1)

```
pip install ucimlrepo
```

```
Requirement already satisfied: ucimlrepo in
/usr/local/lib/python3.10/dist-packages (0.0.3)
```

```
from ucimlrepo import fetch_ucirepo
from sklearn.manifold import TSNE
from sklearn import neighbors
from sklearn import naive_bayes
from sklearn.model_selection import train_test_split
from sklearn.model_selection import cross_val_score
from sklearn.model_selection import GridSearchCV
from sklearn.metrics import confusion_matrix, ConfusionMatrixDisplay,
accuracy_score, precision_score, recall_score
from matplotlib import pyplot as plt
import pandas as pd
import numpy as np

# fetch dataset
breast_cancer_wisconsin_diagnostic = fetch_ucirepo(id=17)

# data (as pandas dataframes)
X = breast_cancer_wisconsin_diagnostic.data.features
y = breast_cancer_wisconsin_diagnostic.data.targets

print((len(X) - round(len(X)*0.7))/len(X))

treino = X.iloc[0:round(len(X)*0.7)]
teste = X.iloc[round(len(X)*0.7):len(X)]

target_treino = y.iloc[0:round(len(X)*0.7)]
target_teste = y.iloc[round(len(X)*0.7):len(X)]

display(treino)
display(teste)
display(target_treino)
```

```
0.30052724077328646
```

```
     radius1  texture1  perimeter1   area1  smoothness1  compactness1
\
0      17.99     10.38      122.80  1001.0      0.11840       0.27760

1      20.57     17.77      132.90  1326.0      0.08474       0.07864

2      19.69     21.25      130.00  1203.0      0.10960       0.15990

3      11.42     20.38       77.58   386.1      0.14250       0.28390
```

```
4      20.29     14.34      135.10  1297.0      0.10030       0.13280

..       ...       ...         ...     ...          ...           ...

393    21.61     22.28      144.40  1407.0      0.11670       0.20870

394    12.10     17.72       78.07   446.2      0.10290       0.09758

395    14.06     17.18       89.75   609.1      0.08045       0.05361

396    13.51     18.89       88.10   558.1      0.10590       0.11470

397    12.80     17.46       83.05   508.3      0.08044       0.08895


     concavity1  concave_points1  symmetry1  fractal_dimension1  ...
radius3  \
0       0.30010          0.14710     0.2419             0.07871  ...
25.38
1       0.08690          0.07017     0.1812             0.05667  ...
24.99
2       0.19740          0.12790     0.2069             0.05999  ...
23.57
3       0.24140          0.10520     0.2597             0.09744  ...
14.91
4       0.19800          0.10430     0.1809             0.05883  ...
22.54
..          ...              ...        ...                 ...  ...
...
393     0.28100          0.15620     0.2162             0.06606  ...
26.23
394     0.04783          0.03326     0.1937             0.06161  ...
13.56
395     0.02681          0.03251     0.1641             0.05764  ...
14.92
396     0.08580          0.05381     0.1806             0.06079  ...
14.80
397     0.07390          0.04083     0.1574             0.05750  ...
13.74

     texture3  perimeter3   area3  smoothness3  compactness3
concavity3  \
0       17.33      184.60  2019.0      0.16220        0.6656
0.7119
1       23.41      158.80  1956.0      0.12380        0.1866
0.2416
2       25.53      152.50  1709.0      0.14440        0.4245
0.4504
3       26.50       98.87   567.7      0.20980        0.8663
0.6869
```

```
4       16.67       152.20  1575.0      0.13740        0.2050
0.4000
..        ...          ...     ...          ...           ...           .
..
393     28.74       172.00  2081.0      0.15020        0.5717
0.7053
394     25.80        88.33   559.5      0.14320        0.1773
0.1603
395     25.34        96.42   684.5      0.10660        0.1231
0.0846
396     27.20        97.33   675.2      0.14280        0.2570
0.3438
397     21.06        90.72   591.0      0.09534        0.1812
0.1901

     concave_points3  symmetry3  fractal_dimension3
0            0.26540     0.4601             0.11890
1            0.18600     0.2750             0.08902
2            0.24300     0.3613             0.08758
3            0.25750     0.6638             0.17300
4            0.16250     0.2364             0.07678
..               ...        ...                 ...
393          0.24220     0.3828             0.10070
394          0.06266     0.3049             0.07081
395          0.07911     0.2523             0.06609
396          0.14530     0.2666             0.07686
397          0.08296     0.1988             0.07053

[398 rows x 30 columns]

     radius1  texture1  perimeter1   area1  smoothness1  compactness1
\
398    11.06     14.83       70.31   378.2      0.07741       0.04768

399    11.80     17.26       75.26   431.9      0.09087       0.06232

400    17.91     21.02      124.40   994.0      0.12300       0.25760

401    11.93     10.91       76.14   442.7      0.08872       0.05242

402    12.96     18.29       84.18   525.2      0.07351       0.07899

..       ...       ...         ...     ...          ...           ...

564    21.56     22.39      142.00  1479.0      0.11100       0.11590

565    20.13     28.25      131.20  1261.0      0.09780       0.10340

566    16.60     28.08      108.30   858.1      0.08455       0.10230

567    20.60     29.33      140.10  1265.0      0.11780       0.27700
```

```
568     7.76     24.54       47.92   181.0      0.05263       0.04362

     concavity1  concave_points1  symmetry1  fractal_dimension1  ...
radius3  \
398     0.02712         0.007246     0.1535             0.06214  ...
12.680
399     0.02853         0.016380     0.1847             0.06019  ...
13.450
400     0.31890         0.119800     0.2113             0.07115  ...
20.800
401     0.02606         0.017960     0.1601             0.05541  ...
13.800
402     0.04057         0.018830     0.1874             0.05899  ...
14.130
..          ...              ...        ...                 ...  ...
...
564     0.24390         0.138900     0.1726             0.05623  ...
25.450
565     0.14400         0.097910     0.1752             0.05533  ...
23.690
566     0.09251         0.053020     0.1590             0.05648  ...
18.980
567     0.35140         0.152000     0.2397             0.07016  ...
25.740
568     0.00000         0.000000     0.1587             0.05884  ...
9.456

     texture3  perimeter3   area3  smoothness3  compactness3
concavity3  \
398     20.35       80.79   496.7      0.11200       0.18790
0.2079
399     24.49       86.00   562.0      0.12440       0.17260
0.1449
400     27.78      149.60  1304.0      0.18730       0.59170
0.9034
401     20.14       87.64   589.5      0.13740       0.15750
0.1514
402     24.61       96.31   621.9      0.09329       0.23180
0.1604
..        ...         ...     ...          ...           ...          .
..
564     26.40      166.10  2027.0      0.14100       0.21130
0.4107
565     38.25      155.00  1731.0      0.11660       0.19220
0.3215
566     34.12      126.70  1124.0      0.11390       0.30940
0.3403
567     39.42      184.60  1821.0      0.16500       0.86810
```

```
0.9387
568     30.37       59.16   268.6      0.08996       0.06444
0.0000

     concave_points3  symmetry3  fractal_dimension3
398          0.05556     0.2590             0.09158
399          0.05356     0.2779             0.08121
400          0.19640     0.3245             0.11980
401          0.06876     0.2460             0.07262
402          0.06608     0.3207             0.07247
..               ...        ...                 ...
564          0.22160     0.2060             0.07115
565          0.16280     0.2572             0.06637
566          0.14180     0.2218             0.07820
567          0.26500     0.4087             0.12400
568          0.00000     0.2871             0.07039

[171 rows x 30 columns]

    Diagnosis
0           M
1           M
2           M
3           M
4           M
..        ...
393         M
394         B
395         B
396         B
397         B

[398 rows x 1 columns]
```

a)

Os valores de média e desvio padrão obtidos mostram uma grande variação entre os parâmetros quanto a escala de valores. Enquanto alguns parâmetros tem valores bem próximos de zero e sem muita variação, há parãmetros com valores na casa das centenas com desvio padrão também na casa das centenas.

```
print('Média e desvio padrão para classe M')
display(treino.loc[target_treino.Diagnosis ==
'M'].describe().loc[['mean','std']])
print('Média e desvio padrão para classe B')
display(treino.loc[target_treino.Diagnosis ==
'B'].describe().loc[['mean','std']])
```

```
Média e desvio padrão para classe M
```

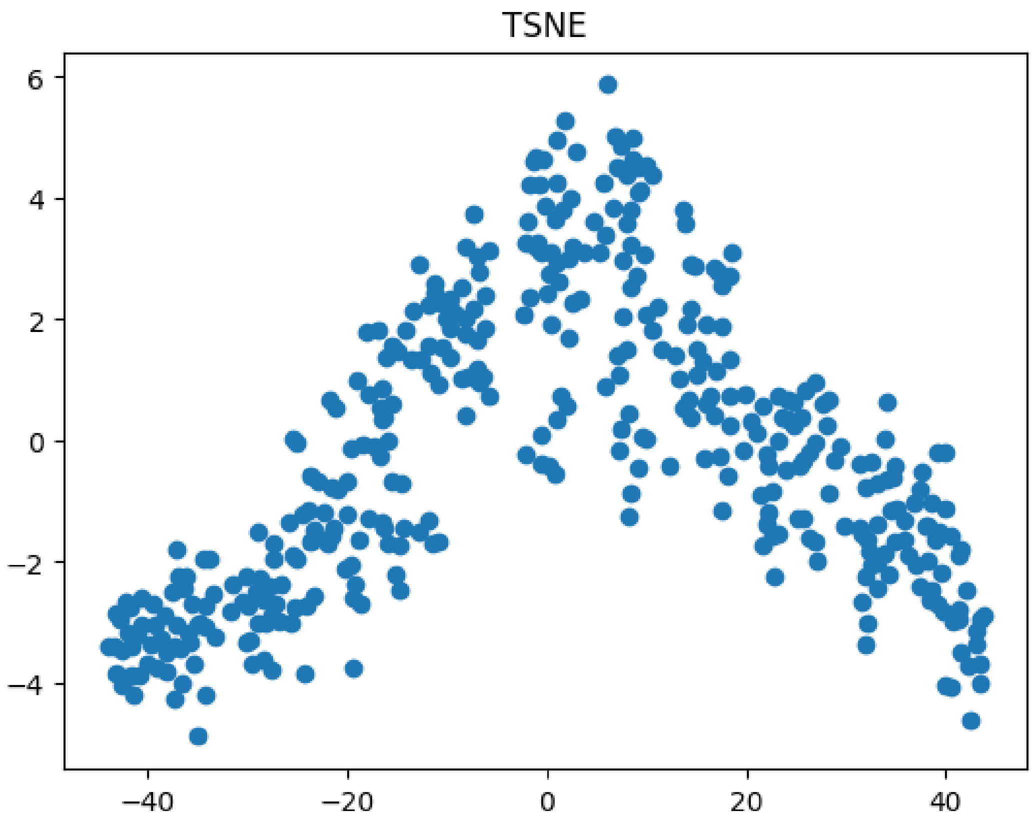
```
        radius1   texture1  perimeter1       area1  smoothness1
compactness1  \
mean  17.274162  21.360983  114.029653  957.232370     0.103080
0.144564
std    3.215195   3.795245   21.882764  362.544383     0.013071
0.054986

      concavity1  concave_points1  symmetry1  fractal_dimension1  ...
\
mean    0.156944         0.086749   0.193865            0.062774  ...

std     0.074200         0.034618   0.028619            0.007837  ...


        radius3   texture3  perimeter3        area3  smoothness3  \
mean  20.980578  29.152312  140.086185  1400.997110     0.145659
std    4.275420   5.519159   29.241505   584.936603     0.022424

      compactness3  concavity3  concave_points3  symmetry3
fractal_dimension3
mean      0.376277    0.443207         0.181295   0.329265
0.091952
std       0.173656    0.174275         0.046430   0.077451
0.022062

[2 rows x 30 columns]

Média e desvio padrão para classe B

        radius1   texture1  perimeter1       area1  smoothness1
compactness1  \
mean  12.076440  17.127156   77.581689  457.226222     0.092321
0.078284
std    1.731315   3.359781   11.437250  128.977373     0.012719
0.033274

      concavity1  concave_points1  symmetry1  fractal_dimension1  ...
\
mean     0.04645         0.025385   0.175124            0.062804  ...

std      0.04925         0.016313   0.025612            0.006771  ...


        radius3   texture3  perimeter3       area3  smoothness3
compactness3  \
mean  13.259400  22.408444   86.098978  548.620000     0.123747
0.175684
std    1.926465   4.832299   13.132041  156.637776     0.019480
0.091804

      concavity3  concave_points3  symmetry3  fractal_dimension3
```

```
mean    0.161529          0.072195   0.271338             0.078731
std     0.152275          0.036115   0.043836             0.013912

[2 rows x 30 columns]
```

b)

