AIML

February 7, 2021

```
[1]: import warnings
     warnings.filterwarnings('ignore')
```

```
[2]: import numpy as np
     import pandas as pd
     import matplotlib.pyplot as plt
     import seaborn as sns
```

```
[3]: df = pd.read_csv("https://raw.githubusercontent.com/ingledarshan/AIML-B2/main/
      ↪data.csv")
```

```
[4]: df.head()
```

```
[4]:          id diagnosis  radius_mean  texture_mean  perimeter_mean  area_mean  \
     0    842302         M        17.99         10.38          122.80     1001.0
     1    842517         M        20.57         17.77          132.90     1326.0
     2  84300903         M        19.69         21.25          130.00     1203.0
     3  84348301         M        11.42         20.38           77.58      386.1
     4  84358402         M        20.29         14.34          135.10     1297.0

        smoothness_mean  compactness_mean  concavity_mean  concave points_mean  \
     0          0.11840           0.27760          0.3001              0.14710
     1          0.08474           0.07864          0.0869              0.07017
     2          0.10960           0.15990          0.1974              0.12790
     3          0.14250           0.28390          0.2414              0.10520
     4          0.10030           0.13280          0.1980              0.10430

        …  texture_worst  perimeter_worst  area_worst  smoothness_worst  \
     0  …          17.33           184.60      2019.0            0.1622
     1  …          23.41           158.80      1956.0            0.1238
     2  …          25.53           152.50      1709.0            0.1444
     3  …          26.50            98.87       567.7            0.2098
     4  …          16.67           152.20      1575.0            0.1374

        compactness_worst  concavity_worst  concave points_worst  symmetry_worst  \
     0             0.6656           0.7119                0.2654          0.4601
     1             0.1866           0.2416                0.1860          0.2750
```

```
2             0.4245           0.4504                 0.2430           0.3613
3             0.8663           0.6869                 0.2575           0.6638
4             0.2050           0.4000                 0.1625           0.2364

   fractal_dimension_worst  Unnamed: 32
0                  0.11890          NaN
1                  0.08902          NaN
2                  0.08758          NaN
3                  0.17300          NaN
4                  0.07678          NaN

[5 rows x 33 columns]
```

```
[5]: df.columns
```

```
[5]: Index(['id', 'diagnosis', 'radius_mean', 'texture_mean', 'perimeter_mean',
            'area_mean', 'smoothness_mean', 'compactness_mean', 'concavity_mean',
            'concave points_mean', 'symmetry_mean', 'fractal_dimension_mean',
            'radius_se', 'texture_se', 'perimeter_se', 'area_se', 'smoothness_se',
            'compactness_se', 'concavity_se', 'concave points_se', 'symmetry_se',
            'fractal_dimension_se', 'radius_worst', 'texture_worst',
            'perimeter_worst', 'area_worst', 'smoothness_worst',
            'compactness_worst', 'concavity_worst', 'concave points_worst',
            'symmetry_worst', 'fractal_dimension_worst', 'Unnamed: 32'],
           dtype='object')
```

```
[1]: df.info()
```

```
---------------------------------------------------------------------------
NameError                                 Traceback (most recent call last)
<ipython-input-1-a74c58233b9e> in <module>
----> 1 df.info()

NameError: name 'df' is not defined
```

```
[7]: df['Unnamed: 32']
```

```
[7]: 0      NaN
     1      NaN
     2      NaN
     3      NaN
     4      NaN
             ..
     564    NaN
     565    NaN
     566    NaN
```

```
567    NaN
568    NaN
Name: Unnamed: 32, Length: 569, dtype: float64
```

