2","3","4",..: 1 2 1 7 1 7 1 1 1 1 ...
##  $ Mitoses        : Factor w/ 9 levels "1","2","3","4",..: 1 1 1 1 1 1 1 1 5 1 ...
##  $ Class          : Factor w/ 2 levels "benign","malignant": 1 1 1 1 1 2 1 1 1 1 ...
```

```
## Preliminary step. Reviewing the Data Structure. Removing missing values. Remove id column as well si

dim(BreastCancer)
```

```
## [1] 699  11
```

```
str(BreastCancer)
```

```
## 'data.frame':    699 obs. of  11 variables:
##  $ Id             : chr  "1000025" "1002945" "1015425" "1016277" ...
##  $ Cl.thickness   : Ord.factor w/ 10 levels "1"<"2"<"3"<"4"<..: 5 5 3 6 4 8 1 2 2 4 ...
##  $ Cell.size      : Ord.factor w/ 10 levels "1"<"2"<"3"<"4"<..: 1 4 1 8 1 10 1 1 1 2 ...
##  $ Cell.shape     : Ord.factor w/ 10 levels "1"<"2"<"3"<"4"<..: 1 4 1 8 1 10 1 2 1 1 ...
##  $ Marg.adhesion  : Ord.factor w/ 10 levels "1"<"2"<"3"<"4"<..: 1 5 1 1 3 8 1 1 1 1 ...
##  $ Epith.c.size   : Ord.factor w/ 10 levels "1"<"2"<"3"<"4"<..: 2 7 2 3 2 7 2 2 2 2 ...
##  $ Bare.nuclei    : Factor w/ 10 levels "1","2","3","4",..: 1 10 2 4 1 10 10 1 1 1 ...
##  $ Bl.cromatin    : Factor w/ 10 levels "1","2","3","4",..: 3 3 3 3 3 9 3 3 1 2 ...
```

```
##  $ Normal.nucleoli: Factor w/ 10 levels "1","2","3","4",..: 1 2 1 7 1 7 1 1 1 1 ...
##  $ Mitoses        : Factor w/ 9 levels "1","2","3","4",..: 1 1 1 1 1 1 1 1 5 1 ...
##  $ Class          : Factor w/ 2 levels "benign","malignant": 1 1 1 1 1 2 1 1 1 1 ...
```

```
missing_values <- is.na(BreastCancer)

# Count missing values
num_missing <- sum(is.na(BreastCancer))

print(num_missing)
```

```
## [1] 16
```

```
# Remove missing values
BreastCancer <- na.omit(BreastCancer)

print(BreastCancer)
```

```
##           Id Cl.thickness Cell.size Cell.shape Marg.adhesion Epith.c.size
## 1    1000025            5         1          1             1            2
## 2    1002945            5         4          4             5            7
## 3    1015425            3         1          1             1            2
## 4    1016277            6         8          8             1            3
## 5    1017023            4         1          1             3            2
## 6    1017122            8        10         10             8            7
## 7    1018099            1         1          1             1            2
## 8    1018561            2         1          2             1            2
## 9    1033078            2         1          1             1            2
## 10   1033078            4         2          1             1            2
## 11   1035283            1         1          1             1            1
## 12   1036172            2         1          1             1            2
## 13   1041801            5         3          3             3            2
## 14   1043999            1         1          1             1            2
## 15   1044572            8         7          5            10            7
## 16   1047630            7         4          6             4            6
## 17   1048672            4         1          1             1            2
## 18   1049815            4         1          1             1            2
## 19   1050670           10         7          7             6            4
## 20   1050718            6         1          1             1            2
## 21   1054590            7         3          2            10            5
## 22   1054593           10         5          5             3            6
## 23   1056784            3         1          1             1            2
## 25   1059552            1         1          1             1            2
## 26   1065726            5         2          3             4            2
## 27   1066373            3         2          1             1            1
## 28   1066979            5         1          1             1            2
## 29   1067444            2         1          1             1            2
## 30   1070935            1         1          3             1            2
## 31   1070935            3         1          1             1            1
## 32   1071760            2         1          1             1            2
## 33   1072179           10         7          7             3            8
## 34   1074610            2         1          1             2            2
## 35   1075123            3         1          2             1            2
```

```
## 36   1079304           2          1          1          1          2
## 37   1080185          10         10         10          8          6
## 38   1081791           6          2          1          1          1
## 39   1084584           5          4          4          9          2
## 40   1091262           2          5          3          3          6
## 42   1099510          10          4          3          1          3
## 43   1100524           6         10         10          2          8
## 44   1102573           5          6          5          6         10
## 45   1103608          10         10         10          4          8
## 46   1103722           1          1          1          1          2
## 47   1105257           3          7          7          4          4
## 48   1105524           1          1          1          1          2
## 49   1106095           4          1          1          3          2
## 50   1106829           7          8          7          2          4
## 51   1108370           9          5          8          1          2
## 52   1108449           5          3          3          4          2
## 53   1110102          10          3          6          2          3
## 54   1110503           5          5          5          8         10
## 55   1110524          10          5          5          6          8
## 56   1111249          10          6          6          3          4
## 57   1112209           8         10         10          1          3
## 58   1113038           8          2          4          1          5
## 59   1113483           5          2          3          1          6
## 60   1113906           9          5          5          2          2
## 61   1115282           5          3          5          5          3
## 62   1115293           1          1          1          1          2
## 63   1116116           9         10         10          1         10
## 64   1116132           6          3          4          1          5
## 65   1116192           1          1          1          1          2
## 66   1116998          10          4          2          1          3
## 67   1117152           4          1          1          1          2
## 68   1118039           5          3          4          1          8
## 69   1120559           8          3          8          3          4
## 70   1121732           1          1          1          1          2
## 71   1121919           5          1          3          1          2
## 72   1123061           6         10          2          8         10
## 73   1124651           1          3          3          2          2
## 74   1125035           9          4          5         10          6
## 75   1126417          10          6          4          1          3
## 76   1131294           1          1          2          1          2
## 77   1132347           1          1          4          1          2
## 78   1133041           5          3          1          2          2
## 79   1133136           3          1          1          1          2
## 80   1136142           2          1          1          1          3
## 81   1137156           2          2          2          1          1
## 82   1143978           4          1          1          2          2
## 83   1143978           5          2          1          1          2
## 84   1147044           3          1          1          1          2
## 85   1147699           3          5          7          8          8
## 86   1147748           5         10          6          1         10
## 87   1148278           3          3          6          4          5
## 88   1148873           3          6          6          6          5
## 89   1152331           4          1          1          1          2
## 90   1155546           2          1          1          2          3
```

```
## 91   1156272          1          1          1          1          2
## 92   1156948          3          1          1          2          2
## 93   1157734          4          1          1          1          2
## 94   1158247          1          1          1          1          2
## 95   1160476          2          1          1          1          2
## 96   1164066          1          1          1          1          2
## 97   1165297          2          1          1          2          2
## 98   1165790          5          1          1          1          2
## 99   1165926          9          6          9          2         10
## 100  1166630          7          5          6         10          5
## 101  1166654         10          3          5          1         10
## 102  1167439          2          3          4          4          2
## 103  1167471          4          1          2          1          2
## 104  1168359          8          2          3          1          6
## 105  1168736         10         10         10         10         10
## 106  1169049          7          3          4          4          3
## 107  1170419         10         10         10          8          2
## 108  1170420          1          6          8         10          8
## 109  1171710          1          1          1          1          2
## 110  1171710          6          5          4          4          3
## 111  1171795          1          3          1          2          2
## 112  1171845          8          6          4          3          5
## 113  1172152         10          3          3         10          2
## 114  1173216         10         10         10          3         10
## 115  1173235          3          3          2          1          2
## 116  1173347          1          1          1          1          2
## 117  1173347          8          3          3          1          2
## 118  1173509          4          5          5         10          4
## 119  1173514          1          1          1          1          4
## 120  1173681          3          2          1          1          2
## 121  1174057          1          1          2          2          2
## 122  1174057          4          2          1          1          2
## 123  1174131         10         10         10          2         10
## 124  1174428          5          3          5          1          8
## 125  1175937          5          4          6          7          9
## 126  1176406          1          1          1          1          2
## 127  1176881          7          5          3          7          4
## 128  1177027          3          1          1          1          2
## 129  1177399          8          3          5          4          5
## 130  1177512          1          1          1          1         10
## 131  1178580          5          1          3          1          2
## 132  1179818          2          1          1          1          2
## 133  1180194          5         10          8         10          8
## 134  1180523          3          1          1          1          2
## 135  1180831          3          1          1          1          3
## 136  1181356          5          1          1          1          2
## 137  1182404          4          1          1          1          2
## 138  1182410          3          1          1          1          2
## 139  1183240          4          1          2          1          2
## 141  1183516          3          1          1          1          2
## 142  1183911          2          1          1          1          2
## 143  1183983          9          5          5          4          4
## 144  1184184          1          1          1          1          2
## 145  1184241          2          1          1          1          2
```

```
## 147  1185609           3          4          5          2          6
## 148  1185610           1          1          1          1          3
## 149  1187457           3          1          1          3          8
## 150  1187805           8          8          7          4         10
## 151  1188472           1          1          1          1          1
## 152  1189266           7          2          4          1          6
## 153  1189286          10         10          8          6          4
## 154  1190394           4          1          1          1          2
## 155  1190485           1          1          1          1          2
## 156  1192325           5          5          5          6          3
## 157  1193091           1          2          2          1          2
## 158  1193210           2          1          1          1          2
## 160  1196295           9          9         10          3          6
## 161  1196915          10          7          7          4          5
## 162  1197080           4          1          1          1          2
## 163  1197270           3          1          1          1          2
## 164  1197440           1          1          1          2          1
## 166  1197979           4          1          1          1          2
## 167  1197993           5          6          7          8          8
## 168  1198128          10          8         10         10          6
## 169  1198641           3          1          1          1          2
## 170  1199219           1          1          1          2          1
## 171  1199731           3          1          1          1          2
## 172  1199983           1          1          1          1          2
## 173  1200772           1          1          1          1          2
## 174  1200847           6         10         10         10          8
## 175  1200892           8          6          5          4          3
## 176  1200952           5          8          7          7         10
## 177  1201834           2          1          1          1          2
## 178  1201936           5         10         10          3          8
## 179  1202125           4          1          1          1          2
## 180  1202812           5          3          3          3          6
## 181  1203096           1          1          1          1          1
## 182  1204242           1          1          1          1          2
## 183  1204898           6          1          1          1          2
## 184  1205138           5          8          8          8          5
## 185  1205579           8          7          6          4          4
## 186  1206089           2          1          1          1          1
## 187  1206695           1          5          8          6          5
## 188  1206841          10          5          6         10          6
## 189  1207986           5          8          4         10          5
## 190  1208301           1          2          3          1          2
## 191  1210963          10         10         10          8          6
## 192  1211202           7          5         10         10         10
## 193  1212232           5          1          1          1          2
## 194  1212251           1          1          1          1          2
## 195  1212422           3          1          1          1          2
## 196  1212422           4          1          1          1          2
## 197  1213375           8          4          4          5          4
## 198  1213383           5          1          1          4          2
## 199  1214092           1          1          1          1          2
## 200  1214556           3          1          1          1          2
## 201  1214966           9          7          7          5          5
## 202  1216694          10          8          8          4         10
```