Pelo gráfico obtido ao se utilizar o TSNE vemos que há possibilidade de separação das amostras em dois grupos, embora para algumas amostras seja possível uma classificação errada devido a não haver uma separação clara no TSNE 2D.

```
tsne_treino = TSNE().fit_transform(treino)
# display(tsne_treino)
# color = [target_treino.loc[i,['Diagnosis']]['Diagnosis'] for i in
range(len(target_treino))]
# for i in range(len(color)):
#   if color[i] == 'M':
#     color[i] = '#1f77b4'
#   else:
#     color[i] = '#2ca02c'
# display(color)
# plt.scatter(tsne_treino[:,0], tsne_treino[:,1], c=color)
plt.scatter(tsne_treino[:,0], tsne_treino[:,1])
plt.title("TSNE")

Text(0.5, 1.0, 'TSNE')
```



c)

```
correl = treino.corr()
# display(correl>0.9)
## display(np.where(correl>0.9))
## display(correl.drop(columns=np.whee(correl>0.9)[0]))

diag_ones = (2*np.ones(len(correl)) - np.triu(np.ones(len(correl)))) -
np.tril(np.ones(len(correl)))
# display(diag_ones)
non_redundant = correl[((diag_ones*correl)<=0.9)&((diag_ones*correl)!
=1)]
# display(non_redundant)
non_redundant = non_redundant.dropna(axis=1)
# display(non_redundant)
treino_non_redundant = treino[non_redundant.columns]
teste_non_redundant = teste[non_redundant.columns]
display(treino_non_redundant)
display(teste_non_redundant)

     smoothness1  compactness1  symmetry1  fractal_dimension1
texture2  \
0        0.11840       0.27760     0.2419             0.07871
0.9053
1        0.08474       0.07864     0.1812             0.05667
```

```
0.7339
2        0.10960       0.15990     0.2069                0.05999
0.7869
3        0.14250       0.28390     0.2597                0.09744
1.1560
4        0.10030       0.13280     0.1809                0.05883
0.7813
..           ...           ...        ...                   ...        ..
.
393      0.11670       0.20870     0.2162                0.06606
0.9209
394      0.10290       0.09758     0.1937                0.06161
1.6520
395      0.08045       0.05361     0.1641                0.05764
1.6850
396      0.10590       0.11470     0.1806                0.06079
1.3320
397      0.08044       0.08895     0.1574                0.05750
1.2650

     smoothness2  compactness2  concavity2  concave_points2  symmetry2
\
0       0.006399       0.04904     0.05373         0.015870    0.03003

1       0.005225       0.01308     0.01860         0.013400    0.01389

2       0.006150       0.04006     0.03832         0.020580    0.02250

3       0.009110       0.07458     0.05661         0.018670    0.05963

4       0.011490       0.02461     0.05688         0.018850    0.01756

..           ...           ...         ...              ...        ...

393     0.005215       0.03726     0.04718         0.012880    0.02045

394     0.008146       0.01631     0.01843         0.007513    0.02015

395     0.005371       0.01273     0.01132         0.009155    0.01719

396     0.005442       0.01957     0.03304         0.013670    0.01315

397     0.005421       0.03477     0.04545         0.013840    0.01869


     fractal_dimension2  smoothness3  compactness3  concavity3
symmetry3  \
0              0.006193      0.16220        0.6656      0.7119
0.4601
1              0.003532      0.12380        0.1866      0.2416
```

```
0.2750
2              0.004571      0.14440        0.4245      0.4504
0.3613
3              0.009208      0.20980        0.8663      0.6869
0.6638
4              0.005115      0.13740        0.2050      0.4000
0.2364
..                  ...          ...           ...         ...
...
393            0.004028      0.15020        0.5717      0.7053
0.3828
394            0.001798      0.14320        0.1773      0.1603
0.3049
395            0.001444      0.10660        0.1231      0.0846
0.2523
396            0.002464      0.14280        0.2570      0.3438
0.2666
397            0.004067      0.09534        0.1812      0.1901
0.1988

     fractal_dimension3
0               0.11890
1               0.08902
2               0.08758
3               0.17300
4               0.07678
..                  ...
393             0.10070
394             0.07081
395             0.06609
396             0.07686
397             0.07053

[398 rows x 16 columns]
     smoothness1  compactness1  symmetry1  fractal_dimension1
texture2  \
398      0.07741       0.04768     0.1535             0.06214
0.6881
399      0.09087       0.06232     0.1847             0.06019
1.1400
400      0.12300       0.25760     0.2113             0.07115
0.7747
401      0.08872       0.05242     0.1601             0.05541
1.0450
402      0.07351       0.07899     0.1874             0.05899
1.2990
..           ...           ...        ...                 ...       ..
.
564      0.11100       0.11590     0.1726             0.05623
```

```
1.2560
565      0.09780       0.10340     0.1752             0.05533
2.4630
566      0.08455       0.10230     0.1590             0.05648
1.0750
567      0.11780       0.27700     0.2397             0.07016
1.5950
568      0.05263       0.04362     0.1587             0.05884
1.4280

     smoothness2  compactness2  concavity2  concave_points2  symmetry2
\
398     0.004259       0.01469     0.01940         0.004168    0.01191

399     0.005463       0.01964     0.02079         0.005398    0.01477

400     0.007159       0.03718     0.06165         0.010510    0.01591

401     0.006175       0.01204     0.01376         0.005832    0.01096

402     0.003629       0.03713     0.03452         0.010650    0.02632

..           ...           ...         ...              ...        ...

564     0.010300       0.02891     0.05198         0.024540    0.01114

565     0.005769       0.02423     0.03950         0.016780    0.01898

566     0.005903       0.03731     0.04730         0.015570    0.01318

567     0.006522       0.06158     0.07117         0.016640    0.02324

568     0.007189       0.00466     0.00000         0.000000    0.02676


     fractal_dimension2  smoothness3  compactness3  concavity3
symmetry3  \
398            0.003537      0.11200       0.18790      0.2079
0.2590
399            0.003071      0.12440       0.17260      0.1449
0.2779
400            0.005099      0.18730       0.59170      0.9034
0.3245
401            0.001857      0.13740       0.15750      0.1514
0.2460
402            0.003705      0.09329       0.23180      0.1604
0.3207
..                  ...          ...           ...         ...
...
564            0.004239      0.14100       0.21130      0.4107
```

```
0.2060
565             0.002498      0.11660       0.19220      0.3215
0.2572
566             0.003892      0.11390       0.30940      0.3403
0.2218
567             0.006185      0.16500       0.86810      0.9387
0.4087
568             0.002783      0.08996       0.06444      0.0000
0.2871

     fractal_dimension3
398             0.09158
399             0.08121
400             0.11980
401             0.07262
402             0.07247
..                  ...
564             0.07115
565             0.06637
566             0.07820
567             0.12400
568             0.07039

[171 rows x 16 columns]
```

d)

```
display(treino_non_redundant.describe())
h = []
p = []
for i in range(len(treino_non_redundant.columns)):
  plt.figure(i)
  n,_,_ =
plt.hist(treino_non_redundant[treino_non_redundant.columns[i]])
  plt.title("Histograma do parâmetro " +
treino_non_redundant.columns[i])
  plt.ylabel("frequência")
  prob = n/sum(n)
  p.insert(len(p),prob)
  h.insert(len(h),-sum(prob*np.log2((n==0)+prob)))
display(p)
display(h)

       smoothness1  compactness1   symmetry1  fractal_dimension1
texture2  \
count   398.000000    398.000000  398.000000          398.000000
398.000000
mean      0.096998      0.107094    0.183271            0.062791
1.197527
std       0.013922      0.054926    0.028487            0.007245
```

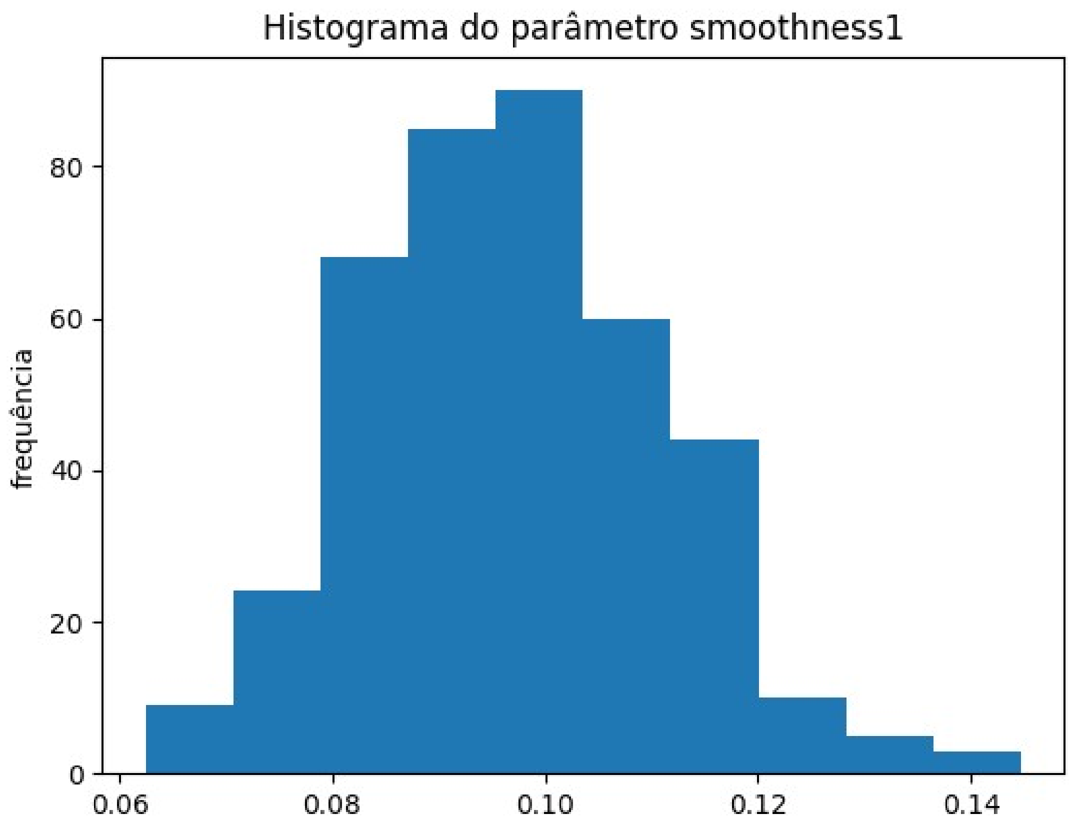
```
0.539097
min       0.062510      0.019380    0.116700              0.049960
0.360200
25%       0.086987      0.066713    0.163500              0.057563
0.826875
50%       0.096935      0.095840    0.180950              0.061400
1.067500
75%       0.106175      0.133400    0.196700              0.065975
1.463750
max       0.144700      0.345400    0.304000              0.097440
4.885000

       smoothness2  compactness2  concavity2  concave_points2
symmetry2  \
count   398.000000    398.000000  398.000000       398.000000
398.000000
mean      0.007021      0.026282    0.033117         0.012115
0.021205
std       0.003073      0.019225    0.033462         0.006447
0.009067
min       0.001713      0.002252    0.000000         0.000000
0.007882
25%       0.005215      0.013413    0.015522         0.007968
0.015205
50%       0.006301      0.020780    0.026355         0.011220
0.018955
75%       0.008097      0.033687    0.042637         0.015043
0.024047
max       0.031130      0.135400    0.396000         0.052790
0.078950

       fractal_dimension2  smoothness3  compactness3  concavity3
symmetry3  \
count          398.000000   398.000000    398.000000  398.000000
398.000000
mean             0.003875     0.133272      0.262877    0.283967
0.296518
std              0.002896     0.023457      0.166533    0.213981
0.067155
min              0.000895     0.071170      0.027290    0.000000
0.156500
25%              0.002214     0.117025      0.146075    0.112975
0.255175
50%              0.003195     0.132350      0.220200    0.243300
0.285150
75%              0.004560     0.148025      0.354125    0.396500
0.325450
max              0.029840     0.222600      1.058000    1.252000
0.663800
```

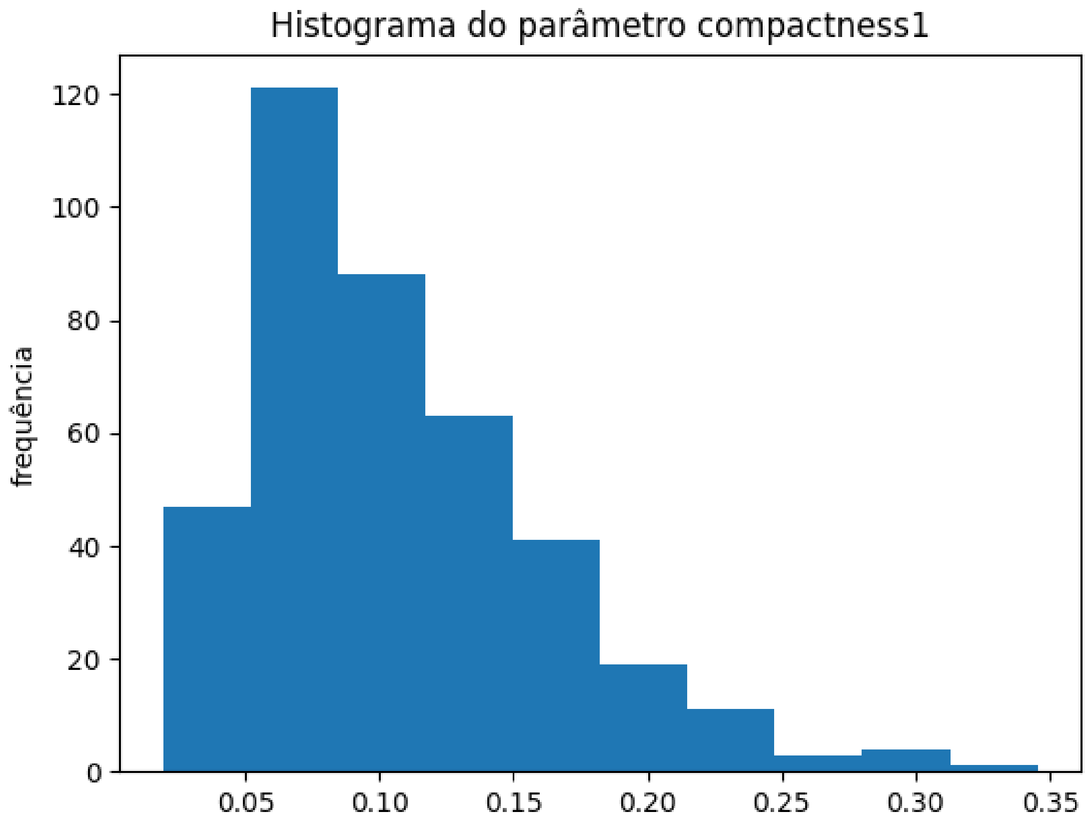
```
       fractal_dimension3
count          398.000000
mean             0.084478
std              0.019056
min              0.055040
25%              0.071165
50%              0.080195
75%              0.092560
max              0.207500
```