[8]:

```
df = df.drop("Unnamed: 32", axis=1)
```

[9]:

```
df.head()
```

[9]:

```
         id diagnosis  radius_mean  texture_mean  perimeter_mean  area_mean  \
0    842302         M        17.99         10.38          122.80     1001.0
1    842517         M        20.57         17.77          132.90     1326.0
2  84300903         M        19.69         21.25          130.00     1203.0
3  84348301         M        11.42         20.38           77.58      386.1
4  84358402         M        20.29         14.34          135.10     1297.0

   smoothness_mean  compactness_mean  concavity_mean  concave points_mean  \
0          0.11840           0.27760          0.3001              0.14710
1          0.08474           0.07864          0.0869              0.07017
2          0.10960           0.15990          0.1974              0.12790
3          0.14250           0.28390          0.2414              0.10520
4          0.10030           0.13280          0.1980              0.10430

   …  radius_worst  texture_worst  perimeter_worst  area_worst  \
0  …         25.38          17.33           184.60      2019.0
1  …         24.99          23.41           158.80      1956.0
2  …         23.57          25.53           152.50      1709.0
3  …         14.91          26.50            98.87       567.7
4  …         22.54          16.67           152.20      1575.0

   smoothness_worst  compactness_worst  concavity_worst  concave points_worst  \
0            0.1622             0.6656           0.7119                0.2654
1            0.1238             0.1866           0.2416                0.1860
2            0.1444             0.4245           0.4504                0.2430
3            0.2098             0.8663           0.6869                0.2575
4            0.1374             0.2050           0.4000                0.1625

   symmetry_worst  fractal_dimension_worst
0          0.4601                  0.11890
1          0.2750                  0.08902
2          0.3613                  0.08758
3          0.6638                  0.17300
4          0.2364                  0.07678

[5 rows x 32 columns]
```

[10]:

```
df.columns
```

```
[10]: Index(['id', 'diagnosis', 'radius_mean', 'texture_mean', 'perimeter_mean',
              'area_mean', 'smoothness_mean', 'compactness_mean', 'concavity_mean',
              'concave points_mean', 'symmetry_mean', 'fractal_dimension_mean',
              'radius_se', 'texture_se', 'perimeter_se', 'area_se', 'smoothness_se',
              'compactness_se', 'concavity_se', 'concave points_se', 'symmetry_se',
              'fractal_dimension_se', 'radius_worst', 'texture_worst',
              'perimeter_worst', 'area_worst', 'smoothness_worst',
              'compactness_worst', 'concavity_worst', 'concave points_worst',
              'symmetry_worst', 'fractal_dimension_worst'],
             dtype='object')
```

```
[11]: df.drop('id', axis=1, inplace=True)
      # df = df.drop('id', axis=1)
```

```
[12]: df.columns
```

```
[12]: Index(['diagnosis', 'radius_mean', 'texture_mean', 'perimeter_mean',
              'area_mean', 'smoothness_mean', 'compactness_mean', 'concavity_mean',
              'concave points_mean', 'symmetry_mean', 'fractal_dimension_mean',
              'radius_se', 'texture_se', 'perimeter_se', 'area_se', 'smoothness_se',
              'compactness_se', 'concavity_se', 'concave points_se', 'symmetry_se',
              'fractal_dimension_se', 'radius_worst', 'texture_worst',
              'perimeter_worst', 'area_worst', 'smoothness_worst',
              'compactness_worst', 'concavity_worst', 'concave points_worst',
              'symmetry_worst', 'fractal_dimension_worst'],
             dtype='object')
```

```
[13]: type(df.columns)
```

```
[13]: pandas.core.indexes.base.Index
```

```
[14]: l = list(df.columns)
      print(l)
```

```
['diagnosis', 'radius_mean', 'texture_mean', 'perimeter_mean', 'area_mean',
'smoothness_mean', 'compactness_mean', 'concavity_mean', 'concave points_mean',
'symmetry_mean', 'fractal_dimension_mean', 'radius_se', 'texture_se',
'perimeter_se', 'area_se', 'smoothness_se', 'compactness_se', 'concavity_se',
'concave points_se', 'symmetry_se', 'fractal_dimension_se', 'radius_worst',
'texture_worst', 'perimeter_worst', 'area_worst', 'smoothness_worst',
'compactness_worst', 'concavity_worst', 'concave points_worst',
'symmetry_worst', 'fractal_dimension_worst']
```

```
[15]: features_mean = l[1:11]

      features_se = l[11:21]

```

```
features_worst = l[21:]
```

[16]:
```
print(features_mean)
```

```
['radius_mean', 'texture_mean', 'perimeter_mean', 'area_mean',
'smoothness_mean', 'compactness_mean', 'concavity_mean', 'concave points_mean',
'symmetry_mean', 'fractal_dimension_mean']
```

[17]:
```
print(features_se)
```

```
['radius_se', 'texture_se', 'perimeter_se', 'area_se', 'smoothness_se',
'compactness_se', 'concavity_se', 'concave points_se', 'symmetry_se']
```