```
## 203  1216947           1          1          1          1          2
## 204  1217051           5          1          1          1          2
## 205  1217264           1          1          1          1          2
## 206  1218105           5         10         10          9          6
## 207  1218741          10         10          9          3          7
## 208  1218860           1          1          1          1          1
## 209  1218860           1          1          1          1          1
## 210  1219406           5          1          1          1          1
## 211  1219525           8         10         10         10          5
## 212  1219859           8         10          8          8          4
## 213  1220330           1          1          1          1          2
## 214  1221863          10         10         10         10          7
## 215  1222047          10         10         10         10          3
## 216  1222936           8          7          8          7          5
## 217  1223282           1          1          1          1          2
## 218  1223426           1          1          1          1          2
## 219  1223793           6         10          7          7          6
## 220  1223967           6          1          3          1          2
## 221  1224329           1          1          1          2          2
## 222  1225799          10          6          4          3         10
## 223  1226012           4          1          1          3          1
## 224  1226612           7          5          6          3          3
## 225  1227210          10          5          5          6          3
## 226  1227244           1          1          1          1          2
## 227  1227481          10          5          7          4          4
## 228  1228152           8          9          9          5          3
## 229  1228311           1          1          1          1          1
## 230  1230175          10         10         10          3         10
## 231  1230688           7          4          7          4          3
## 232  1231387           6          8          7          5          6
## 233  1231706           8          4          6          3          3
## 234  1232225          10          4          5          5          5
## 235  1236043           3          3          2          1          3
## 237  1241559          10          8          8          2          8
## 238  1241679           9          8          8          5          6
## 239  1242364           8         10         10          8          6
## 240  1243256          10          4          3          2          3
## 241  1270479           5          1          3          3          2
## 242  1276091           3          1          1          3          1
## 243  1277018           2          1          1          1          2
## 244   128059           1          1          1          1          2
## 245  1285531           1          1          1          1          2
## 246  1287775           5          1          1          2          2
## 247   144888           8         10         10          8          5
## 248   145447           8          4          4          1          2
## 249   167528           4          1          1          1          2
## 251   183913           1          2          2          1          2
## 252   191250          10          4          4         10          2
## 253  1017023           6          3          3          5          3
## 254  1100524           6         10         10          2          8
## 255  1116116           9         10         10          1         10
## 256  1168736           5          6          6          2          4
## 257  1182404           3          1          1          1          2
## 258  1182404           3          1          1          1          2
```

```
## 259  1198641           3         1         1          1           2
## 260   242970           5         7         7          1           5
## 261   255644          10         5         8         10           3
## 262   263538           5        10        10          6          10
## 263   274137           8         8         9          4           5
## 264   303213          10         4         4         10           6
## 265   314428           7         9         4         10          10
## 266  1182404           5         1         4          1           2
## 267  1198641          10        10         6          3           3
## 268   320675           3         3         5          2           3
## 269   324427          10         8         8          2           3
## 270   385103           1         1         1          1           2
## 271   390840           8         4         7          1           3
## 272   411453           5         1         1          1           2
## 273   320675           3         3         5          2           3
## 274   428903           7         2         4          1           3
## 275   431495           3         1         1          1           2
## 277   434518           3         1         1          1           2
## 278   452264           1         1         1          1           2
## 279   456282           1         1         1          1           2
## 280   476903          10         5         7          3           3
## 281   486283           3         1         1          1           2
## 282   486662           2         1         1          2           2
## 283   488173           1         4         3         10           4
## 284   492268          10         4         6          1           2
## 285   508234           7         4         5         10           2
## 286   527363           8        10        10         10           8
## 287   529329          10        10        10         10          10
## 288   535331           3         1         1          1           3
## 289   543558           6         1         3          1           4
## 290   555977           5         6         6          8           6
## 291   560680           1         1         1          1           2
## 292   561477           1         1         1          1           2
## 294   601265          10         4         4          6           2
## 296   606722           5         5         7          8           6
## 297   616240           5         3         4          3           4
## 299   625201           8         2         1          1           5
## 300    63375           9         1         2          6           4
## 301   635844           8         4        10          5           4
## 302   636130           1         1         1          1           2
## 303   640744          10        10        10          7           9
## 304   646904           1         1         1          1           2
## 305   653777           8         3         4          9           3
## 306   659642          10         8         4          4           4
## 307   666090           1         1         1          1           2
## 308   666942           1         1         1          1           2
## 309   667204           7         8         7          6           4
## 310   673637           3         1         1          1           2
## 311   684955           2         1         1          1           3
## 312   688033           1         1         1          1           2
## 313   691628           8         6         4         10          10
## 314   693702           1         1         1          1           2
## 315   704097           1         1         1          1           1
## 317   706426           5         5         5          2           5
```

```
## 318   709287          6         8          7          8          6
## 319   718641          1         1          1          1          5
## 320   721482          4         4          4          4          6
## 321   730881          7         6          3          2          5
## 323   733639          3         1          1          1          2
## 324   733823          5         4          6         10          2
## 325   740492          1         1          1          1          2
## 326   743348          3         2          2          1          2
## 327   752904         10         1          1          1          2
## 328   756136          1         1          1          1          2
## 329   760001          8        10          3          2          6
## 330   760239         10         4          6          4          5
## 331    76389         10         4          7          2          2
## 332   764974          5         1          1          1          2
## 333   770066          5         2          2          2          2
## 334   785208          5         4          6          6          4
## 335   785615          8         6          7          3          3
## 336   792744          1         1          1          1          2
## 337   797327          6         5          5          8          4
## 338   798429          1         1          1          1          2
## 339   704097          1         1          1          1          1
## 340   806423          8         5          5          5          2
## 341   809912         10         3          3          1          2
## 342   810104          1         1          1          1          2
## 343   814265          2         1          1          1          2
## 344   814911          1         1          1          1          2
## 345   822829          7         6          4          8         10
## 346   826923          1         1          1          1          2
## 347   830690          5         2          2          2          3
## 348   831268          1         1          1          1          1
## 349   832226          3         4          4         10          5
## 350   832567          4         2          3          5          3
## 351   836433          5         1          1          3          2
## 352   837082          2         1          1          1          2
## 353   846832          3         4          5          3          7
## 354   850831          2         7         10         10          7
## 355   855524          1         1          1          1          2
## 356   857774          4         1          1          1          3
## 357   859164          5         3          3          1          3
## 358   859350          8        10         10          7         10
## 359   866325          8        10          5          3          8
## 360   873549         10         3          5          4          3
## 361   877291          6        10         10         10         10
## 362   877943          3        10          3         10          6
## 363   888169          3         2          2          1          4
## 364   888523          4         4          4          2          2
## 365   896404          2         1          1          1          2
## 366   897172          2         1          1          1          2
## 367    95719          6        10         10         10          8
## 368   160296          5         8          8         10          5
## 369   342245          1         1          3          1          2
## 370   428598          1         1          3          1          1
## 371   492561          4         3          2          1          3
## 372   493452          1         1          3          1          2
```

```
## 373   493452           4         1          2          1          2
## 374   521441           5         1          1          2          2
## 375   560680           3         1          2          1          2
## 376   636437           1         1          1          1          2
## 377   640712           1         1          1          1          2
## 378   654244           1         1          1          1          1
## 379   657753           3         1          1          4          3
## 380   685977           5         3          4          1          4
## 381   805448           1         1          1          1          2
## 382   846423          10         6          3          6          4
## 383  1002504           3         2          2          2          2
## 384  1022257           2         1          1          1          2
## 385  1026122           2         1          1          1          2
## 386  1071084           3         3          2          2          3
## 387  1080233           7         6          6          3          2
## 388  1114570           5         3          3          2          3
## 389  1114570           2         1          1          1          2
## 390  1116715           5         1          1          1          3
## 391  1131411           1         1          1          2          2
## 392  1151734          10         8          7          4          3
## 393  1156017           3         1          1          1          2
## 394  1158247           1         1          1          1          1
## 395  1158405           1         2          3          1          2
## 396  1168278           3         1          1          1          2
## 397  1176187           3         1          1          1          2
## 398  1196263           4         1          1          1          2
## 399  1196475           3         2          1          1          2
## 400  1206314           1         2          3          1          2
## 401  1211265           3        10          8          7          6
## 402  1213784           3         1          1          1          2
## 403  1223003           5         3          3          1          2
## 404  1223306           3         1          1          1          2
## 405  1223543           1         2          1          3          2
## 406  1229929           1         1          1          1          2
## 407  1231853           4         2          2          1          2
## 408  1234554           1         1          1          1          2
## 409  1236837           2         3          2          2          2
## 410  1237674           3         1          2          1          2
## 411  1238021           1         1          1          1          2
## 413  1238633          10        10         10          6          8
## 414  1238915           5         1          2          1          2
## 415  1238948           8         5          6          2          3
## 416  1239232           3         3          2          6          3
## 417  1239347           8         7          8          5         10
## 418  1239967           1         1          1          1          2
## 419  1240337           5         2          2          2          2
## 420  1253505           2         3          1          1          5
## 421  1255384           3         2          2          3          2
## 422  1257200          10        10         10          7         10
## 423  1257648           4         3          3          1          2
## 424  1257815           5         1          3          1          2
## 425  1257938           3         1          1          1          2
## 426  1258549           9        10         10         10         10
## 427  1258556           5         3          6          1          2
```