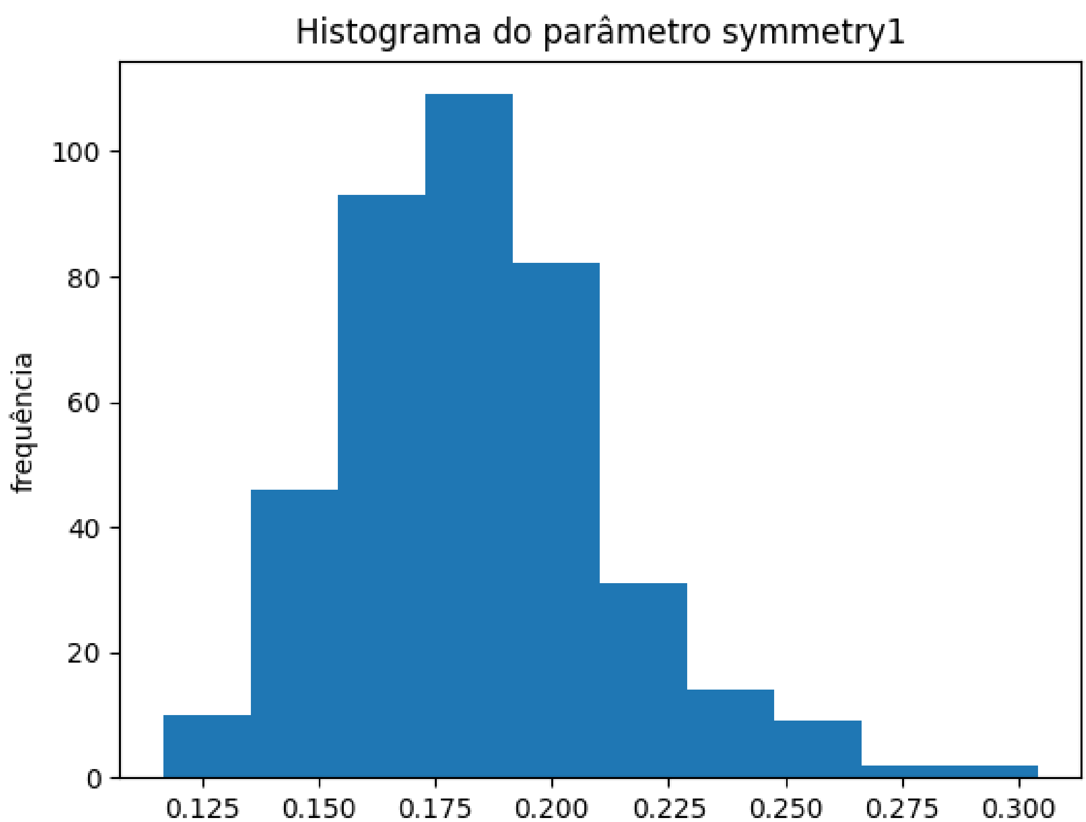
```
[array([0.02261307, 0.06030151, 0.17085427, 0.21356784, 0.22613065,
        0.15075377, 0.11055276, 0.02512563, 0.01256281, 0.00753769]),
 array([0.11809045, 0.3040201 , 0.22110553, 0.15829146, 0.10301508,
        0.04773869, 0.02763819, 0.00753769, 0.01005025, 0.00251256]),
 array([0.02512563, 0.11557789, 0.23366834, 0.27386935, 0.20603015,
        0.07788945, 0.03517588, 0.02261307, 0.00502513, 0.00502513]),
 array([0.07788945, 0.2839196 , 0.29899497, 0.16582915, 0.0879397 ,
        0.05276382, 0.0201005 , 0.00502513, 0.00251256, 0.00502513]),
 array([0.23366834, 0.39698492, 0.22613065, 0.09045226, 0.03517588,
        0.01005025, 0.00251256, 0.00251256, 0.        , 0.00251256]),
 array([0.16834171, 0.53015075, 0.20854271, 0.05527638, 0.02261307,
        0.00753769, 0.00251256, 0.00251256, 0.        , 0.00251256]),
 array([0.35427136, 0.3040201 , 0.19849246, 0.06532663, 0.03517588,
        0.01256281, 0.01758794, 0.01005025, 0.        , 0.00251256]),
 array([0.72361809, 0.2160804 , 0.04271357, 0.01256281, 0.        ,
        0.        , 0.        , 0.00251256, 0.        , 0.00251256]),
 array([0.09045226, 0.36432161, 0.33417085, 0.14070352, 0.04020101,
        0.01507538, 0.00753769, 0.00502513, 0.        , 0.00251256]),
 array([0.2361809 , 0.44472362, 0.18090452, 0.07537688, 0.03015075,
        0.01256281, 0.01256281, 0.00502513, 0.        , 0.00251256]),
 array([0.63316583, 0.27135678, 0.06030151, 0.01758794, 0.00753769,
        0.00251256, 0.        , 0.00502513, 0.        , 0.00251256]),
 array([0.01256281, 0.07788945, 0.15075377, 0.25376884, 0.24371859,
        0.15075377, 0.0678392 , 0.03517588, 0.        , 0.00753769]),
 array([0.21356784, 0.31909548, 0.18844221, 0.14824121, 0.06030151,
        0.03768844, 0.01758794, 0.00502513, 0.00753769, 0.00251256]),
 array([0.27889447, 0.23115578, 0.1959799 , 0.13316583, 0.07537688,
        0.06030151, 0.01758794, 0.00251256, 0.00251256, 0.00251256]),
 array([0.04773869, 0.22110553, 0.37939698, 0.2160804 , 0.07537688,
        0.02763819, 0.0201005 , 0.00753769, 0.00251256, 0.00251256]),
 array([0.22110553, 0.4120603 , 0.1959799 , 0.10050251, 0.04522613,
        0.01758794, 0.00251256, 0.00251256, 0.        , 0.00251256])]
```

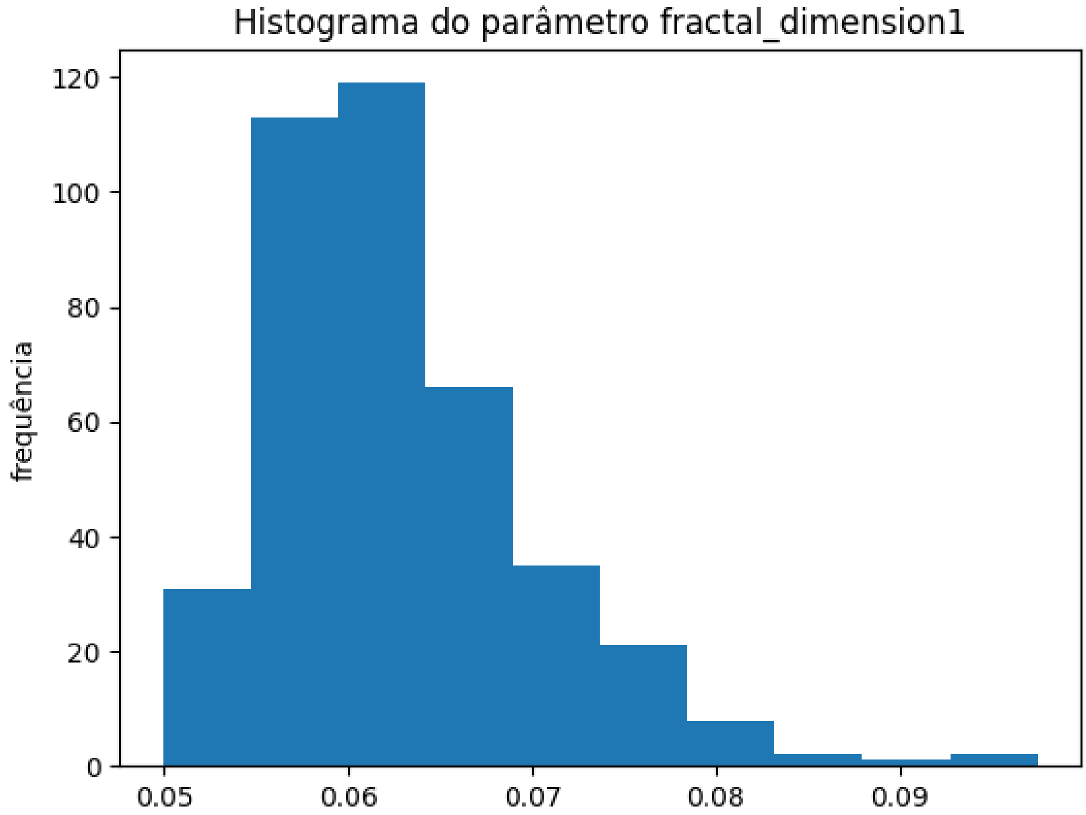
```
[2.7929232578333147,
 2.620479807449189,
 2.6217788022429174,
 2.4973351593435478,
 2.1194734263842783,
 1.862504305204839,
 2.2129226154839454,
```

```
 1.132369147941993,
 2.161666780926907,
 2.1100475266943577,
 1.4098711960976489,
 2.6739931582599343,
 2.501832265268997,
 2.543442910430135,
 2.3330722514144857,
 2.172008684502034]
```

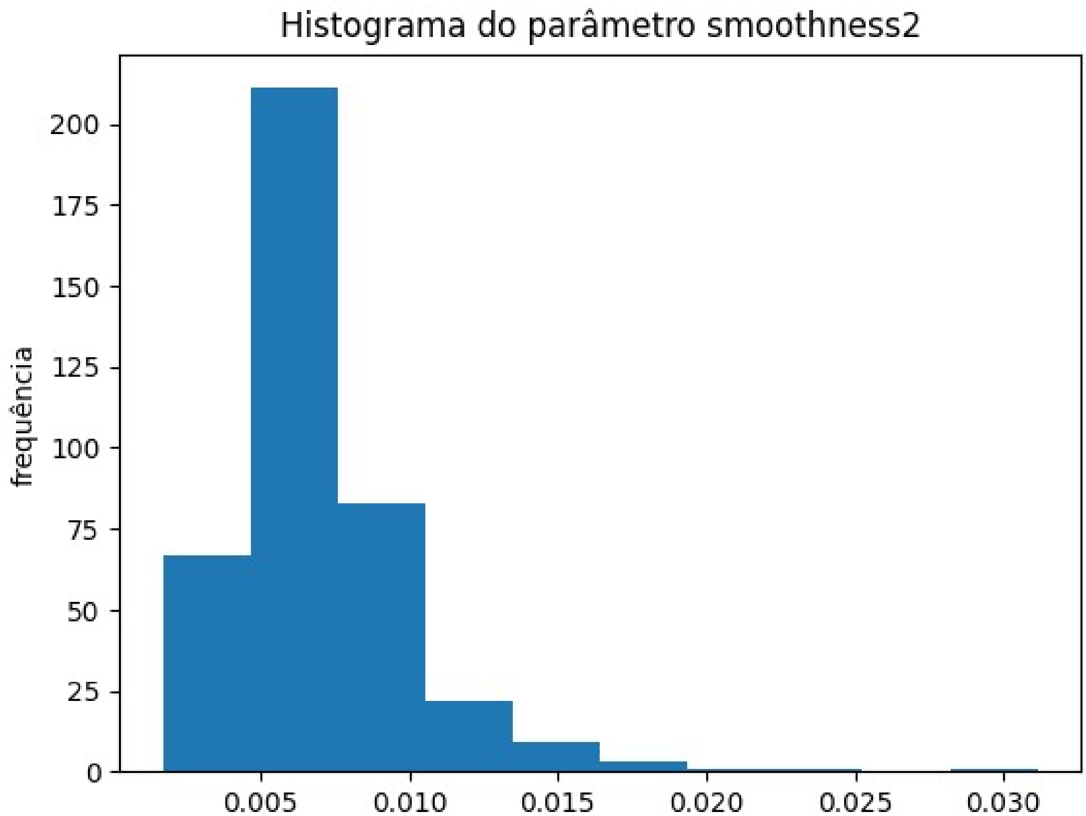


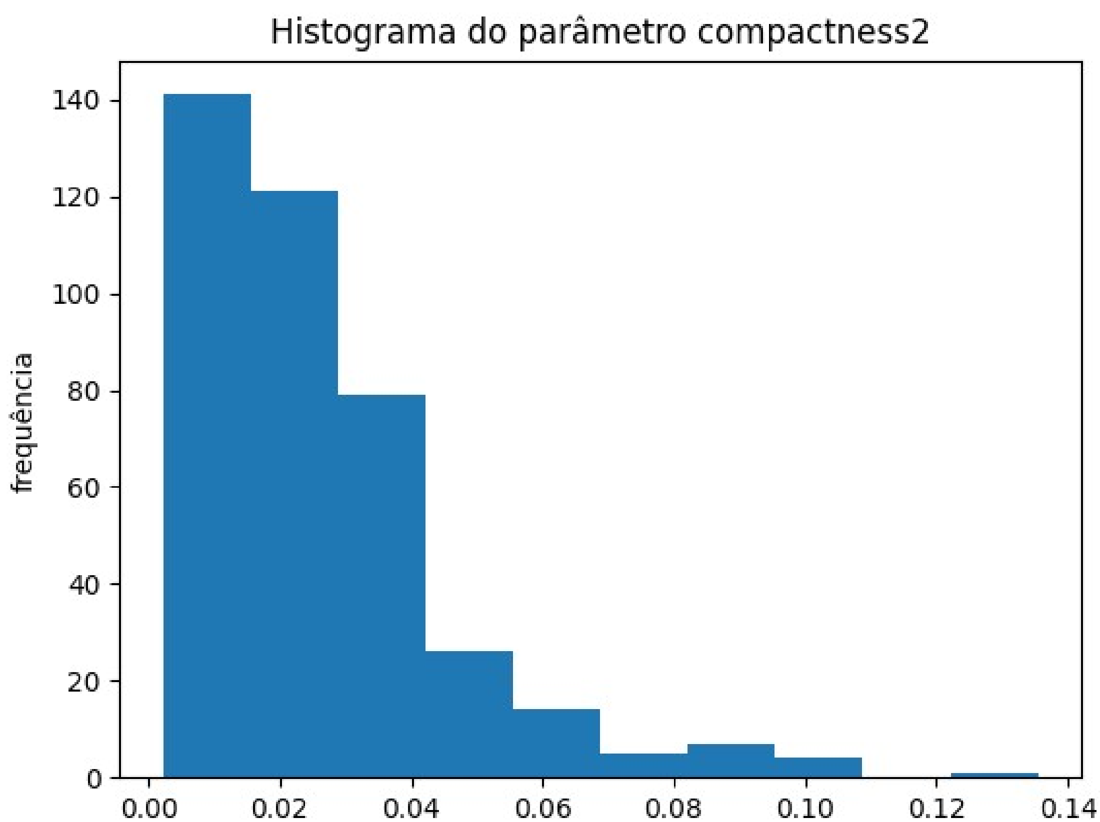

Histograma do parâmetro compactness1
frequência
0
20
40
60
80
100
120
0.05
0.10
0.15
0.20
0.25
0.30
0.35