```
## 428  1266154           8         7         8           2           4
## 429  1272039           1         1         1           1           2
## 430  1276091           2         1         1           1           2
## 431  1276091           1         3         1           1           2
## 432  1276091           5         1         1           3           4
## 433  1277629           5         1         1           1           2
## 434  1293439           3         2         2           3           2
## 435  1293439           6         9         7           5           5
## 436  1294562          10         8        10           1           3
## 437  1295186          10        10        10           1           6
## 438   527337           4         1         1           1           2
## 439   558538           4         1         3           3           2
## 440   566509           5         1         1           1           2
## 441   608157          10         4         3          10           4
## 442   677910           5         2         2           4           2
## 443   734111           1         1         1           3           2
## 444   734111           1         1         1           1           2
## 445   780555           5         1         1           6           3
## 446   827627           2         1         1           1           2
## 447  1049837           1         1         1           1           2
## 448  1058849           5         1         1           1           2
## 449  1182404           1         1         1           1           1
## 450  1193544           5         7         9           8           6
## 451  1201870           4         1         1           3           1
## 452  1202253           5         1         1           1           2
## 453  1227081           3         1         1           3           2
## 454  1230994           4         5         5           8           6
## 455  1238410           2         3         1           1           3
## 456  1246562          10         2         2           1           2
## 457  1257470          10         6         5           8           5
## 458  1259008           8         8         9           6           6
## 459  1266124           5         1         2           1           2
## 460  1267898           5         1         3           1           2
## 461  1268313           5         1         1           3           2
## 462  1268804           3         1         1           1           2
## 463  1276091           6         1         1           3           2
## 464  1280258           4         1         1           1           2
## 465  1293966           4         1         1           1           2
## 466  1296572          10         9         8           7           6
## 467  1298416          10         6         6           2           4
## 468  1299596           6         6         6           5           4
## 469  1105524           4         1         1           1           2
## 470  1181685           1         1         2           1           2
## 471  1211594           3         1         1           1           1
## 472  1238777           6         1         1           3           2
## 473  1257608           6         1         1           1           1
## 474  1269574           4         1         1           1           2
## 475  1277145           5         1         1           1           2
## 476  1287282           3         1         1           1           2
## 477  1296025           4         1         2           1           2
## 478  1296263           4         1         1           1           2
## 479  1296593           5         2         1           1           2
## 480  1299161           4         8         7          10           4
## 481  1301945           5         1         1           1           1
```

```
## 482  1302428           5         3          2           4           2
## 483  1318169           9        10         10          10          10
## 484   474162           8         7          8           5           5
## 485   787451           5         1          2           1           2
## 486  1002025           1         1          1           3           1
## 487  1070522           3         1          1           1           1
## 488  1073960          10        10         10          10           6
## 489  1076352           3         6          4          10           3
## 490  1084139           6         3          2           1           3
## 491  1115293           1         1          1           1           2
## 492  1119189           5         8          9           4           3
## 493  1133991           4         1          1           1           1
## 494  1142706           5        10         10          10           6
## 495  1155967           5         1          2          10           4
## 496  1170945           3         1          1           1           1
## 497  1181567           1         1          1           1           1
## 498  1182404           4         2          1           1           2
## 499  1204558           4         1          1           1           2
## 500  1217952           4         1          1           1           2
## 501  1224565           6         1          1           1           2
## 502  1238186           4         1          1           1           2
## 503  1253917           4         1          1           2           2
## 504  1265899           4         1          1           1           2
## 505  1268766           1         1          1           1           2
## 506  1277268           3         3          1           1           2
## 507  1286943           8        10         10          10           7
## 508  1295508           1         1          1           1           2
## 509  1297327           5         1          1           1           2
## 510  1297522           2         1          1           1           2
## 511  1298360           1         1          1           1           2
## 512  1299924           5         1          1           1           2
## 513  1299994           5         1          1           1           2
## 514  1304595           3         1          1           1           1
## 515  1306282           6         6          7          10           3
## 516  1313325           4        10          4           7           3
## 517  1320077           1         1          1           1           1
## 518  1320077           1         1          1           1           1
## 519  1320304           3         1          2           2           2
## 520  1330439           4         7          8           3           4
## 521   333093           1         1          1           1           3
## 522   369565           4         1          1           1           3
## 523   412300          10         4          5           4           3
## 524   672113           7         5          6          10           4
## 525   749653           3         1          1           1           2
## 526   769612           3         1          1           2           2
## 527   769612           4         1          1           1           2
## 528   798429           4         1          1           1           2
## 529   807657           6         1          3           2           2
## 530  8233704           4         1          1           1           1
## 531   837480           7         4          4           3           4
## 532   867392           4         2          2           1           2
## 533   869828           1         1          1           1           1
## 534  1043068           3         1          1           1           2
## 535  1056171           2         1          1           1           2
```

```
## 536  1061990            1          1           3            2           2
## 537  1113061            5          1           1            1           2
## 538  1116192            5          1           2            1           2
## 539  1135090            4          1           1            1           2
## 540  1145420            6          1           1            1           2
## 541  1158157            5          1           1            1           2
## 542  1171578            3          1           1            1           2
## 543  1174841            5          3           1            1           2
## 544  1184586            4          1           1            1           2
## 545  1186936            2          1           3            2           2
## 546  1197527            5          1           1            1           2
## 547  1222464            6         10          10           10           4
## 548  1240603            2          1           1            1           1
## 549  1240603            3          1           1            1           1
## 550  1241035            7          8           3            7           4
## 551  1287971            3          1           1            1           2
## 552  1289391            1          1           1            1           2
## 553  1299924            3          2           2            2           2
## 554  1306339            4          4           2            1           2
## 555  1313658            3          1           1            1           2
## 556  1313982            4          3           1            1           2
## 557  1321264            5          2           2            2           1
## 558  1321321            5          1           1            3           2
## 559  1321348            2          1           1            1           2
## 560  1321931            5          1           1            1           2
## 561  1321942            5          1           1            1           2
## 562  1321942            5          1           1            1           2
## 563  1328331            1          1           1            1           2
## 564  1328755            3          1           1            1           2
## 565  1331405            4          1           1            1           2
## 566  1331412            5          7          10           10           5
## 567  1333104            3          1           2            1           2
## 568  1334071            4          1           1            1           2
## 569  1343068            8          4           4            1           6
## 570  1343374           10         10           8           10           6
## 571  1344121            8         10           4            4           8
## 572   142932            7          6          10            5           3
## 573   183936            3          1           1            1           2
## 574   324382            1          1           1            1           2
## 575   378275           10          9           7            3           4
## 576   385103            5          1           2            1           2
## 577   690557            5          1           1            1           2
## 578   695091            1          1           1            1           2
## 579   695219            1          1           1            1           2
## 580   824249            1          1           1            1           2
## 581   871549            5          1           2            1           2
## 582   878358            5          7          10            6           5
## 583  1107684            6         10           5            5           4
## 584  1115762            3          1           1            1           2
## 585  1217717            5          1           1            6           3
## 586  1239420            1          1           1            1           2
## 587  1254538            8         10          10           10           6
## 588  1261751            5          1           1            1           2
## 589  1268275            9          8           8            9           6
```

```
## 590  1272166           5          1          1          1          2
## 591  1294261           4         10          8          5          4
## 592  1295529           2          5          7          6          4
## 593  1298484          10          3          4          5          3
## 594  1311875           5          1          2          1          2
## 595  1315506           4          8          6          3          4
## 596  1320141           5          1          1          1          2
## 597  1325309           4          1          2          1          2
## 598  1333063           5          1          3          1          2
## 599  1333495           3          1          1          1          2
## 600  1334659           5          2          4          1          1
## 601  1336798           3          1          1          1          2
## 602  1344449           1          1          1          1          1
## 603  1350568           4          1          1          1          2
## 604  1352663           5          4          6          8          4
## 605   188336           5          3          2          8          5
## 606   352431          10          5         10          3          5
## 607   353098           4          1          1          2          2
## 608   411453           1          1          1          1          2
## 609   557583           5         10         10         10         10
## 610   636375           5          1          1          1          2
## 611   736150          10          4          3         10          3
## 612   803531           5         10         10         10          5
## 613   822829           8         10         10         10          6
## 614  1016634           2          3          1          1          2
## 615  1031608           2          1          1          1          1
## 616  1041043           4          1          3          1          2
## 617  1042252           3          1          1          1          2
## 619  1061990           4          1          1          1          2
## 620  1073836           5          1          1          1          2
## 621  1083817           3          1          1          1          2
## 622  1096352           6          3          3          3          3
## 623  1140597           7          1          2          3          2
## 624  1149548           1          1          1          1          2
## 625  1174009           5          1          1          2          1
## 626  1183596           3          1          3          1          3
## 627  1190386           4          6          6          5          7
## 628  1190546           2          1          1          1          2
## 629  1213273           2          1          1          1          2
## 630  1218982           4          1          1          1          2
## 631  1225382           6          2          3          1          2
## 632  1235807           5          1          1          1          2
## 633  1238777           1          1          1          1          2
## 634  1253955           8          7          4          4          5
## 635  1257366           3          1          1          1          2
## 636  1260659           3          1          4          1          2
## 637  1268952          10         10          7          8          7
## 638  1275807           4          2          4          3          2
## 639  1277792           4          1          1          1          2
## 640  1277792           5          1          1          3          2
## 641  1285722           4          1          1          3          2
## 642  1288608           3          1          1          1          2
## 643  1290203           3          1          1          1          2
## 644  1294413           1          1          1          1          2
```