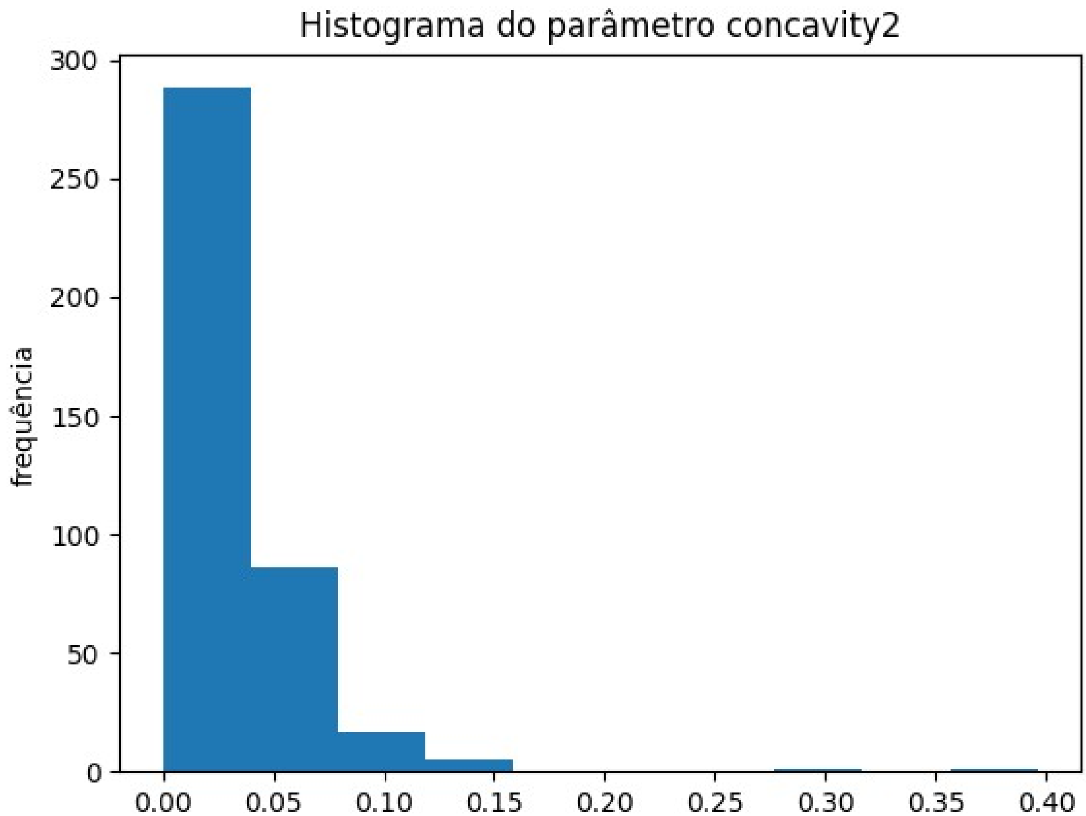

Histograma do parâmetro symmetry1
frequência
0
20
40
60
80
100
0.125
0.150
0.175
0.200
0.225
0.250
0.275
0.300

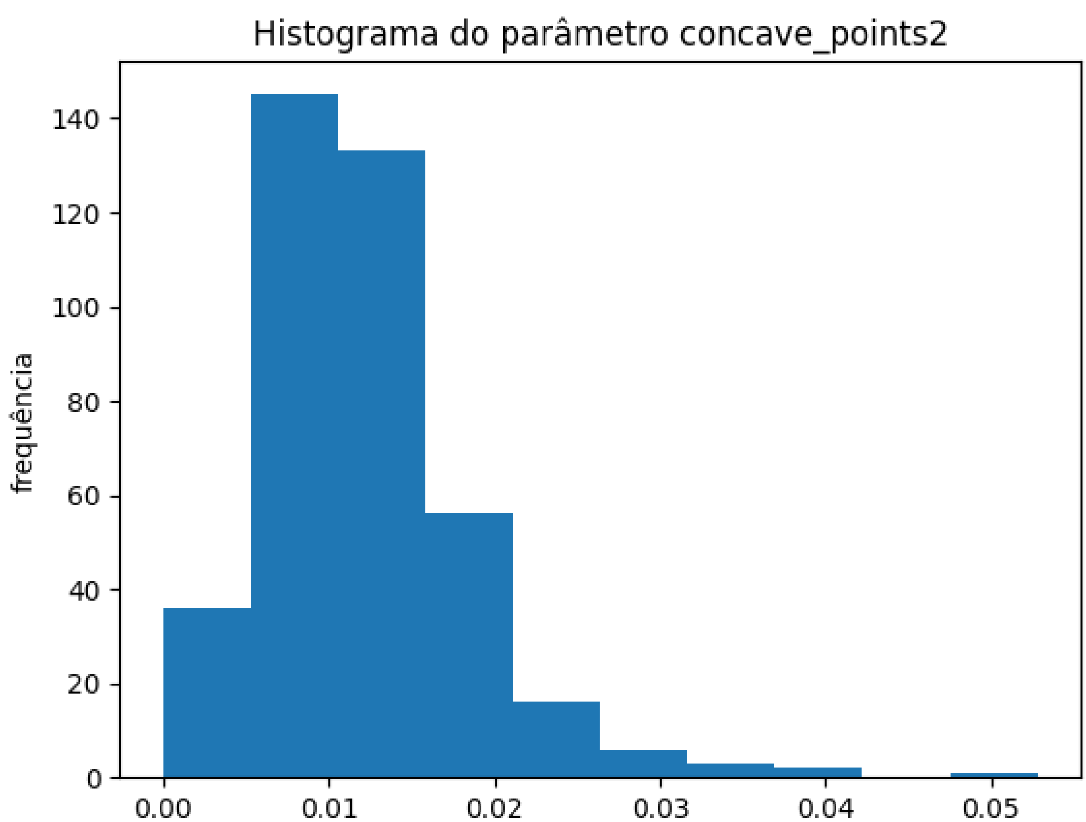

Histograma do parâmetro fractal_dimension1
frequência
0
20
40
60
80
100
120
0.05
0.06
0.07
0.08
0.09

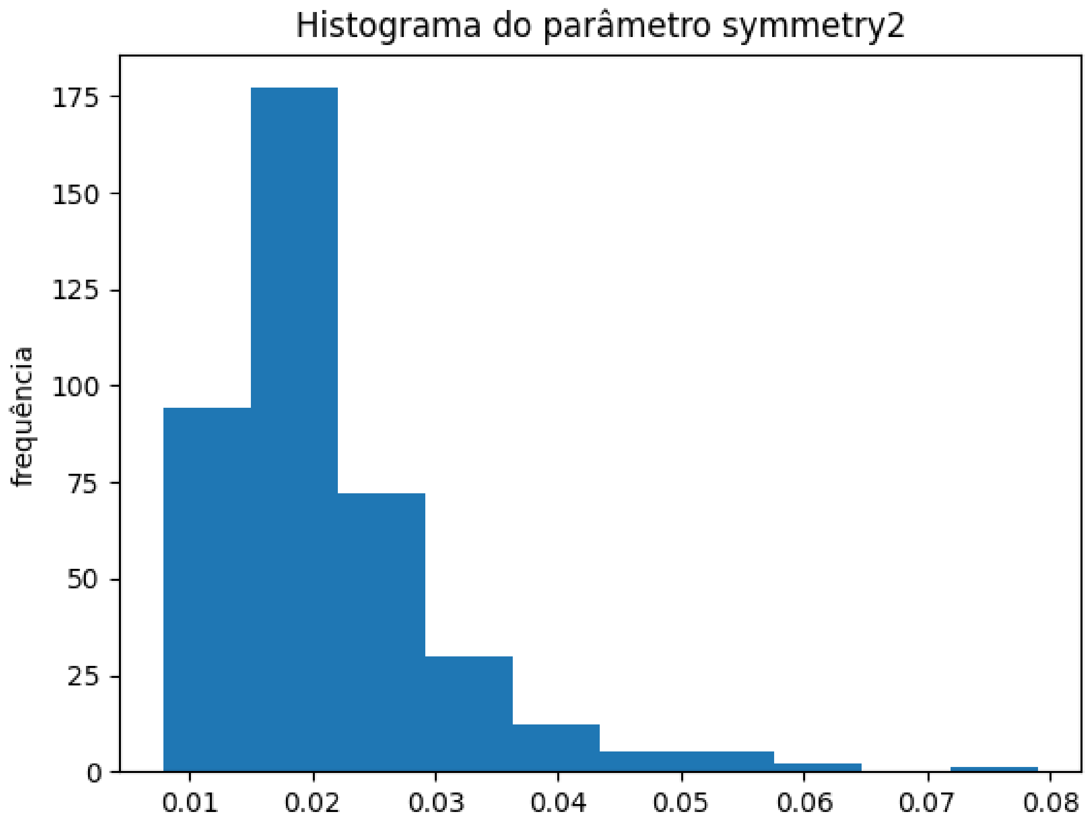

Histograma do parâmetro texture2
frequência
0
20
40
60
80
100
120
140
160
1
2
3
4
5

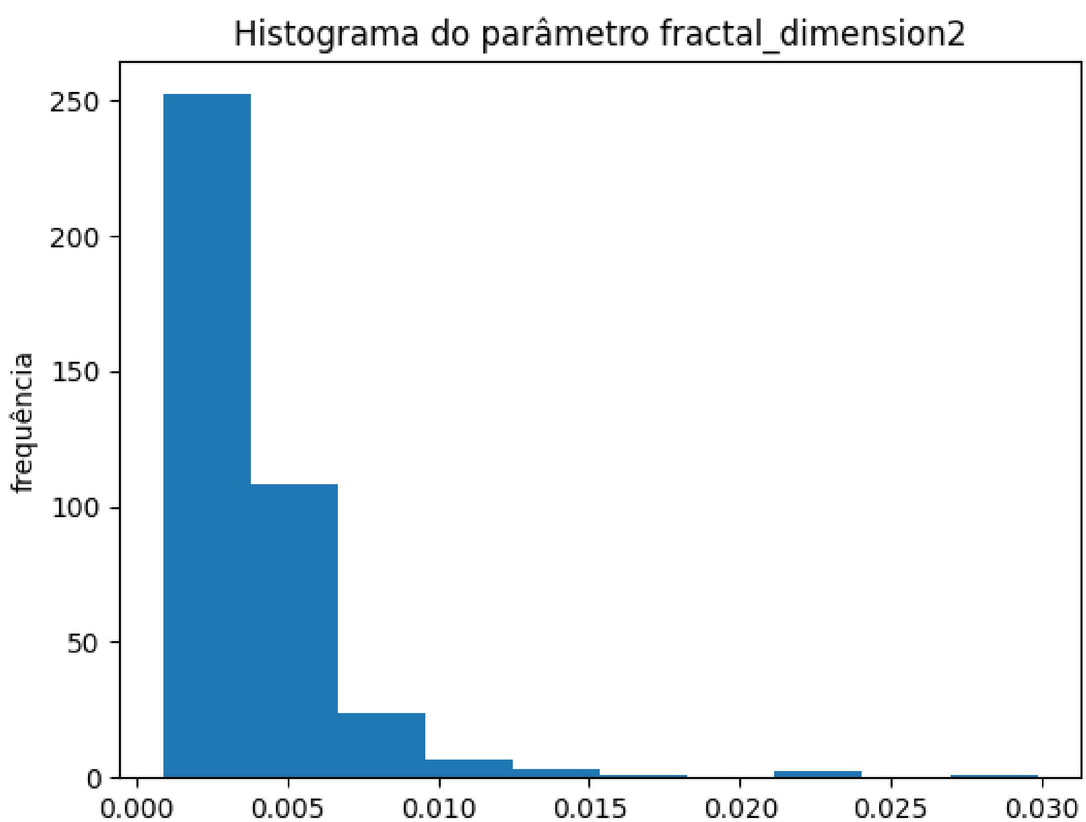

Histograma do parâmetro smoothness2
frequência
0
25
50
75
100
125
150
175
200
0.005
0.010
0.015
0.020
0.025
0.030