```
## 645  1299596           2         1          1           1           2
## 646  1303489           3         1          1           1           2
## 647  1311033           1         2          2           1           2
## 648  1311108           1         1          1           3           2
## 649  1315807           5        10         10          10          10
## 650  1318671           3         1          1           1           2
## 651  1319609           3         1          1           2           3
## 652  1323477           1         2          1           3           2
## 653  1324572           5         1          1           1           2
## 654  1324681           4         1          1           1           2
## 655  1325159           3         1          1           1           2
## 656  1326892           3         1          1           1           2
## 657  1330361           5         1          1           1           2
## 658  1333877           5         4          5           1           8
## 659  1334015           7         8          8           7           3
## 660  1334667           1         1          1           1           2
## 661  1339781           1         1          1           1           2
## 662  1339781           4         1          1           1           2
## 663 13454352           1         1          3           1           2
## 664  1345452           1         1          3           1           2
## 665  1345593           3         1          1           3           2
## 666  1347749           1         1          1           1           2
## 667  1347943           5         2          2           2           2
## 668  1348851           3         1          1           1           2
## 669  1350319           5         7          4           1           6
## 670  1350423           5        10         10           8           5
## 671  1352848           3        10          7           8           5
## 672  1353092           3         2          1           2           2
## 673  1354840           2         1          1           1           2
## 674  1354840           5         3          2           1           3
## 675  1355260           1         1          1           1           2
## 676  1365075           4         1          4           1           2
## 677  1365328           1         1          2           1           2
## 678  1368267           5         1          1           1           2
## 679  1368273           1         1          1           1           2
## 680  1368882           2         1          1           1           2
## 681  1369821          10        10         10          10           5
## 682  1371026           5        10         10          10           4
## 683  1371920           5         1          1           1           2
## 684   466906           1         1          1           1           2
## 685   466906           1         1          1           1           2
## 686   534555           1         1          1           1           2
## 687   536708           1         1          1           1           2
## 688   566346           3         1          1           1           2
## 689   603148           4         1          1           1           2
## 690   654546           1         1          1           1           2
## 691   654546           1         1          1           3           2
## 692   695091           5        10         10           5           4
## 693   714039           3         1          1           1           2
## 694   763235           3         1          1           1           2
## 695   776715           3         1          1           1           3
## 696   841769           2         1          1           1           2
## 697   888820           5        10         10           3           7
## 698   897471           4         8          6           4           3
```

```
## 699   897471            4         8          8            5            4
##     Bare.nuclei Bl.cromatin Normal.nucleoli Mitoses     Class
## 1             1           3               1       1    benign
## 2            10           3               2       1    benign
## 3             2           3               1       1    benign
## 4             4           3               7       1    benign
## 5             1           3               1       1    benign
## 6            10           9               7       1 malignant
## 7            10           3               1       1    benign
## 8             1           3               1       1    benign
## 9             1           1               1       5    benign
## 10            1           2               1       1    benign
## 11            1           3               1       1    benign
## 12            1           2               1       1    benign
## 13            3           4               4       1 malignant
## 14            3           3               1       1    benign
## 15            9           5               5       4 malignant
## 16            1           4               3       1 malignant
## 17            1           2               1       1    benign
## 18            1           3               1       1    benign
## 19           10           4               1       2 malignant
## 20            1           3               1       1    benign
## 21           10           5               4       4 malignant
## 22            7           7              10       1 malignant
## 23            1           2               1       1    benign
## 25            1           3               1       1    benign
## 26            7           3               6       1 malignant
## 27            1           2               1       1    benign
## 28            1           2               1       1    benign
## 29            1           2               1       1    benign
## 30            1           1               1       1    benign
## 31            1           2               1       1    benign
## 32            1           3               1       1    benign
## 33            5           7               4       3 malignant
## 34            1           3               1       1    benign
## 35            1           2               1       1    benign
## 36            1           2               1       1    benign
## 37            1           8               9       1 malignant
## 38            1           7               1       1    benign
## 39           10           5               6       1 malignant
## 40            7           7               5       1 malignant
## 42            3           6               5       2 malignant
## 43           10           7               3       3 malignant
## 44            1           3               1       1 malignant
## 45            1           8              10       1 malignant
## 46            1           2               1       2    benign
## 47            9           4               8       1 malignant
## 48            1           2               1       1    benign
## 49            1           3               1       1    benign
## 50            8           3               8       2 malignant
## 51            3           2               1       5 malignant
## 52            4           3               4       1 malignant
## 53            5           4              10       2 malignant
## 54            8           7               3       7 malignant
```

```
## 55            8           7            1       1 malignant
## 56            5           3            6       1 malignant
## 57            6           3            9       1 malignant
## 58            1           5            4       4 malignant
## 59           10           5            1       1 malignant
## 60            2           5            1       1 malignant
## 61            3           4           10       1 malignant
## 62            2           2            1       1    benign
## 63            8           3            3       1 malignant
## 64            2           3            9       1 malignant
## 65            1           2            1       1    benign
## 66            2           4            3      10 malignant
## 67            1           3            1       1    benign
## 68           10           4            9       1 malignant
## 69            9           8            9       8 malignant
## 70            1           3            2       1    benign
## 71            1           2            1       1    benign
## 72            2           7            8      10 malignant
## 73            1           7            2       1    benign
## 74           10           4            8       1 malignant
## 75            4           3            2       3 malignant
## 76            2           4            2       1    benign
## 77            1           2            1       1    benign
## 78            1           2            1       1    benign
## 79            3           3            1       1    benign
## 80            1           2            1       1    benign
## 81            1           7            1       1    benign
## 82            1           2            1       1    benign
## 83            1           3            1       1    benign
## 84            2           7            1       1    benign
## 85            9           7           10       7 malignant
## 86            4           4           10      10 malignant
## 87            8           4            4       1 malignant
## 88           10           6            8       3 malignant
## 89            1           3            1       1    benign
## 90            1           2            1       1    benign
## 91            1           3            1       1    benign
## 92            1           1            1       1    benign
## 93            1           3            1       1    benign
## 94            1           2            1       1    benign
## 95            1           3            1       1    benign
## 96            1           3            1       1    benign
## 97            1           1            1       1    benign
## 98            1           3            1       1    benign
## 99            6           2            9      10 malignant
## 100          10           7            9       4 malignant
## 101           5           3           10       2 malignant
## 102           5           2            5       1 malignant
## 103           1           3            1       1    benign
## 104           3           7            1       1 malignant
## 105           1           8            8       8 malignant
## 106           3           3            2       7 malignant
## 107          10           4            1       1 malignant
## 108          10           5            7       1 malignant
```

```
## 109          1          2           3       1    benign
## 110          9          7           8       3 malignant
## 111          2          5           3       2    benign
## 112          9          3           1       1 malignant
## 113         10          7           3       3 malignant
## 114          8          8           1       1 malignant
## 115          3          3           1       1    benign
## 116          5          1           1       1    benign
## 117          2          3           2       1    benign
## 118         10          7           5       8 malignant
## 119          3          1           1       1    benign
## 120          2          3           1       1    benign
## 121          1          3           1       1    benign
## 122          2          3           1       1    benign
## 123         10          5           3       3 malignant
## 124         10          5           3       1 malignant
## 125          7          8          10       1 malignant
## 126          1          2           1       1    benign
## 127         10          7           5       5 malignant
## 128          1          3           1       1    benign
## 129         10          1           6       2 malignant
## 130          1          1           1       1    benign
## 131          1          2           1       1    benign
## 132          1          3           1       1    benign
## 133         10          3           6       3 malignant
## 134          1          2           2       1    benign
## 135          1          2           1       1    benign
## 136          2          3           3       1    benign
## 137          1          2           1       1    benign
## 138          1          1           1       1    benign
## 139          1          2           1       1    benign
## 141          1          1           1       1    benign
## 142          1          1           1       1    benign
## 143          5          4           3       3 malignant
## 144          5          1           1       1    benign
## 145          1          2           1       1    benign
## 147          8          4           1       1 malignant
## 148          2          2           1       1    benign
## 149          1          5           8       1    benign
## 150         10          7           8       7 malignant
## 151          1          3           1       1    benign
## 152         10          5           4       3 malignant
## 153          5          8          10       1 malignant
## 154          3          1           1       1    benign
## 155          1          1           1       1    benign
## 156         10          3           1       1 malignant
## 157          1          2           1       1    benign
## 158          1          3           1       1    benign
## 160         10          7          10       6 malignant
## 161         10          5           7       2 malignant
## 162          1          3           2       1    benign
## 163          1          3           1       1    benign
## 164          3          1           1       7    benign
## 166          2          3           2       1    benign
```

```
## 167          10           3           10       3 malignant
## 168           1           3            1      10 malignant
## 169           1           3            1       1    benign
## 170           1           1            1       1    benign
## 171           1           1            1       1    benign
## 172           1           3            1       1    benign
## 173           1           2            1       1    benign
## 174          10          10           10       7 malignant
## 175          10           6            1       1 malignant
## 176          10           5            7       1 malignant
## 177           1           3            1       1    benign
## 178           1           5           10       3 malignant
## 179           1           3            1       1    benign
## 180          10           3            1       1 malignant
## 181           1           3            1       1    benign
## 182           1           1            1       1    benign
## 183           1           3            1       1    benign
## 184          10           7            8       1 malignant
## 185          10           5            1       1 malignant
## 186           1           3            1       1    benign
## 187           8           7           10       1 malignant
## 188          10           7            7      10 malignant
## 189           8           9           10       1 malignant
## 190           1           3            1       1    benign
## 191           8           7           10       1 malignant
## 192          10           4           10       3 malignant
## 193           1           2            1       1    benign
## 194           1           3            1       1    benign
## 195           1           3            1       1    benign
## 196           1           3            1       1    benign
## 197           7           7            8       2    benign
## 198           1           3            1       1    benign
## 199           1           1            1       1    benign
## 200           1           2            1       1    benign
## 201          10           7            8       3 malignant
## 202          10           8            1       1 malignant
## 203           1           3            1       1    benign
## 204           1           3            1       1    benign
## 205           1           3            1       1    benign
## 206          10           7           10       5 malignant
## 207           5           3            5       1 malignant
## 208           1           3            1       1    benign
## 209           1           3            1       1    benign
## 210           1           3            1       1    benign
## 211          10           8           10       6 malignant
## 212           8           7            7       1 malignant
## 213           1           3            1       1    benign
## 214          10           7           10       4 malignant
## 215          10          10            6       1 malignant
## 216           5           5           10       2 malignant
## 217           1           2            1       1    benign
## 218           1           3            1       1    benign
## 219           4           8           10       2 malignant
## 220           1           3            1       1    benign
```