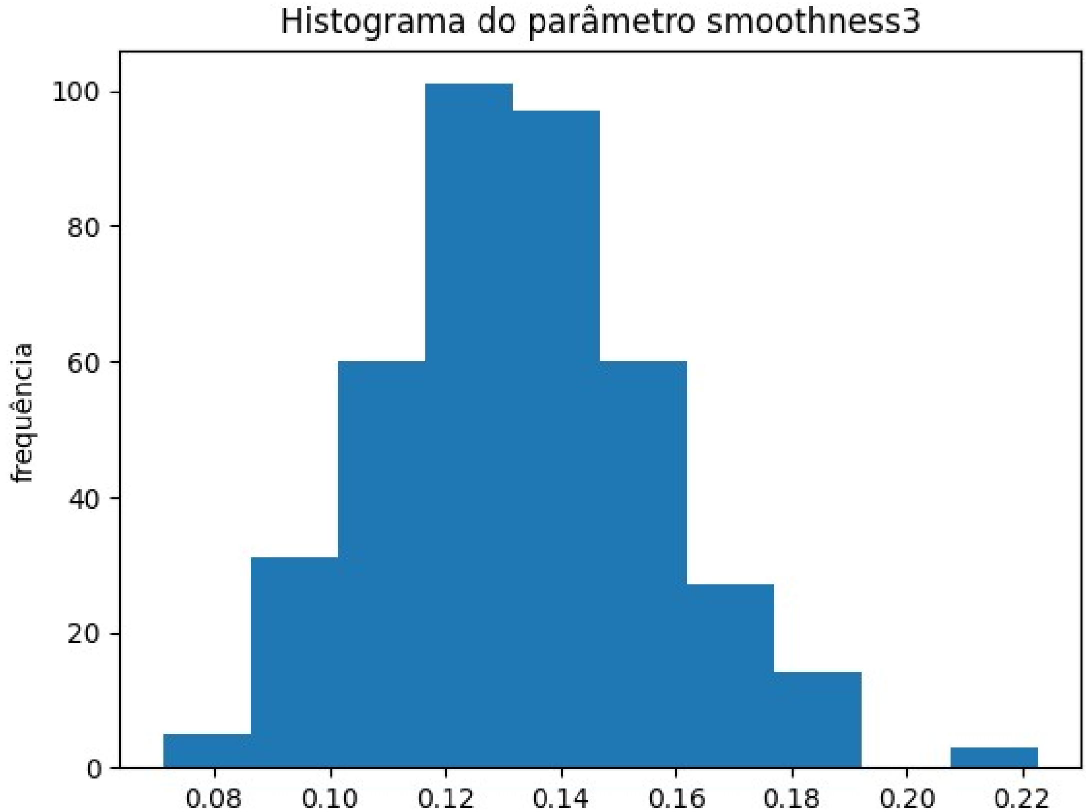

Histograma do parâmetro compactness2
frequência
0
20
40
60
80
100
120
140
0.00
0.02
0.04
0.06
0.08
0.10
0.12
0.14

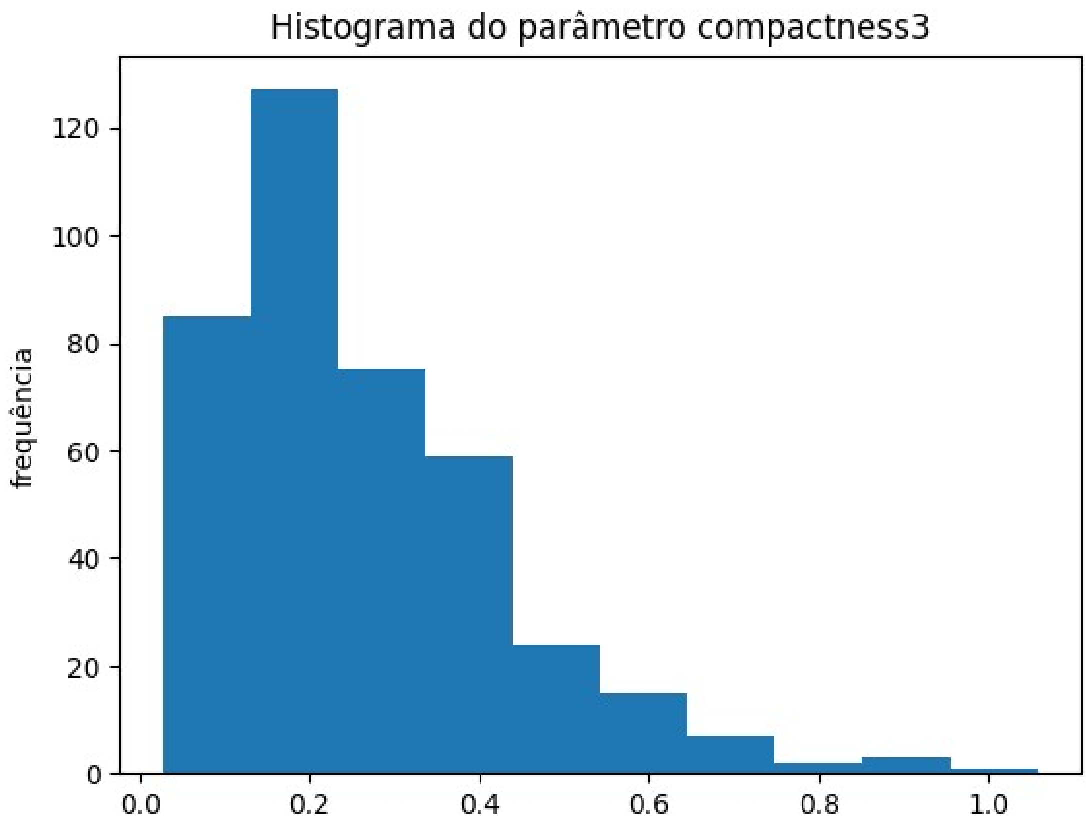

Histograma do parâmetro concavity2
frequência
300
250
200
150
100
50
0
0.00
0.05
0.10
0.15
0.20
0.25
0.30
0.35
0.40

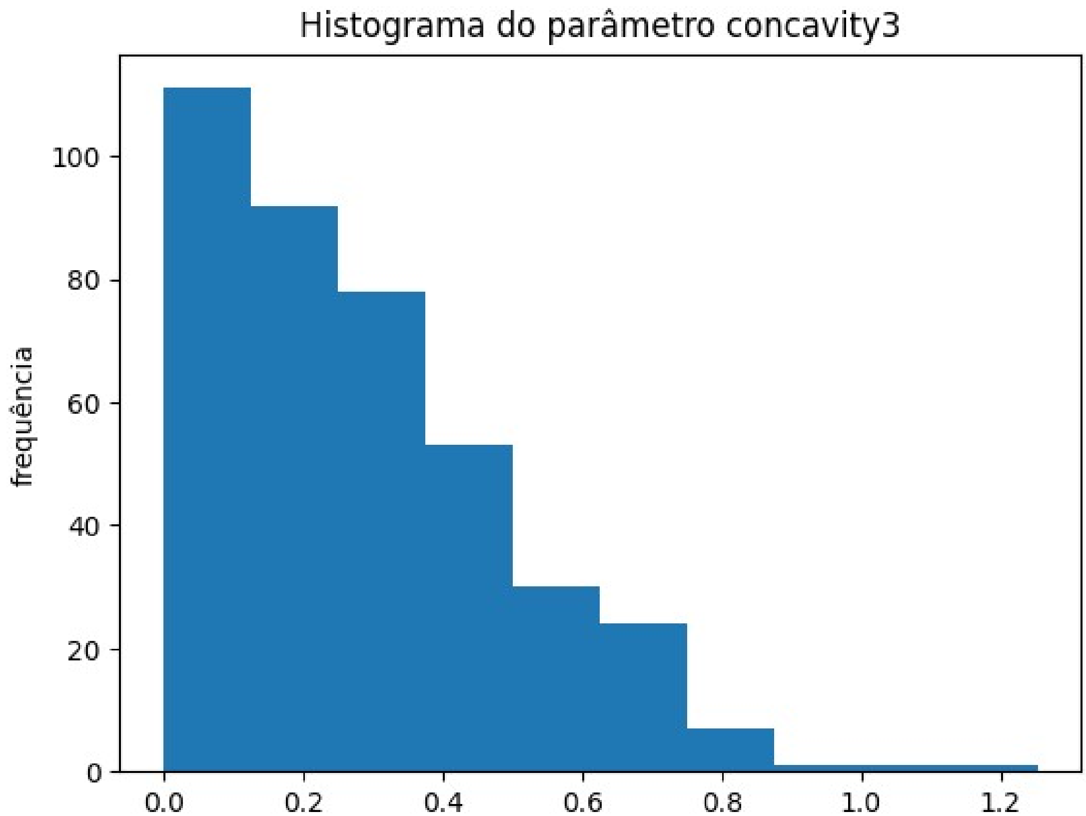

Histograma do parâmetro concave_points2
frequência
140
120
100
80
60
40
20
0
0.00
0.01
0.02
0.03
0.04
0.05

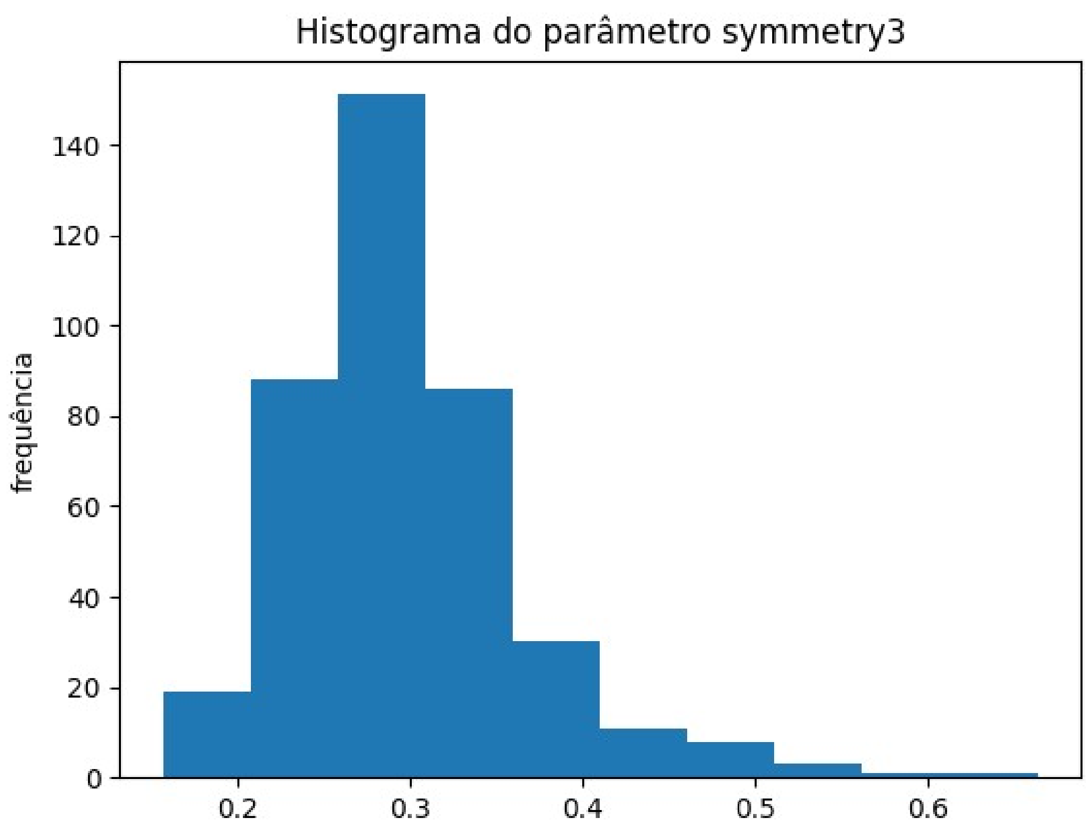

Histograma do parâmetro symmetry2
frequência
0
25
50
75
100
125
150
175
0.01
0.02
0.03
0.04
0.05
0.06
0.07
0.08

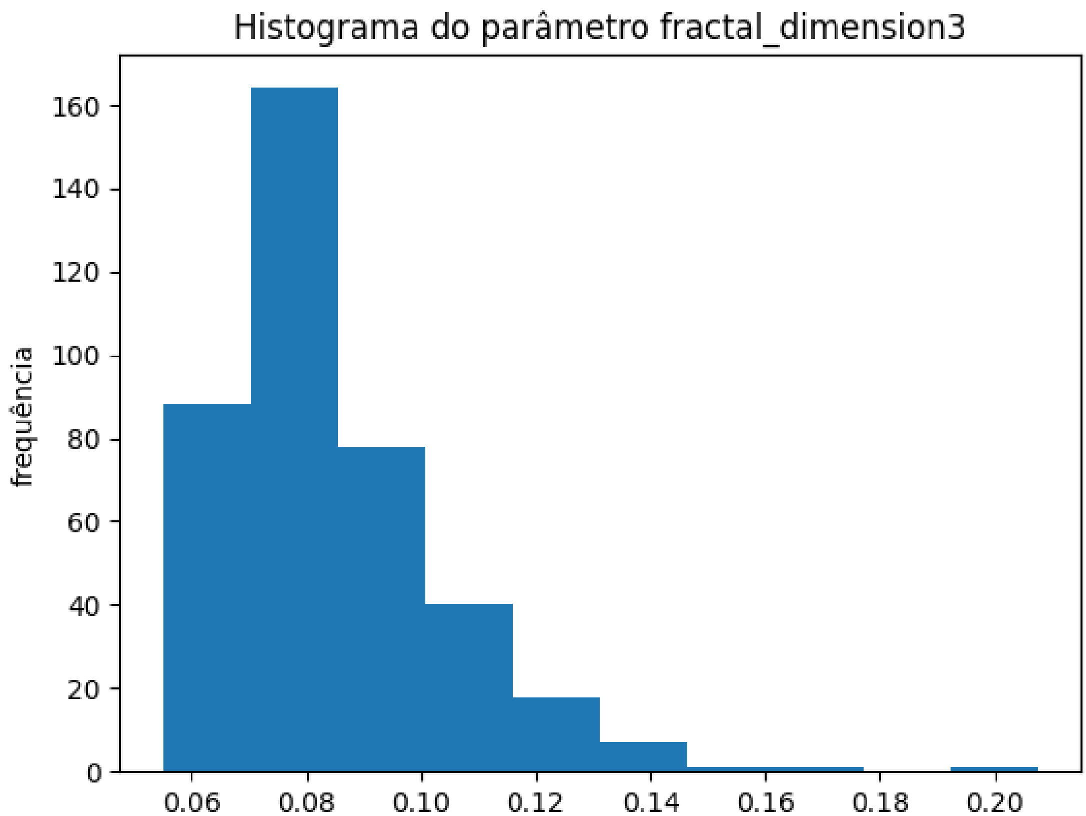

Histograma do parâmetro fractal_dimension2
frequência
0
50
100
150
200
250
0.000
0.005
0.010
0.015
0.020
0.025
0.030


Histograma do parâmetro smoothness3
frequência
0
20
40
60
80
100
0.08
0.10
0.12
0.14
0.16
0.18
0.20
0.22


Histograma do parâmetro compactness3
frequência
0
20
40
60
80
100
120
0.0
0.2
0.4
0.6
0.8
1.0


Histograma do parâmetro concavity3
frequência
0
20
40
60
80
100
0.0
0.2
0.4
0.6
0.8
1.0
1.2

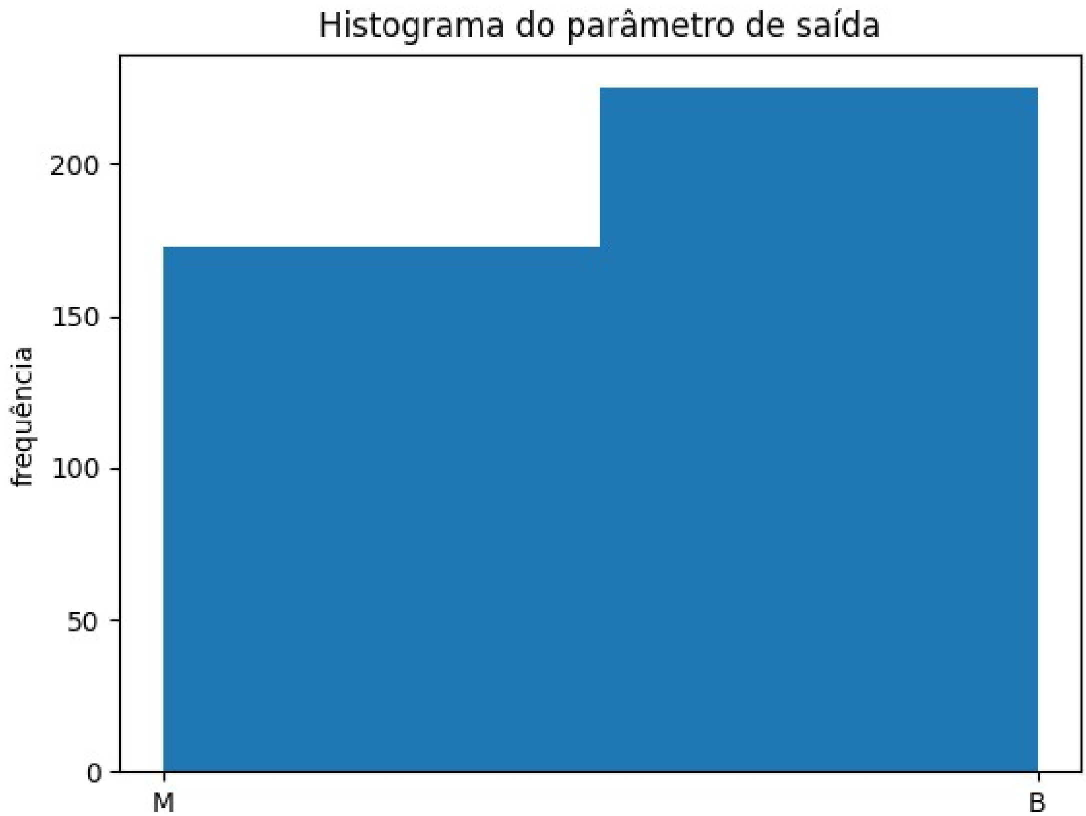

Histograma do parâmetro symmetry3
frequência
0
20
40
60
80
100
120
140
0.2
0.3
0.4
0.5
0.6




```
plt.figure(100)
n,_,_ = plt.hist(target_treino,len(target_treino.drop_duplicates()))
plt.title("Histograma do parâmetro de saída")
plt.ylabel("frequência")
p_target = n/sum(n)
display(p_target)
h_target = -sum(p_target*np.log2((n==0) + p_target))
display(h_target)
```

```
array([0.43467337, 0.56532663])
```

```
0.98765112455122
```




```
display(treino_non_redundant)
display(target_treino)

temp = pd.concat([treino_non_redundant,target_treino], axis=1)
h_in2out = []
p = []
freq = []
for i in range(len(treino_non_redundant.columns)):
  freq.insert(len(freq),
(temp[temp.columns[[i,16]]].value_counts()).tolist())
n = sum([sum(freq) for freq in freq])

for i in range(len(treino_non_redundant.columns)):
  prob = [(freq/n) for freq in freq[i]]
  p.insert(len(p),prob)
  h_in2out.insert(len(h_in2out),-sum((prob)*np.log2(prob)))
# display(sum([item for row in p for item in row]))
display(h_in2out)

     smoothness1  compactness1  symmetry1  fractal_dimension1
texture2  \
0        0.11840       0.27760     0.2419             0.07871
0.9053
1        0.08474       0.07864     0.1812             0.05667
```

```
0.7339
2        0.10960       0.15990     0.2069              0.05999
0.7869
3        0.14250       0.28390     0.2597              0.09744
1.1560
4        0.10030       0.13280     0.1809              0.05883
0.7813
..           ...           ...        ...                 ...        ..
.
393      0.11670       0.20870     0.2162              0.06606
0.9209
394      0.10290       0.09758     0.1937              0.06161
1.6520
395      0.08045       0.05361     0.1641              0.05764
1.6850
396      0.10590       0.11470     0.1806              0.06079
1.3320
397      0.08044       0.08895     0.1574              0.05750
1.2650

     smoothness2  compactness2  concavity2  concave_points2  symmetry2
\
0       0.006399       0.04904     0.05373         0.015870    0.03003

1       0.005225       0.01308     0.01860         0.013400    0.01389

2       0.006150       0.04006     0.03832         0.020580    0.02250

3       0.009110       0.07458     0.05661         0.018670    0.05963

4       0.011490       0.02461     0.05688         0.018850    0.01756

..           ...           ...         ...              ...        ...

393     0.005215       0.03726     0.04718         0.012880    0.02045

394     0.008146       0.01631     0.01843         0.007513    0.02015

395     0.005371       0.01273     0.01132         0.009155    0.01719

396     0.005442       0.01957     0.03304         0.013670    0.01315

397     0.005421       0.03477     0.04545         0.013840    0.01869


     fractal_dimension2  smoothness3  compactness3  concavity3
symmetry3  \
0              0.006193      0.16220        0.6656      0.7119
0.4601
1              0.003532      0.12380        0.1866      0.2416
```

```
0.2750
2              0.004571      0.14440        0.4245      0.4504
0.3613
3              0.009208      0.20980        0.8663      0.6869
0.6638
4              0.005115      0.13740        0.2050      0.4000
0.2364
..                  ...          ...           ...         ...
...
393            0.004028      0.15020        0.5717      0.7053
0.3828
394            0.001798      0.14320        0.1773      0.1603
0.3049
395            0.001444      0.10660        0.1231      0.0846
0.2523
396            0.002464      0.14280        0.2570      0.3438
0.2666
397            0.004067      0.09534        0.1812      0.1901
0.1988

     fractal_dimension3
0               0.11890
1               0.08902
2               0.08758
3               0.17300
4               0.07678
..                  ...
393             0.10070
394             0.07081
395             0.06609
396             0.07686
397             0.07053

[398 rows x 16 columns]

    Diagnosis
0           M
1           M
2           M
3           M
4           M
..        ...
393         M
394         B
395         B
396         B
397         B

[398 rows x 1 columns]
```

```
[0.7789505416092561,
 0.7866483352663943,
 0.7773801898504621,
 0.7843312989124113,
 0.7863342649146355,
 0.7866483352663943,
 0.7872764759699119,
 0.7835623609488057,
 0.7835623609488057,
 0.7855875803194464,
 0.7872764759699119,
 0.7734928017376854,
 0.7853920538593591,
 0.7851327127075998,
 0.7841357724523239,
 0.7869624056181531]
```

```
# display(h_target)
# display(h)
# display(h_in2out)
m = h_target + h - h_in2out
display(m)
display(sorted(m))
display(sorted(np.argsort(m)[(len(m)-10):len(m)]))
treino_non_redundant =
treino_non_redundant[treino_non_redundant.columns[sorted(np.argsort(m)
[(len(m)-10):len(m)])]]
teste_non_redundant =
teste_non_redundant[teste_non_redundant.columns[sorted(np.argsort(m)
[(len(m)-10):len(m)])]]
display(treino_non_redundant)
display(teste_non_redundant)
```

```
array([3.00162384, 2.8214826 , 2.83204974, 2.70065498, 2.32079029,
       2.06350709, 2.41329726, 1.33645791, 2.36575554, 2.31211107,
       1.61024584, 2.88815148, 2.70409134, 2.74596132, 2.5365876 ,
       2.3726974 ])
```

```
[1.3364579115444073,
 1.610245844678957,
 2.0635070944896645,
 2.3121110709261314,
 2.3207902860208627,
 2.3657555445293212,
 2.372697403435101,
 2.4132972640652537,
 2.536587603513382,
 2.7006549849823567,
 2.704091335960858,
 2.7459613222737556,
```

```
 2.8214825967340147,
 2.8320497369436755,
 2.8881514810734688,
 3.0016238407752787]
```

```
[0, 1, 2, 3, 6, 11, 12, 13, 14, 15]
```

```
     smoothness1  compactness1  symmetry1  fractal_dimension1  
compactness2  \
0        0.11840       0.27760     0.2419             0.07871  
0.04904   
1        0.08474       0.07864     0.1812             0.05667  
0.01308   
2        0.10960       0.15990     0.2069             0.05999  
0.04006   
3        0.14250       0.28390     0.2597             0.09744  
0.07458   
4        0.10030       0.13280     0.1809             0.05883  
0.02461   
..           ...           ...        ...                 ...  
...   
393      0.11670       0.20870     0.2162             0.06606  
0.03726   
394      0.10290       0.09758     0.1937             0.06161  
0.01631   
395      0.08045       0.05361     0.1641             0.05764  
0.01273   
396      0.10590       0.11470     0.1806             0.06079  
0.01957   
397      0.08044       0.08895     0.1574             0.05750  
0.03477   

     smoothness3  compactness3  concavity3  symmetry3  
fractal_dimension3  
0        0.16220        0.6656      0.7119     0.4601  
0.11890  
1        0.12380        0.1866      0.2416     0.2750  
0.08902  
2        0.14440        0.4245      0.4504     0.3613  
0.08758  
3        0.20980        0.8663      0.6869     0.6638  
0.17300  
4        0.13740        0.2050      0.4000     0.2364  
0.07678  
..           ...           ...         ...        ...  
...  
393      0.15020        0.5717      0.7053     0.3828  
0.10070  
394      0.14320        0.1773      0.1603     0.3049  
0.07081  
```

```
395      0.10660       0.1231      0.0846     0.2523
0.06609
396      0.14280       0.2570      0.3438     0.2666
0.07686
397      0.09534       0.1812      0.1901     0.1988
0.07053

[398 rows x 10 columns]

     smoothness1  compactness1  symmetry1  fractal_dimension1
compactness2  \
398      0.07741       0.04768     0.1535             0.06214
0.01469
399      0.09087       0.06232     0.1847             0.06019
0.01964
400      0.12300       0.25760     0.2113             0.07115
0.03718
401      0.08872       0.05242     0.1601             0.05541
0.01204
402      0.07351       0.07899     0.1874             0.05899
0.03713
..           ...           ...        ...                 ...
...
564      0.11100       0.11590     0.1726             0.05623
0.02891
565      0.09780       0.10340     0.1752             0.05533
0.02423
566      0.08455       0.10230     0.1590             0.05648
0.03731
567      0.11780       0.27700     0.2397             0.07016
0.06158
568      0.05263       0.04362     0.1587             0.05884
0.00466

     smoothness3  compactness3  concavity3  symmetry3
fractal_dimension3
398      0.11200       0.18790      0.2079     0.2590
0.09158
399      0.12440       0.17260      0.1449     0.2779
0.08121
400      0.18730       0.59170      0.9034     0.3245
0.11980
401      0.13740       0.15750      0.1514     0.2460
0.07262
402      0.09329       0.23180      0.1604     0.3207
0.07247
..           ...           ...         ...        ...
...
564      0.14100       0.21130      0.4107     0.2060
0.07115
```

```
565      0.11660      0.19220      0.3215      0.2572
0.06637
566      0.11390      0.30940      0.3403      0.2218
0.07820
567      0.16500      0.86810      0.9387      0.4087
0.12400
568      0.08996      0.06444      0.0000      0.2871
0.07039

[171 rows x 10 columns]
```

e)

```
### Rocchio

treino_treino0, treino_validacao0, target_treino_treino0,
target_validacao0 = train_test_split(treino_non_redundant,
target_treino, test_size=0.2,

#  random_state=1,

stratify = target_treino)

model = neighbors.NearestCentroid()
model.fit(treino_treino0, np.ravel(target_treino_treino0))
# print(model.centroids_)
target_pred0 = model.predict(treino_validacao0)
acc = model.score(treino_validacao0, target_validacao0)
print(f"Acurácia do Rocchio do sklearn para parâmetros selecionados:
{acc*100}%")

Acurácia do Rocchio do sklearn para parâmetros selecionados: 85.0%

### kNN

treino_treino1, treino_validacao1, target_treino_treino1,
target_validacao1 = train_test_split(treino_non_redundant,
target_treino, test_size=0.2,

#  random_state=1,

stratify = target_treino)

model = neighbors.KNeighborsClassifier(n_neighbors = 3)
model.fit(treino_treino1, np.ravel(target_treino_treino1))
model.predict(treino_validacao1)
acc = model.score(treino_validacao1, target_validacao1)
print(f"Acurácia 3NN: {acc*100}%")

#k-fold
```

```python
cv_scores = cross_val_score(model, treino_non_redundant,
np.ravel(target_treino), cv=5, scoring = "accuracy")
print(cv_scores)
print("(k-fold cv=5) cv_scores médio: {}".format(np.mean(cv_scores)))

#Grid Search
model = neighbors.KNeighborsClassifier()
param_grid = {"n_neighbors": np.arange(1, 10)}
knn_gscv = GridSearchCV(model, param_grid, cv=5)
knn_gscv.fit(treino_treino1, np.ravel(target_treino_treino1))
print(f"Melhor valor de k do kNN: {knn_gscv.best_params_} e melhor
resultado: {knn_gscv.best_score_}")

for dicts in knn_gscv.best_params_:
 k = knn_gscv.best_params_[dicts]

model = neighbors.KNeighborsClassifier(n_neighbors = k)
model.fit(treino_treino1, np.ravel(target_treino_treino1))
target_pred1 = model.predict(treino_validacao1)
acc = model.score(treino_validacao1, np.ravel(target_validacao1))
print(f"Acurácia do {k}NN: {acc*100}%")
```

```
Acurácia 3NN: 81.25%
[0.85       0.9        0.8625     0.87341772 0.84810127]
(k-fold cv=5) cv_scores médio: 0.8668037974683545
Melhor valor de k do kNN: {'n_neighbors': 8} e melhor resultado:
0.8898809523809523
Acurácia do 8NN: 83.75%
```

```python
### Naive Bayes

treino_treino2, treino_validacao2, target_treino_treino2,
target_validacao2 = train_test_split(treino_non_redundant,
target_treino, test_size=0.2,

#  random_state=1,

stratify = target_treino)

#considerando atributos com distribuição Gaussiana
model = naive_bayes.GaussianNB()
model.fit(treino_treino2, np.ravel(target_treino_treino2))
target_pred2 = model.predict(treino_validacao2)
print("Acurácia de %d amostras usando Gaussiana: %d%%"
  % (treino_validacao2.shape[0], 100*(np.ravel(target_validacao2) ==
target_pred2).sum()/treino_validacao2.shape[0]))
```

```
Acurácia de 80 amostras usando Gaussiana: 78%
```

f)