```
## 221          1           3            1       1    benign
## 222         10           9           10       1 malignant
## 223          5           2            1       1 malignant
## 224          8           7            4       1 malignant
## 225         10           7            9       2 malignant
## 226          1           2            1       1    benign
## 227         10           8            9       1 malignant
## 228          5           7            7       1 malignant
## 229          1           3            1       1    benign
## 230         10           9           10       1 malignant
## 231          7           7            6       1 malignant
## 232          8           8            9       2 malignant
## 233          1           4            3       1    benign
## 234         10           4            1       1 malignant
## 235          1           3            6       1    benign
## 237         10           4            8      10 malignant
## 238          2           4           10       4 malignant
## 239          9           3           10      10 malignant
## 240         10           5            3       2 malignant
## 241          2           2            3       1    benign
## 242          1           3            1       1    benign
## 243          1           3            1       1    benign
## 244          5           5            1       1    benign
## 245          1           3            1       1    benign
## 246          2           3            1       1    benign
## 247         10           7            8       1 malignant
## 248          9           3            3       1 malignant
## 249          1           3            6       1    benign
## 251          1           1            1       1    benign
## 252         10           5            3       3 malignant
## 253         10           3            5       3    benign
## 254         10           7            3       3 malignant
## 255          8           3            3       1 malignant
## 256         10           3            6       1 malignant
## 257          1           1            1       1    benign
## 258          1           2            1       1    benign
## 259          1           3            1       1    benign
## 260          8           3            4       1    benign
## 261         10           5            1       3 malignant
## 262         10          10            6       5 malignant
## 263         10           7            8       1 malignant
## 264         10           5            5       1 malignant
## 265          3           5            3       3 malignant
## 266          1           3            2       1    benign
## 267         10           4            3       2 malignant
## 268         10           7            1       1 malignant
## 269          4           8            7       8 malignant
## 270          1           3            1       1    benign
## 271         10           3            9       2 malignant
## 272          1           3            1       1    benign
## 273         10           7            1       1 malignant
## 274          4           3            3       1 malignant
## 275          1           3            2       1    benign
## 277          1           2            1       1    benign
```

```
## 278          1           2           1       1    benign
## 279          1           3           1       1    benign
## 280          7           3           3       8 malignant
## 281          1           3           1       1    benign
## 282          1           3           1       1    benign
## 283         10           5           6       1 malignant
## 284         10           5           3       1 malignant
## 285         10           3           8       2 malignant
## 286         10          10           7       3 malignant
## 287         10           4          10      10 malignant
## 288          1           2           1       1    benign
## 289          5           5          10       1 malignant
## 290         10           4          10       4 malignant
## 291          1           1           1       1    benign
## 292          1           3           1       1    benign
## 294         10           2           3       1 malignant
## 296         10           7           4       1 malignant
## 297          5           4           7       1    benign
## 299          1           1           1       1    benign
## 300         10           7           7       2 malignant
## 301          4           7          10       1 malignant
## 302          1           3           1       1    benign
## 303         10           7          10      10 malignant
## 304          1           3           1       1    benign
## 305         10           3           3       1 malignant
## 306         10           3          10       4 malignant
## 307          1           3           1       1    benign
## 308          1           3           1       1    benign
## 309          3           8           8       4 malignant
## 310          5           5           1       1    benign
## 311          1           2           1       1    benign
## 312          1           1           1       1    benign
## 313          1           3           5       1 malignant
## 314          1           1           1       1    benign
## 315          1           2           1       1    benign
## 317         10           4           3       1 malignant
## 318          8           8           9       1 malignant
## 319          1           3           1       1    benign
## 320          5           7           3       1    benign
## 321         10           7           4       6 malignant
## 323          1           3           1       1    benign
## 324         10           4           1       1 malignant
## 325          1           3           1       1    benign
## 326          1           2           3       1    benign
## 327         10           5           4       1 malignant
## 328          1           2           1       1    benign
## 329          4           3          10       1 malignant
## 330         10           7           1       1 malignant
## 331          8           6           1       1 malignant
## 332          1           3           1       2    benign
## 333          1           2           2       1    benign
## 334         10           4           3       1 malignant
## 335         10           3           4       2 malignant
## 336          1           1           1       1    benign
```

```
## 337          10           3            4       1 malignant
## 338           1           3            1       1    benign
## 339           1           2            1       1    benign
## 340          10           4            3       1 malignant
## 341          10           7            6       1 malignant
## 342           1           3            1       1    benign
## 343           1           1            1       1    benign
## 344           1           1            1       1    benign
## 345          10           9            5       3 malignant
## 346           1           1            1       1    benign
## 347           1           1            3       1    benign
## 348           1           1            3       1    benign
## 349           1           3            3       1 malignant
## 350           8           7            6       1 malignant
## 351           1           1            1       1    benign
## 352           1           3            1       1    benign
## 353           3           4            6       1    benign
## 354          10           4            9       4 malignant
## 355           1           2            1       1    benign
## 356           1           2            2       1    benign
## 357           3           3            3       3 malignant
## 358          10           7            3       8 malignant
## 359           4           4           10       3 malignant
## 360           7           3            5       3 malignant
## 361          10           8           10      10 malignant
## 362          10           5            1       4 malignant
## 363           3           2            1       1    benign
## 364           3           2            1       1    benign
## 365           1           3            1       1    benign
## 366           1           2            1       1    benign
## 367          10           7           10       7 malignant
## 368          10           8           10       3 malignant
## 369           1           1            1       1    benign
## 370           1           2            1       1    benign
## 371           1           2            1       1    benign
## 372           1           1            1       1    benign
## 373           1           2            1       1    benign
## 374           1           2            1       1    benign
## 375           1           2            1       1    benign
## 376           1           1            1       1    benign
## 377           1           2            1       1    benign
## 378           1           2            1       1    benign
## 379           1           2            2       1    benign
## 380           1           3            1       1    benign
## 381           1           1            1       1    benign
## 382          10           7            8       4 malignant
## 383           1           3            2       1    benign
## 384           1           1            1       1    benign
## 385           1           1            1       1    benign
## 386           1           1            2       3    benign
## 387          10           7            1       1 malignant
## 388           1           3            1       1    benign
## 389           1           2            2       1    benign
## 390           2           2            2       1    benign
```

```
## 391          1           2           1       1    benign
## 392         10           7           9       1 malignant
## 393          1           2           1       1    benign
## 394          1           1           1       1    benign
## 395          1           2           1       1    benign
## 396          1           2           1       1    benign
## 397          1           3           1       1    benign
## 398          1           1           1       1    benign
## 399          1           2           2       1    benign
## 400          1           1           1       1    benign
## 401          9           9           3       8 malignant
## 402          1           1           1       1    benign
## 403          1           2           1       1    benign
## 404          4           1           1       1    benign
## 405          1           1           2       1    benign
## 406          1           2           1       1    benign
## 407          1           2           1       1    benign
## 408          1           2           1       1    benign
## 409          2           3           1       1    benign
## 410          1           2           1       1    benign
## 411          1           2           1       1    benign
## 413          4           8           5       1 malignant
## 414          1           3           1       1    benign
## 415         10           6           6       1 malignant
## 416          3           3           5       1    benign
## 417         10           7           2       1 malignant
## 418          1           2           1       1    benign
## 419          2           3           2       2    benign
## 420          1           1           1       1    benign
## 421          3           3           1       1    benign
## 422         10           8           2       1 malignant
## 423          1           3           3       1    benign
## 424          1           2           1       1    benign
## 425          1           1           1       1    benign
## 426         10          10          10       1 malignant
## 427          1           1           1       1    benign
## 428          2           5          10       1 malignant
## 429          1           2           1       1    benign
## 430          1           2           1       1    benign
## 431          1           2           2       1    benign
## 432          1           3           2       1    benign
## 433          1           2           2       1    benign
## 434          1           1           1       1    benign
## 435          8           4           2       1    benign
## 436         10           5           1       1 malignant
## 437          1           2           8       1 malignant
## 438          1           1           1       1    benign
## 439          1           1           1       1    benign
## 440          1           1           1       1    benign
## 441         10          10           1       1 malignant
## 442          4           1           1       1    benign
## 443          3           1           1       1    benign
## 444          2           1           1       1    benign
## 445          1           2           1       1    benign
```

```
## 446          1           1            1       1    benign
## 447          1           1            1       1    benign
## 448          1           1            1       1    benign
## 449          1           1            1       1    benign
## 450         10           8           10       1 malignant
## 451          1           2            1       1    benign
## 452          1           1            1       1    benign
## 453          1           1            1       1    benign
## 454         10          10            7       1 malignant
## 455          1           1            1       1    benign
## 456          6           1            1       2 malignant
## 457         10           8            6       1 malignant
## 458          3          10           10       1 malignant
## 459          1           1            1       1    benign
## 460          1           1            1       1    benign
## 461          1           1            1       1    benign
## 462          5           1            1       1    benign
## 463          1           1            1       1    benign
## 464          1           1            2       1    benign
## 465          1           1            1       1    benign
## 466          4           7           10       3 malignant
## 467         10           9            7       1 malignant
## 468         10           7            6       2 malignant
## 469          1           1            1       1    benign
## 470          1           2            1       1    benign
## 471          1           2            1       1    benign
## 472          1           1            1       1    benign
## 473          1           1            1       1    benign
## 474          1           1            1       1    benign
## 475          1           1            1       1    benign
## 476          1           1            1       1    benign
## 477          1           1            1       1    benign
## 478          1           1            1       1    benign
## 479          1           1            1       1    benign
## 480         10           7            5       1 malignant
## 481          1           1            1       1    benign
## 482          1           1            1       1    benign
## 483          5          10           10      10 malignant
## 484         10           9           10       1 malignant
## 485          1           1            1       1    benign
## 486          3           1            1       1    benign
## 487          1           2            1       1    benign
## 488         10           8            1       5 malignant
## 489          3           3            4       1 malignant
## 490          4           4            1       1 malignant
## 491          1           1            1       1    benign
## 492         10           7            1       1 malignant
## 493          1           2            1       1    benign
## 494         10           6            5       2 malignant
## 495          5           2            1       1    benign
## 496          1           2            1       1    benign
## 497          1           1            1       1    benign
## 498          1           1            1       1    benign
## 499          1           2            1       1    benign
```