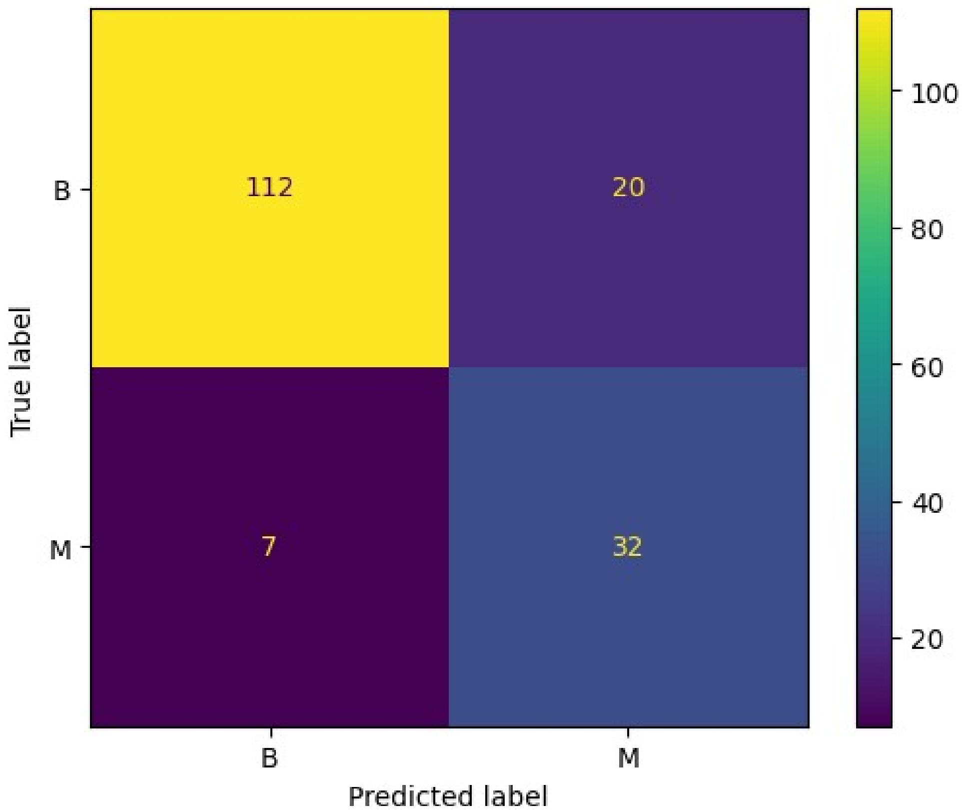
```
model = neighbors.NearestCentroid()
model.fit(treino_treino0, np.ravel(target_treino_treino0))
target_pred0 = model.predict(teste_non_redundant)

C0 = confusion_matrix(target_teste,target_pred0, labels =
np.unique(target_teste))

recall_v = recall_score(target_teste,target_pred0, average=None)
print(f"Recall VN Rocchio: {recall_v[0]*100}%% \nRecall VP Rocchio:
{recall_v[1]*100}%%")
precision_v = precision_score(target_teste,target_pred0, average=None)
print(f"Precisão VN Rocchio: {precision_v[0]*100}%% \nPrecisão VP
Rocchio: {precision_v[1]*100}%%")
accuracy = accuracy_score(target_teste,target_pred0)
print(f"Acurácia Rocchio: {accuracy*100}%%\n")

model = neighbors.KNeighborsClassifier(n_neighbors = k)
model.fit(treino_treino1, np.ravel(target_treino_treino1))
target_pred1 = model.predict(teste_non_redundant)

C1 = confusion_matrix(target_teste,target_pred1, labels =
np.unique(target_teste))

recall_v = recall_score(target_teste,target_pred1, average=None)
print(f"Recall VN kNN: {recall_v[0]*100}%% \nRecall VP kNN:
{recall_v[1]*100}%%")
precision_v = precision_score(target_teste,target_pred1, average=None)
print(f"Precisão VN kNN: {precision_v[0]*100}%% \nPrecisão VP kNN:
{precision_v[1]*100}%%")
accuracy = accuracy_score(target_teste,target_pred1)
print(f"Acurácia kNN: {accuracy*100}%%\n")

model = naive_bayes.GaussianNB()
model.fit(treino_treino2, np.ravel(target_treino_treino2))
target_pred2 = model.predict(teste_non_redundant)

C2 = confusion_matrix(target_teste,target_pred2, labels =
np.unique(target_teste))

recall_v = recall_score(target_teste,target_pred2, average=None)
print(f"Recall VN Naive Bayes distribuição gaussiana:
{recall_v[0]*100}%% \nRecall VP Naive Bayes distribuição gaussiana:
{recall_v[1]*100}%%")
precision_v = precision_score(target_teste,target_pred2, average=None)
print(f"Precisão VN Naive Bayes distribuição gaussiana:
{precision_v[0]*100}%% \nPrecisão VP Naive Bayes distribuição
gaussiana: {precision_v[1]*100}%%")
accuracy = accuracy_score(target_teste,target_pred2)
print(f"Acurácia Naive Bayes distribuição gaussiana: {accuracy*100}%%\
```

```
n")

plt.figure(1000)
ConfusionMatrixDisplay(confusion_matrix=C0, display_labels =
np.unique(target_validacao0)).plot()
plt.figure(2000)
ConfusionMatrixDisplay(confusion_matrix=C1, display_labels =
np.unique(target_validacao1)).plot()
plt.figure(3000)
ConfusionMatrixDisplay(confusion_matrix=C2, display_labels =
np.unique(target_validacao2)).plot()
```

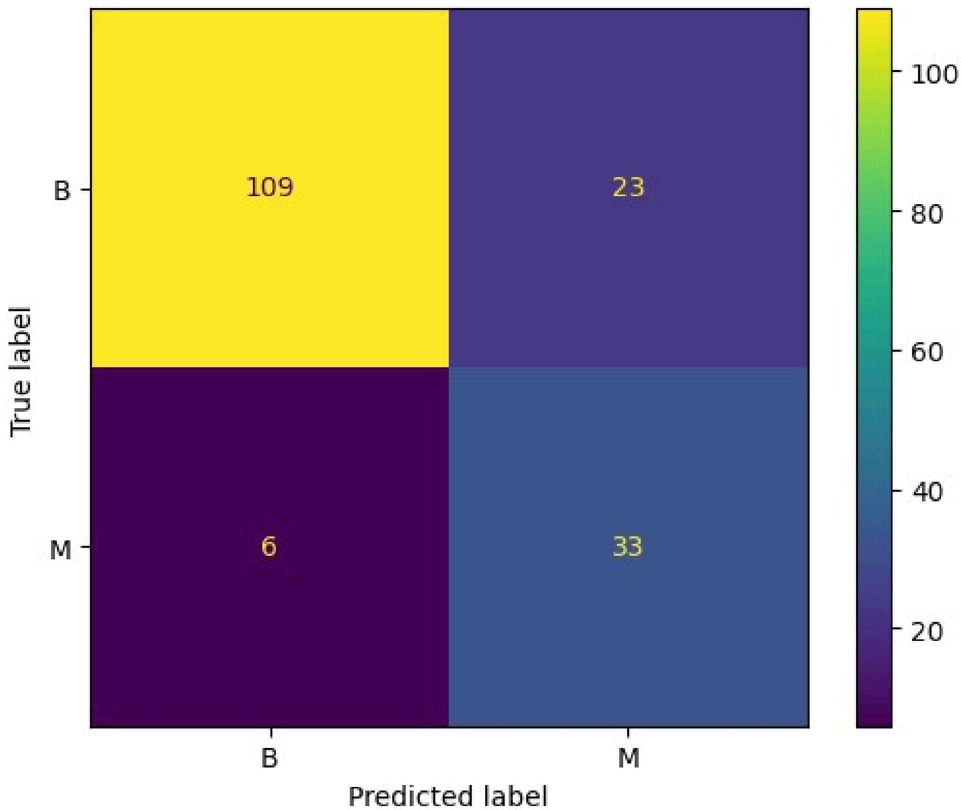
```
Recall VN Rocchio: 84.84848484848484%%
Recall VP Rocchio: 82.05128205128204%%
Precisão VN Rocchio: 94.11764705882352%%
Precisão VP Rocchio: 61.53846153846154%%
Acurácia Rocchio: 84.21052631578947%%

Recall VN kNN: 82.57575757575758%%
Recall VP kNN: 84.61538461538461%%
Precisão VN kNN: 94.78260869565217%%
Precisão VP kNN: 58.92857142857143%%
Acurácia kNN: 83.04093567251462%%

Recall VN Naive Bayes distribuição gaussiana: 87.12121212121212%%
Recall VP Naive Bayes distribuição gaussiana: 64.1025641025641%%
Precisão VN Naive Bayes distribuição gaussiana: 89.14728682170544%%
Precisão VP Naive Bayes distribuição gaussiana: 59.523809523809526%%
Acurácia Naive Bayes distribuição gaussiana: 81.87134502923976%%
```

```
<sklearn.metrics._plot.confusion_matrix.ConfusionMatrixDisplay at
0x7ac3fa81fe50>
```

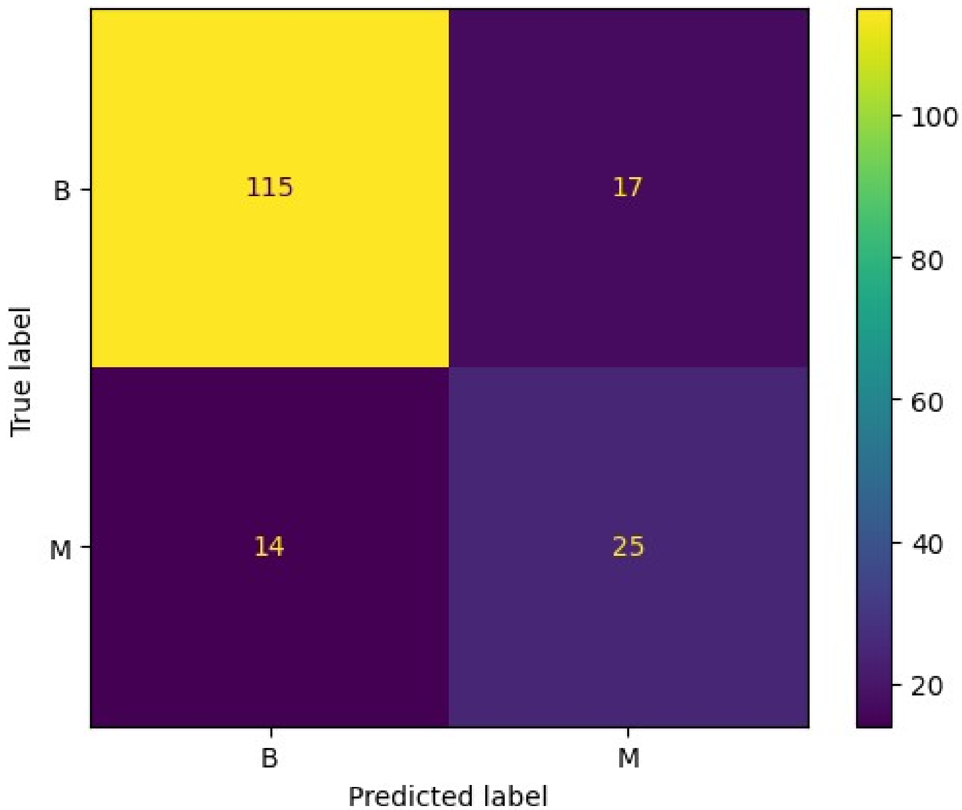
```
<Figure size 640x480 with 0 Axes>
```




```
<Figure size 640x480 with 0 Axes>
```




```
<Figure size 640x480 with 0 Axes>
```



g)