```
## 500          1          2           1       1    benign
## 501          1          3           1       1    benign
## 502          1          2           1       1    benign
## 503          1          2           1       1    benign
## 504          1          3           1       1    benign
## 505          1          1           1       1    benign
## 506          1          1           1       1    benign
## 507          5          4           8       7 malignant
## 508          4          1           1       1    benign
## 509          1          1           1       1    benign
## 510          1          1           1       1    benign
## 511          1          1           1       1    benign
## 512          1          2           1       1    benign
## 513          1          1           1       1    benign
## 514          1          2           1       1    benign
## 515         10          8          10       2 malignant
## 516         10          9          10       1 malignant
## 517          1          1           1       1    benign
## 518          1          2           1       1    benign
## 519          1          1           1       1    benign
## 520         10          9           1       1 malignant
## 521          1          1           1       1    benign
## 522          1          1           1       1    benign
## 523          5          7           3       1 malignant
## 524         10          5           3       1 malignant
## 525          1          2           1       1    benign
## 526          1          1           1       1    benign
## 527          1          1           1       1    benign
## 528          1          3           1       1    benign
## 529          1          1           1       1    benign
## 530          1          2           1       1    benign
## 531         10          6           9       1 malignant
## 532          1          2           1       1    benign
## 533          1          3           1       1    benign
## 534          1          2           1       1    benign
## 535          1          2           1       1    benign
## 536          1          3           1       1    benign
## 537          1          3           1       1    benign
## 538          1          3           1       1    benign
## 539          1          2           1       1    benign
## 540          1          2           1       1    benign
## 541          2          2           1       1    benign
## 542          1          1           1       1    benign
## 543          1          1           1       1    benign
## 544          1          2           1       1    benign
## 545          1          2           1       1    benign
## 546          1          2           1       1    benign
## 547         10          7          10       1 malignant
## 548          1          1           1       1    benign
## 549          1          1           1       1    benign
## 550          5          7           8       2 malignant
## 551          1          2           1       1    benign
## 552          1          3           1       1    benign
## 553          1          4           2       1    benign
```

```
## 554          5           2            1       2    benign
## 555          1           1            1       1    benign
## 556          1           4            8       1    benign
## 557          1           2            1       1    benign
## 558          1           1            1       1    benign
## 559          1           2            1       1    benign
## 560          1           2            1       1    benign
## 561          1           3            1       1    benign
## 562          1           3            1       1    benign
## 563          1           3            1       1    benign
## 564          1           2            1       1    benign
## 565          1           3            2       1    benign
## 566         10          10           10       1 malignant
## 567          1           3            1       1    benign
## 568          3           2            1       1    benign
## 569         10           2            5       2 malignant
## 570          5          10            3       1 malignant
## 571         10           8            2       1 malignant
## 572         10           9           10       2 malignant
## 573          1           2            1       1    benign
## 574          1           2            1       1    benign
## 575          2           7            7       1 malignant
## 576          1           3            1       1    benign
## 577          1           2            1       1    benign
## 578          1           2            1       1    benign
## 579          1           2            1       1    benign
## 580          1           3            1       1    benign
## 581          1           2            1       1    benign
## 582         10           7            5       1 malignant
## 583         10           6           10       1 malignant
## 584          1           1            1       1    benign
## 585          1           1            1       1    benign
## 586          1           1            1       1    benign
## 587         10          10           10       1 malignant
## 588          1           2            2       1    benign
## 589          3           4            1       1 malignant
## 590          1           1            1       1    benign
## 591          1          10            1       1 malignant
## 592         10           7            6       1 malignant
## 593         10           4            1       1 malignant
## 594          1           1            1       1    benign
## 595         10           7            1       1 malignant
## 596          1           2            1       1    benign
## 597          1           2            1       1    benign
## 598          1           3            1       1    benign
## 599          1           2            1       1    benign
## 600          1           1            1       1    benign
## 601          1           2            1       1    benign
## 602          1           2            1       1    benign
## 603          1           2            1       1    benign
## 604          1           8           10       1 malignant
## 605         10           8            1       2 malignant
## 606          8           7            8       3 malignant
## 607          1           1            1       1    benign
```

```
## 608          1           1            1       1    benign
## 609         10          10            1       1 malignant
## 610          1           1            1       1    benign
## 611         10           7            1       2 malignant
## 612          2           8            5       1 malignant
## 613         10          10           10      10 malignant
## 614          1           2            1       1    benign
## 615          1           2            1       1    benign
## 616          1           2            1       1    benign
## 617          1           2            1       1    benign
## 619          1           2            1       1    benign
## 620          1           2            1       1    benign
## 621          1           2            1       1    benign
## 622          2           6            1       1    benign
## 623          1           2            1       1    benign
## 624          1           1            1       1    benign
## 625          1           2            1       1    benign
## 626          4           1            1       1    benign
## 627          6           7            7       3 malignant
## 628          5           1            1       1    benign
## 629          1           1            1       1    benign
## 630          1           1            1       1    benign
## 631          1           1            1       1    benign
## 632          1           2            1       1    benign
## 633          1           1            1       1    benign
## 634          3           5           10       1 malignant
## 635          1           1            1       1    benign
## 636          1           1            1       1    benign
## 637          1          10           10       3 malignant
## 638          2           2            1       1    benign
## 639          1           1            1       1    benign
## 640          1           1            1       1    benign
## 641          1           1            1       1    benign
## 642          1           2            1       1    benign
## 643          1           2            1       1    benign
## 644          1           1            1       1    benign
## 645          1           1            1       1    benign
## 646          1           2            1       1    benign
## 647          1           1            1       1    benign
## 648          1           1            1       1    benign
## 649          2          10           10      10 malignant
## 650          1           2            1       1    benign
## 651          4           1            1       1    benign
## 652          1           2            1       1    benign
## 653          1           2            2       1    benign
## 654          1           2            1       1    benign
## 655          1           3            1       1    benign
## 656          1           2            1       1    benign
## 657          1           2            1       1    benign
## 658          1           3            6       1    benign
## 659         10           7            2       3 malignant
## 660          1           1            1       1    benign
## 661          1           2            1       1    benign
## 662          1           3            1       1    benign
```

```
## 663          1           2            1       1    benign
## 664          1           2            1       1    benign
## 665          1           2            1       1    benign
## 666          1           1            1       1    benign
## 667          1           1            1       2    benign
## 668          1           3            1       1    benign
## 669          1           7           10       3 malignant
## 670          5           7           10       1 malignant
## 671          8           7            4       1 malignant
## 672          1           3            1       1    benign
## 673          1           3            1       1    benign
## 674          1           1            1       1    benign
## 675          1           2            1       1    benign
## 676          1           1            1       1    benign
## 677          1           2            1       1    benign
## 678          1           1            1       1    benign
## 679          1           1            1       1    benign
## 680          1           1            1       1    benign
## 681         10          10           10       7 malignant
## 682         10           5            6       3 malignant
## 683          1           3            2       1    benign
## 684          1           1            1       1    benign
## 685          1           1            1       1    benign
## 686          1           1            1       1    benign
## 687          1           1            1       1    benign
## 688          1           2            3       1    benign
## 689          1           1            1       1    benign
## 690          1           1            1       8    benign
## 691          1           1            1       1    benign
## 692          5           4            4       1 malignant
## 693          1           1            1       1    benign
## 694          1           2            1       2    benign
## 695          2           1            1       1    benign
## 696          1           1            1       1    benign
## 697          3           8           10       2 malignant
## 698          4          10            6       1 malignant
## 699          5          10            4       1 malignant
```

```
# Remove Id column
BreastCancer <- BreastCancer[, -1]

# Now, the Class variable is converted into a factor since we need to do this in order to do classifica
## 1 = Benign and 0 = Malignant
# Convert "Class" into a factor with levels 1 and 0
BreastCancer$Class <- factor(BreastCancer$Class, levels = c("benign", "malignant"), labels = c(1, 0))

str(BreastCancer)
```

```
## 'data.frame':    683 obs. of  10 variables:
##  $ Cl.thickness   : Ord.factor w/ 10 levels "1"<"2"<"3"<"4"<..: 5 5 3 6 4 8 1 2 2 4 ...
##  $ Cell.size      : Ord.factor w/ 10 levels "1"<"2"<"3"<"4"<..: 1 4 1 8 1 10 1 1 1 2 ...
##  $ Cell.shape     : Ord.factor w/ 10 levels "1"<"2"<"3"<"4"<..: 1 4 1 8 1 10 1 2 1 1 ...
##  $ Marg.adhesion  : Ord.factor w/ 10 levels "1"<"2"<"3"<"4"<..: 1 5 1 1 3 8 1 1 1 1 ...
##  $ Epith.c.size   : Ord.factor w/ 10 levels "1"<"2"<"3"<"4"<..: 2 7 2 3 2 7 2 2 2 2 ...
```

```
##  $ Bare.nuclei    : Factor w/ 10 levels "1","2","3","4",..: 1 10 2 4 1 10 10 1 1 1 ...
##  $ Bl.cromatin    : Factor w/ 10 levels "1","2","3","4",..: 3 3 3 3 3 9 3 3 1 2 ...
##  $ Normal.nucleoli: Factor w/ 10 levels "1","2","3","4",..: 1 2 1 7 1 7 1 1 1 1 ...
##  $ Mitoses        : Factor w/ 9 levels "1","2","3","4",..: 1 1 1 1 1 1 1 1 5 1 ...
##  $ Class          : Factor w/ 2 levels "1","0": 1 1 1 1 1 2 1 1 1 1 ...
```

```
## After reviewing the data we have determined that Class Variable will be the response variable to ana

## We will need to determine if the data is balanced by reviewing the count of the class column.



Class_counts <- table(BreastCancer$Class)
print(Class_counts)
```

```
##
##   1   0
## 444 239
```

```
## Since the "class" count is not balanced we will use random sampling method to randomly select from 1

# Separate the data into two data frames
class_0 <- BreastCancer[BreastCancer$Class == 0, ]
class_1 <- BreastCancer[BreastCancer$Class == 1, ]

minority_size <- nrow(class_0)

# Randomly sample rows from the majority class to match the minority class size
class_1_sampled <- class_1[sample(nrow(class_1), minority_size), ]

# Combine the sampled majority class with the minority class
balanced_data <- rbind(class_1_sampled, class_0)

# Shuffle the rows to randomize the order
balanced_data <- balanced_data[sample(nrow(balanced_data)), ]

# Check the class distribution after balancing
table(balanced_data$Class)
```

```
##
##   1   0
## 239 239
```

```
## Class is now balanced for a count of 239 each for 0 and 1. Now we will create a training and test da

library(caret)
```

```
## Loading required package: ggplot2
```

```
## Loading required package: lattice
```

```r
# Create data partition indices
train_index <- createDataPartition(balanced_data$Class, p = 0.7, list = FALSE)

# Create training and test sets
train <- balanced_data[train_index, ]
test <- balanced_data[-train_index, ]

# Convert ordinal factors to numeric
train$Cl.thickness <- as.numeric(train$Cl.thickness)
test$Cl.thickness <- as.numeric(test$Cl.thickness)

# Check dimensions of train and test sets
dim(train)
```

```
## [1] 336  10
```

```r
dim(test)
```

```
## [1] 142  10
```

```r
str(train)
```

```
## 'data.frame':    336 obs. of  10 variables:
##  $ Cl.thickness   : num  10 5 1 9 8 1 5 10 3 4 ...
##  $ Cell.size      : Ord.factor w/ 10 levels "1"<"2"<"3"<"4"<..: 5 10 1 9 10 1 3 8 1 1 ...
##  $ Cell.shape     : Ord.factor w/ 10 levels "1"<"2"<"3"<"4"<..: 7 10 3 10 10 1 4 8 1 1 ...
##  $ Marg.adhesion  : Ord.factor w/ 10 levels "1"<"2"<"3"<"4"<..: 3 10 2 3 10 1 1 2 1 1 ...
##  $ Epith.c.size   : Ord.factor w/ 10 levels "1"<"2"<"3"<"4"<..: 3 10 2 6 5 3 8 3 2 1 ...
##  $ Bare.nuclei    : Factor w/ 10 levels "1","2","3","4",..: 7 2 1 10 10 2 10 4 1 1 ...
##  $ Bl.cromatin    : Factor w/ 10 levels "1","2","3","4",..: 3 10 3 7 8 2 4 8 1 2 ...
##  $ Normal.nucleoli: Factor w/ 10 levels "1","2","3","4",..: 3 10 1 10 10 1 9 7 1 1 ...
##  $ Mitoses        : Factor w/ 9 levels "1","2","3","4",..: 8 9 1 6 6 1 1 8 1 1 ...
##  $ Class          : Factor w/ 2 levels "1","0": 2 2 1 2 2 1 2 2 1 1 ...
```

```r
str(test)
```

```
## 'data.frame':    142 obs. of  10 variables:
##  $ Cl.thickness   : num  10 1 9 5 5 3 3 7 5 2 ...
##  $ Cell.size      : Ord.factor w/ 10 levels "1"<"2"<"3"<"4"<..: 10 1 10 3 1 2 4 6 10 1 ...
##  $ Cell.shape     : Ord.factor w/ 10 levels "1"<"2"<"3"<"4"<..: 10 1 10 5 1 2 5 10 10 1 ...
##  $ Marg.adhesion  : Ord.factor w/ 10 levels "1"<"2"<"3"<"4"<..: 8 3 1 5 2 1 2 5 6 1 ...
##  $ Epith.c.size   : Ord.factor w/ 10 levels "1"<"2"<"3"<"4"<..: 2 1 10 3 2 2 6 3 10 3 ...
##  $ Bare.nuclei    : Factor w/ 10 levels "1","2","3","4",..: 10 3 8 3 2 1 8 10 10 1 ...
##  $ Bl.cromatin    : Factor w/ 10 levels "1","2","3","4",..: 4 1 3 4 3 2 4 9 10 2 ...
##  $ Normal.nucleoli: Factor w/ 10 levels "1","2","3","4",..: 1 1 3 10 1 3 1 10 6 1 ...
##  $ Mitoses        : Factor w/ 9 levels "1","2","3","4",..: 1 1 1 1 1 1 1 2 5 1 ...
##  $ Class          : Factor w/ 2 levels "1","0": 2 1 2 2 1 1 2 2 2 1 ...
```

```r
## We will run 4 different types of model. Logistic Regression, Naive Bayes, SVM and Random Forest. Ran

## Logistic regression did not perform well for this data. Probabaly because there is ordinal data.
```

```r
library(caret)

# Fit logistic regression model
model <- glm(Class ~ ., data = train, family = binomial)
```

```
## Warning: glm.fit: algorithm did not converge
```

```
## Warning: glm.fit: fitted probabilities numerically 0 or 1 occurred
```

```r
# Predict probabilities for the training data
train_probabilities <- predict(model, newdata = train, type = "response")

# Convert probabilities to class predictions for training data
train_predictions <- ifelse(train_probabilities >= 0.5, 1, 0)  # Assuming 0.5 threshold for binary clas

# Predict probabilities for the test data
test_probabilities <- predict(model, newdata = test, type = "response")

# Convert probabilities to class predictions for test data
test_predictions <- ifelse(test_probabilities >= 0.5, 1, 0)  # Assuming 0.5 threshold for binary classi

# Function to compute performance measures
compute_performance <- function(predictions, true_labels) {
  # Create confusion matrix
  conf_mat <- confusionMatrix(as.factor(predictions), as.factor(true_labels))

  # Extract performance measures
  accuracy <- conf_mat$overall['Accuracy']
  recall <- conf_mat$byClass['Sensitivity']
  precision <- conf_mat$byClass['Pos Pred Value']
  f1_score <- 2 * (precision * recall) / (precision + recall)

  # Return performance measures
  return(list(conf_mat = conf_mat$table,
              accuracy = accuracy,
              recall = recall,
              precision = precision,
              f1_score = f1_score))
}

# Compute performance measures for training data
train_performance <- compute_performance(train_predictions, train$Class)
```

```
## Warning in confusionMatrix.default(as.factor(predictions),
## as.factor(true_labels)): Levels are not in the same order for reference and
## data. Refactoring data to match.
```

```r
# Compute performance measures for test data
test_performance <- compute_performance(test_predictions, test$Class)
```

```
## Warning in confusionMatrix.default(as.factor(predictions),
## as.factor(true_labels)): Levels are not in the same order for reference and
## data. Refactoring data to match.
```

```r
# Print performance measures for training data
cat("Performance measures for training data:\n")
```

```
## Performance measures for training data:
```

```r
cat("Confusion Matrix:\n")
```

```
## Confusion Matrix:
```

```r
print(train_performance$conf_mat)
```

```
##           Reference
## Prediction   1   0
##          1   0 168
##          0 168   0
```

```r
cat("\nAccuracy:", train_performance$accuracy)
```

```
##
## Accuracy: 0
```

```r
cat("\nRecall (Sensitivity):", train_performance$recall)
```

```
##
## Recall (Sensitivity): 0
```

```r
cat("\nPrecision (Positive Predictive Value):", train_performance$precision)
```

```
##
## Precision (Positive Predictive Value): 0
```

```r
cat("\nF1-score:", train_performance$f1_score)
```

```
##
## F1-score: NaN
```

```r
# Print performance measures for test data
cat("\n\nPerformance measures for test data:\n")
```

```
##
##
## Performance measures for test data:
```

```r
cat("Confusion Matrix:\n")
```

```
## Confusion Matrix:
```

```r
print(test_performance$conf_mat)
```

```
##           Reference
## Prediction  1  0
##          1  1 62
##          0 70  9
```

```r
cat("\nAccuracy:", test_performance$accuracy)
```

```
##
## Accuracy: 0.07042254
```

```r
cat("\nRecall (Sensitivity):", test_performance$recall)
```

```
##
## Recall (Sensitivity): 0.01408451
```

```r
cat("\nPrecision (Positive Predictive Value):", test_performance$precision)
```

```
##
## Precision (Positive Predictive Value): 0.01587302
```

```r
cat("\nF1-score:", test_performance$f1_score)
```

```
##
## F1-score: 0.01492537
```

```r
## Naive Bayes: Did well, but concerned about overfitting.

# Load the required library
library(e1071)

# Fit Naive Bayes model to the training data
nb_model <- naiveBayes(Class ~ ., data = train)

# Make predictions on the train and test data
train_predictions <- predict(nb_model, train)
test_predictions <- predict(nb_model, test)

# Evaluate model performance on train data
train_confusion_matrix <- table(train_predictions, train$Class)
train_accuracy <- sum(diag(train_confusion_matrix)) / sum(train_confusion_matrix)
train_precision <- train_confusion_matrix[2, 2] / sum(train_confusion_matrix[, 2])
train_recall <- train_confusion_matrix[2, 2] / sum(train_confusion_matrix[2, ])
train_f1_score <- 2 * train_precision * train_recall / (train_precision + train_recall)

# Evaluate model performance on test data
test_confusion_matrix <- table(test_predictions, test$Class)
test_accuracy <- sum(diag(test_confusion_matrix)) / sum(test_confusion_matrix)
```

```r
test_precision <- test_confusion_matrix[2, 2] / sum(test_confusion_matrix[, 2])
test_recall <- test_confusion_matrix[2, 2] / sum(test_confusion_matrix[2, ])
test_f1_score <- 2 * test_precision * test_recall / (test_precision + test_recall)

# Print performance measures for train data
cat("Performance measures for train data:\n")
```

```
## Performance measures for train data:
```

```r
cat("Confusion Matrix:\n", train_confusion_matrix, "\n")
```

```
## Confusion Matrix:
##  164 4 2 166
```

```r
cat("\nAccuracy:", train_accuracy)
```

```
##
## Accuracy: 0.9821429
```

```r
cat("\nPrecision:", train_precision)
```

```
##
## Precision: 0.9880952
```

```r
cat("\nRecall (Sensitivity):", train_recall)
```

```
##
## Recall (Sensitivity): 0.9764706
```

```r
cat("\nF1-score:", train_f1_score, "\n")
```

```
##
## F1-score: 0.9822485
```

```r
# Print performance measures for test data
cat("\nPerformance measures for test data:\n")
```

```
##
## Performance measures for test data:
```

```r
cat("Confusion Matrix:\n", test_confusion_matrix, "\n")
```

```
## Confusion Matrix:
##  70 1 1 70
```

```r
cat("\nAccuracy:", test_accuracy)
```

```
##
## Accuracy: 0.9859155
```

```r
cat("\nPrecision:", test_precision)
```

```
##
## Precision: 0.9859155
```

```r
cat("\nRecall (Sensitivity):", test_recall)
```

```
##
## Recall (Sensitivity): 0.9859155
```

```r
cat("\nF1-score:", test_f1_score)
```

```
##
## F1-score: 0.9859155
```

```r
# Load the required library
library(randomForest)
```

```
## randomForest 4.7-1.1

## Type rfNews() to see new features/changes/bug fixes.

##
## Attaching package: 'randomForest'

## The following object is masked from 'package:ggplot2':
##
##     margin
```

```r
# Assuming you have a training dataset named 'train' and a test dataset named 'test'