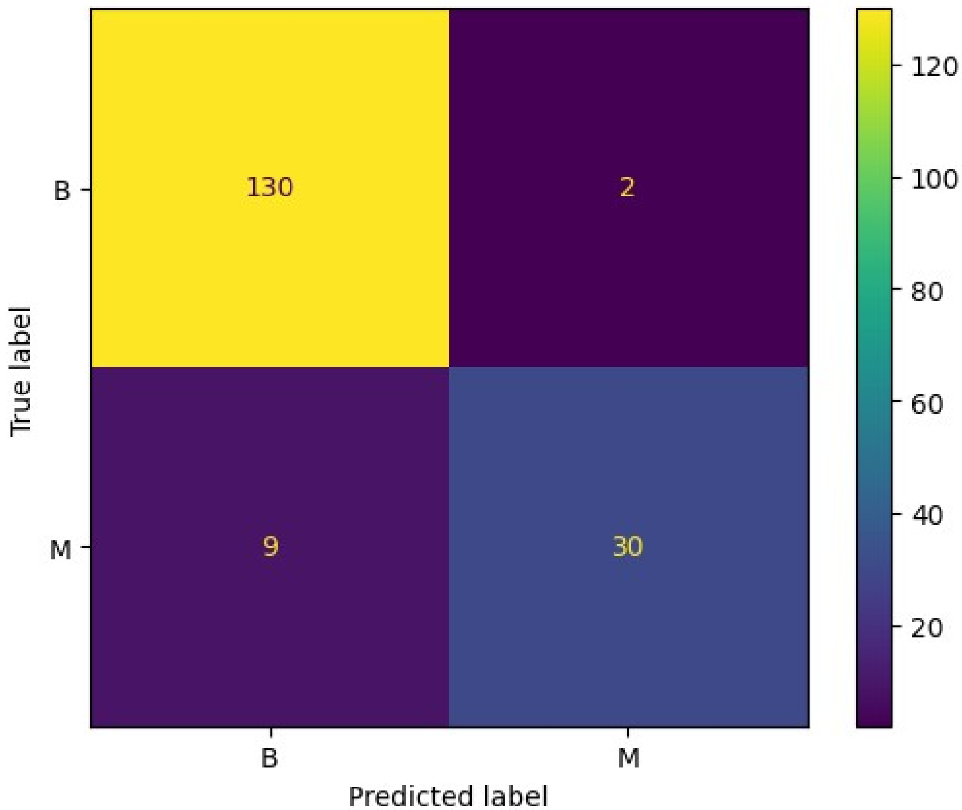
```
### Rocchio

treino_treino0, treino_validacao0, target_treino_treino0,
target_validacao0 = train_test_split(treino, target_treino,
test_size=0.2,

#  random_state=1,

stratify = target_treino)

model = neighbors.NearestCentroid()
model.fit(treino_treino0, np.ravel(target_treino_treino0))
# print(model.centroids_)
target_pred0 = model.predict(treino_validacao0)
acc = model.score(treino_validacao0, target_validacao0)
print(f"Acurácia do Rocchio do sklearn para todos os parâmetros:
{acc*100}%")

### kNN

treino_treino1, treino_validacao1, target_treino_treino1,
target_validacao1 = train_test_split(treino, target_treino,
test_size=0.2,
```

```
#  random_state=1,

stratify = target_treino)

model = neighbors.KNeighborsClassifier(n_neighbors = 3)
model.fit(treino_treino1, np.ravel(target_treino_treino1))
model.predict(treino_validacao1)
acc = model.score(treino_validacao1, target_validacao1)
print(f"Acurácia 3NN: {acc*100}%")

#k-fold
cv_scores = cross_val_score(model, treino_non_redundant,
np.ravel(target_treino), cv=5, scoring = "accuracy")
print(cv_scores)
print("(k-fold cv=5) cv_scores médio: {}".format(np.mean(cv_scores)))

#Grid Search
model = neighbors.KNeighborsClassifier()
param_grid = {"n_neighbors": np.arange(1, 10)}
knn_gscv = GridSearchCV(model, param_grid, cv=5)
knn_gscv.fit(treino_treino1, np.ravel(target_treino_treino1))
print(f"Melhor valor de k do kNN: {knn_gscv.best_params_} e melhor
resultado: {knn_gscv.best_score_}")

for dicts in knn_gscv.best_params_:
 k = knn_gscv.best_params_[dicts]

model = neighbors.KNeighborsClassifier(n_neighbors = k)
model.fit(treino_treino1, np.ravel(target_treino_treino1))
target_pred1 = model.predict(treino_validacao1)
acc = model.score(treino_validacao1, np.ravel(target_validacao1))
print(f"Acurácia do {k}NN: {acc*100}%")

### Naive Bayes

treino_treino2, treino_validacao2, target_treino_treino2,
target_validacao2 = train_test_split(treino, target_treino,
test_size=0.2,

#  random_state=1,

stratify = target_treino)

#considerando atributos com distribuição Gaussiana
model = naive_bayes.GaussianNB()
model.fit(treino_treino2, np.ravel(target_treino_treino2))
target_pred2 = model.predict(treino_validacao2)
print("Acurácia de %d amostras usando Gaussiana: %d%%"
  % (treino_validacao2.shape[0], 100*(np.ravel(target_validacao2) ==
```

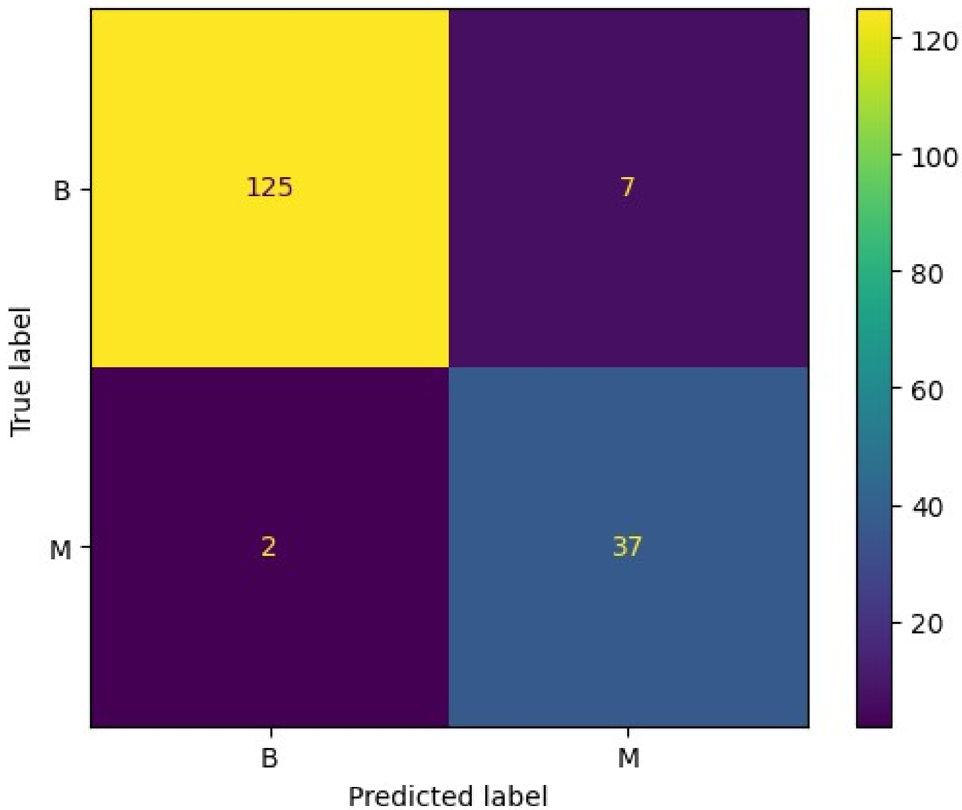
```
target_pred2).sum()/treino_validacao2.shape[0]))

model = neighbors.NearestCentroid()
model.fit(treino_treino0, np.ravel(target_treino_treino0))
target_pred0 = model.predict(teste)

C0 = confusion_matrix(target_teste,target_pred0, labels =
np.unique(target_teste))

recall_v = recall_score(target_teste,target_pred0, average=None)
print(f"Recall VN Rocchio: {recall_v[0]*100}%% \nRecall VP Rocchio:
{recall_v[1]*100}%%")
precision_v = precision_score(target_teste,target_pred0, average=None)
print(f"Precisão VN Rocchio: {precision_v[0]*100}%% \nPrecisão VP
Rocchio: {precision_v[1]*100}%%")
accuracy = accuracy_score(target_teste,target_pred0)
print(f"Acurácia Rocchio: {accuracy*100}%%\n")

model = neighbors.KNeighborsClassifier(n_neighbors = k)
model.fit(treino_treino1, np.ravel(target_treino_treino1))
target_pred1 = model.predict(teste)

C1 = confusion_matrix(target_teste,target_pred1, labels =
np.unique(target_teste))

recall_v = recall_score(target_teste,target_pred1, average=None)
print(f"Recall VN kNN: {recall_v[0]*100}%% \nRecall VP kNN:
{recall_v[1]*100}%%")
precision_v = precision_score(target_teste,target_pred1, average=None)
print(f"Precisão VN kNN: {precision_v[0]*100}%% \nPrecisão VP kNN:
{precision_v[1]*100}%%")
accuracy = accuracy_score(target_teste,target_pred1)
print(f"Acurácia kNN: {accuracy*100}%%\n")

model = naive_bayes.GaussianNB()
model.fit(treino_treino2, np.ravel(target_treino_treino2))
target_pred2 = model.predict(teste)

C2 = confusion_matrix(target_teste,target_pred2, labels =
np.unique(target_teste))

recall_v = recall_score(target_teste,target_pred2, average=None)
print(f"Recall VN Naive Bayes distribuição gaussiana:
{recall_v[0]*100}%% \nRecall VP Naive Bayes distribuição gaussiana:
{recall_v[1]*100}%%")
precision_v = precision_score(target_teste,target_pred2, average=None)
print(f"Precisão VN Naive Bayes distribuição gaussiana:
{precision_v[0]*100}%% \nPrecisão VP Naive Bayes distribuição
gaussiana: {precision_v[1]*100}%%")
accuracy = accuracy_score(target_teste,target_pred2)
```

```
print(f"Acurácia Naive Bayes distribuição gaussiana: {accuracy*100}%%\
n")

plt.figure(1001)
ConfusionMatrixDisplay(confusion_matrix=C0, display_labels =
np.unique(target_validacao0)).plot()
plt.figure(2001)
ConfusionMatrixDisplay(confusion_matrix=C1, display_labels =
np.unique(target_validacao1)).plot()
plt.figure(3001)
ConfusionMatrixDisplay(confusion_matrix=C2, display_labels =
np.unique(target_validacao2)).plot()
```

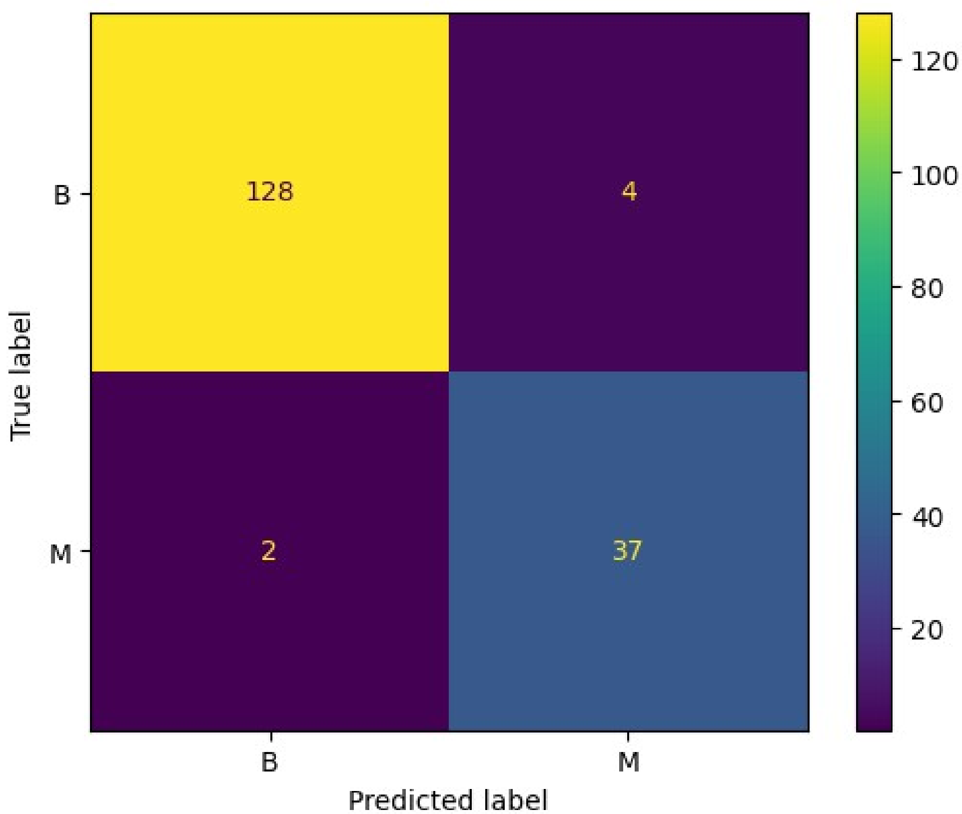
```
Acurácia do Rocchio do sklearn para todos os parâmetros: 85.0%
Acurácia 3NN: 92.5%
[0.85       0.9        0.8625     0.87341772 0.84810127]
(k-fold cv=5) cv_scores médio: 0.8668037974683545
Melhor valor de k do kNN: {'n_neighbors': 7} e melhor resultado:
0.9309027777777776
Acurácia do 7NN: 90.0%
Acurácia de 80 amostras usando Gaussiana: 91%
Recall VN Rocchio: 98.48484848484848%%
Recall VP Rocchio: 76.92307692307693%%
Precisão VN Rocchio: 93.5251798561151%%
Precisão VP Rocchio: 93.75%%
Acurácia Rocchio: 93.56725146198829%%

Recall VN kNN: 94.6969696969697%%
Recall VP kNN: 94.87179487179486%%
Precisão VN kNN: 98.4251968503937%%
Precisão VP kNN: 84.0909090909091%%
Acurácia kNN: 94.73684210526315%%

Recall VN Naive Bayes distribuição gaussiana: 96.96969696969697%%
Recall VP Naive Bayes distribuição gaussiana: 94.87179487179486%%
Precisão VN Naive Bayes distribuição gaussiana: 98.46153846153847%%
Precisão VP Naive Bayes distribuição gaussiana: 90.2439024390244%%
Acurácia Naive Bayes distribuição gaussiana: 96.49122807017544%%


<sklearn.metrics._plot.confusion_matrix.ConfusionMatrixDisplay at
0x7ac3f2faded0>

<Figure size 640x480 with 0 Axes>
```




```
<Figure size 640x480 with 0 Axes>
```




```
<Figure size 640x480 with 0 Axes>
```


128
4
2
37
B
M
B
M
True label
Predicted label
120
100
80
60
40
20