# Fit Random Forest model
rf_model <- randomForest(Class ~ ., data = train)

# Make predictions on the training data
train_predictions <- predict(rf_model, train)

# Evaluate model performance on the training data
train_confusion_matrix <- table(train_predictions, train$Class)
train_accuracy <- sum(diag(train_confusion_matrix)) / sum(train_confusion_matrix)
train_precision <- train_confusion_matrix[2, 2] / sum(train_confusion_matrix[, 2])
train_recall <- train_confusion_matrix[2, 2] / sum(train_confusion_matrix[2, ])
train_f1_score <- 2 * train_precision * train_recall / (train_precision + train_recall)

# Print performance measures for the training data
cat("Performance measures for training data:\n")
```

```
## Performance measures for training data:
```

```
cat("Confusion Matrix:\n", train_confusion_matrix, "\n")
```

```
## Confusion Matrix:
##  168 0 0 168
```

```
cat("\nAccuracy:", train_accuracy)
```

```
##
## Accuracy: 1
```

```
cat("\nPrecision:", train_precision)
```

```
##
## Precision: 1
```

```
cat("\nRecall (Sensitivity):", train_recall)
```

```
##
## Recall (Sensitivity): 1
```

```
cat("\nF1-score:", train_f1_score)
```

```
##
## F1-score: 1
```

```
# Make predictions on the test data
test_predictions <- predict(rf_model, test)

# Evaluate model performance on the test data
test_confusion_matrix <- table(test_predictions, test$Class)
test_accuracy <- sum(diag(test_confusion_matrix)) / sum(test_confusion_matrix)
test_precision <- test_confusion_matrix[2, 2] / sum(test_confusion_matrix[, 2])
test_recall <- test_confusion_matrix[2, 2] / sum(test_confusion_matrix[2, ])
test_f1_score <- 2 * test_precision * test_recall / (test_precision + test_recall)

# Print performance measures for the test data
cat("\n\nPerformance measures for test data:\n")
```

```
##
##
## Performance measures for test data:
```

```
cat("Confusion Matrix:\n", test_confusion_matrix, "\n")
```

```
## Confusion Matrix:
##  70 1 2 69
```

```r
cat("\nAccuracy:", test_accuracy)
```

```
##
## Accuracy: 0.9788732
```

```r
cat("\nPrecision:", test_precision)
```

```
##
## Precision: 0.971831
```

```r
cat("\nRecall (Sensitivity):", test_recall)
```

```
##
## Recall (Sensitivity): 0.9857143
```

```r
cat("\nF1-score:", test_f1_score)
```

```
##
## F1-score: 0.9787234
```

```r
## SVM Model

# Load the required library
library(e1071)

# Fit SVM model
svm_model <- svm(Class ~ ., data = train)

# Make predictions on the train data
svm_train_predictions <- predict(svm_model, train)

# Evaluate model performance on train data
svm_train_confusion_matrix <- table(svm_train_predictions, train$Class)
train_accuracy <- sum(diag(svm_train_confusion_matrix)) / sum(svm_train_confusion_matrix)
train_precision <- svm_train_confusion_matrix[2, 2] / sum(svm_train_confusion_matrix[, 2])
train_recall <- svm_train_confusion_matrix[2, 2] / sum(svm_train_confusion_matrix[2, ])
train_f1_score <- 2 * train_precision * train_recall / (train_precision + train_recall)

# Print performance measures for train data
cat("Performance measures for train data:\n")
```

```
## Performance measures for train data:
```

```r
cat("Confusion Matrix:\n", svm_train_confusion_matrix, "\n")
```

```
## Confusion Matrix:
##  162 6 1 167
```

```r
cat("\nAccuracy:", train_accuracy)
```

```
##
## Accuracy: 0.9791667
```

```r
cat("\nPrecision:", train_precision)
```

```
##
## Precision: 0.9940476
```

```r
cat("\nRecall (Sensitivity):", train_recall)
```

```
##
## Recall (Sensitivity): 0.9653179
```

```r
cat("\nF1-score:", train_f1_score)
```

```
##
## F1-score: 0.9794721
```

```r
# Make predictions on the test data
svm_test_predictions <- predict(svm_model, test)

# Evaluate model performance on test data
svm_test_confusion_matrix <- table(svm_test_predictions, test$Class)
test_accuracy <- sum(diag(svm_test_confusion_matrix)) / sum(svm_test_confusion_matrix)
test_precision <- svm_test_confusion_matrix[2, 2] / sum(svm_test_confusion_matrix[, 2])
test_recall <- svm_test_confusion_matrix[2, 2] / sum(svm_test_confusion_matrix[2, ])
test_f1_score <- 2 * test_precision * test_recall / (test_precision + test_recall)

# Print performance measures for test data
cat("\n\nPerformance measures for test data:\n")
```

```
##
##
## Performance measures for test data:
```

```r
cat("Confusion Matrix:\n", svm_test_confusion_matrix, "\n")
```

```
## Confusion Matrix:
##  70 1 1 70
```

```r
cat("\nAccuracy:", test_accuracy)
```

```
##
## Accuracy: 0.9859155
```

```r
cat("\nPrecision:", test_precision)
```

```
##
## Precision: 0.9859155
```

```r
cat("\nRecall (Sensitivity):", test_recall)
```

```
##
## Recall (Sensitivity): 0.9859155
```

```r
cat("\nF1-score:", test_f1_score)
```

```
##
## F1-score: 0.9859155
```

```r
## Combine the classifiers in an ensemble
# Load required libraries
library(caret)
library(e1071)
library(randomForest)

# Assuming you have your data loaded as train and test datasets

# Fit models
logistic_model <- glm(Class ~ ., data = train, family = "binomial")
```

```
## Warning: glm.fit: algorithm did not converge
```

```
## Warning: glm.fit: fitted probabilities numerically 0 or 1 occurred
```

```r
nb_model <- naiveBayes(Class ~ ., data = train)
svm_model <- svm(Class ~ ., data = train)
rf_model <- randomForest(Class ~ ., data = train)

# Make predictions for each model
logistic_predictions_train <- predict(logistic_model, newdata = train, type = "response")
nb_predictions_train <- predict(nb_model, newdata = train, type = "raw")
svm_predictions_train <- predict(svm_model, newdata = train, probability = TRUE)
```

```
## Warning in predict.svm(svm_model, newdata = train, probability = TRUE): SVM has
## not been trained using `probability = TRUE`, probabilities not available for
## predictions.
```

```r
rf_predictions_train <- predict(rf_model, newdata = train, type = "response")

# Combine predictions into a data frame
combined_predictions_train <- data.frame(
  Logistic = logistic_predictions_train,
  NaiveBayes = nb_predictions_train,
```

```
  SVM = svm_predictions_train,
  RandomForest = rf_predictions_train
)

# Take a majority vote for each observation
ensemble_predictions_train <- apply(combined_predictions_train, 1, function(row) {
  majority_vote <- ifelse(sum(row == "1") >= sum(row == "0"), "1", "0")
})

# Convert predictions to factors with the same levels as train$Class
ensemble_predictions_train <- factor(ensemble_predictions_train, levels = levels(train$Class))

# Evaluate model performance for training data
ensemble_confusion_matrix_train <- confusionMatrix(ensemble_predictions_train, train$Class)
print("Performance measures for train data:")
```

```
## [1] "Performance measures for train data:"
```

```
print(ensemble_confusion_matrix_train)
```

```
## Confusion Matrix and Statistics
##
##           Reference
## Prediction   1   0
##          1 168   0
##          0   0 168
##
##                Accuracy : 1
##                  95% CI : (0.9891, 1)
##     No Information Rate : 0.5
##     P-Value [Acc > NIR] : < 2.2e-16
##
##                   Kappa : 1
##
##  Mcnemar's Test P-Value : NA
##
##             Sensitivity : 1.0
##             Specificity : 1.0
##          Pos Pred Value : 1.0
##          Neg Pred Value : 1.0
##              Prevalence : 0.5
##          Detection Rate : 0.5
##    Detection Prevalence : 0.5
##       Balanced Accuracy : 1.0
##
##        'Positive' Class : 1
##
```

```
# Make predictions for test data
logistic_predictions_test <- predict(logistic_model, newdata = test, type = "response")
nb_predictions_test <- predict(nb_model, newdata = test, type = "raw")
svm_predictions_test <- predict(svm_model, newdata = test, probability = TRUE)
```

```
## Warning in predict.svm(svm_model, newdata = test, probability = TRUE): SVM has
## not been trained using 'probability = TRUE', probabilities not available for
## predictions.
```

```
rf_predictions_test <- predict(rf_model, newdata = test, type = "response")

# Combine predictions into a data frame for test data
combined_predictions_test <- data.frame(
  Logistic = logistic_predictions_test,
  NaiveBayes = nb_predictions_test,
  SVM = svm_predictions_test,
  RandomForest = rf_predictions_test
)

# Take a majority vote for each observation for test data
ensemble_predictions_test <- apply(combined_predictions_test, 1, function(row) {
  majority_vote <- ifelse(sum(row == "1") >= sum(row == "0"), "1", "0")
})

# Convert predictions to factors with the same levels as test$Class
ensemble_predictions_test <- factor(ensemble_predictions_test, levels = levels(test$Class))


# Evaluate model performance for test data
ensemble_confusion_matrix_test <- confusionMatrix(ensemble_predictions_test, test$Class)
print("Performance measures for test data:")
```

```
## [1] "Performance measures for test data:"
```

```
print(ensemble_confusion_matrix_test)
```

```
## Confusion Matrix and Statistics
##
##           Reference
## Prediction  1  0
##          1 70  2
##          0  1 69
##
##                Accuracy : 0.9789
##                  95% CI : (0.9395, 0.9956)
##     No Information Rate : 0.5
##     P-Value [Acc > NIR] : <2e-16
##
##                   Kappa : 0.9577
##
##  Mcnemar's Test P-Value : 1
##
##             Sensitivity : 0.9859
##             Specificity : 0.9718
##          Pos Pred Value : 0.9722
##          Neg Pred Value : 0.9857
##              Prevalence : 0.5000
##          Detection Rate : 0.4930
```

```
##    Detection Prevalence : 0.5070
##       Balanced Accuracy : 0.9789
##
##        'Positive' Class : 1
##
```

‘‘‘