[18]:
```
print(features_worst)
```

```
['radius_worst', 'texture_worst', 'perimeter_worst', 'area_worst',
'smoothness_worst', 'compactness_worst', 'concavity_worst', 'concave
points_worst', 'symmetry_worst', 'fractal_dimension_worst']
```

[19]:
```
df.head(2)
```

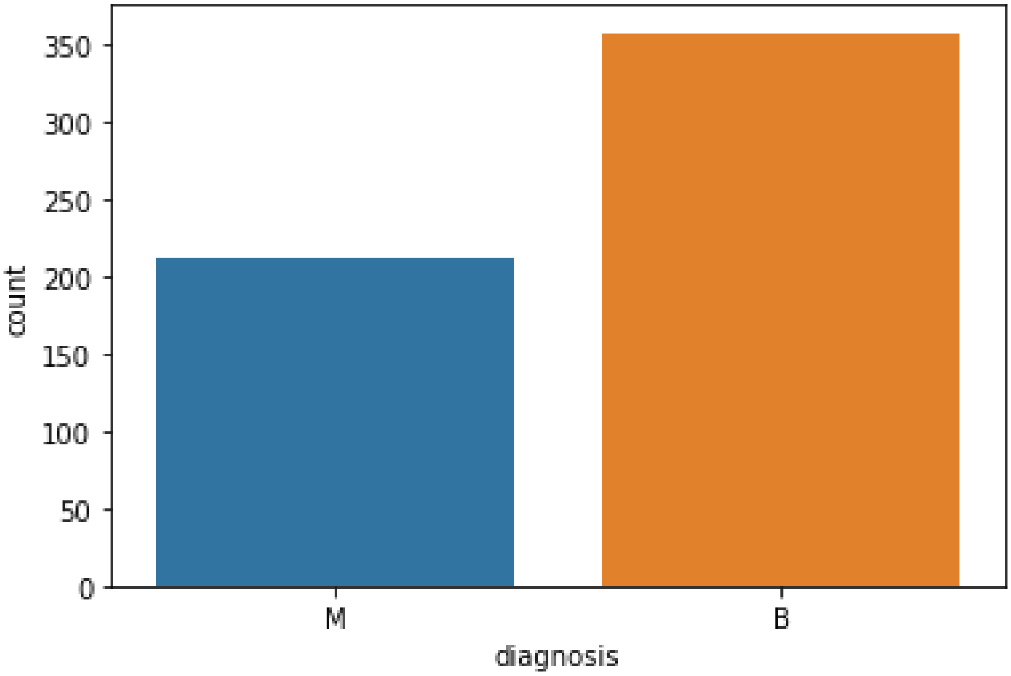
[19]:
```
  diagnosis  radius_mean  texture_mean  perimeter_mean  area_mean  \
0         M        17.99         10.38           122.8     1001.0
1         M        20.57         17.77           132.9     1326.0

   smoothness_mean  compactness_mean  concavity_mean  concave points_mean  \
0          0.11840           0.27760          0.3001              0.14710
1          0.08474           0.07864          0.0869              0.07017

   symmetry_mean  …  radius_worst  texture_worst  perimeter_worst  \
0         0.2419  …         25.38          17.33            184.6
1         0.1812  …         24.99          23.41            158.8

   area_worst  smoothness_worst  compactness_worst  concavity_worst  \
0      2019.0            0.1622             0.6656           0.7119
1      1956.0            0.1238             0.1866           0.2416

   concave points_worst  symmetry_worst  fractal_dimension_worst
0                0.2654          0.4601                  0.11890
1                0.1860          0.2750                  0.08902

[2 rows x 31 columns]
```

[20]:
```
df['diagnosis'].unique()
# M= Malignant, B= Benign
```

[20]:
```
array(['M', 'B'], dtype=object)
```

[21]:

```
sns.countplot(df['diagnosis'], label="Count",);
```



[22]:

```
df['diagnosis'].value_counts()
```

[22]:

```
B    357
M    212
Name: diagnosis, dtype: int64
```

[23]:

```
df.shape
```

[23]:

```
(569, 31)
```

1 Explore the data

[24]:

```
df.describe()
# summary of all the numeric columns
```

[24]:

```
       radius_mean  texture_mean  perimeter_mean   area_mean  \
count   569.000000    569.000000      569.000000  569.000000
mean     14.127292     19.289649       91.969033  654.889104
std       3.524049      4.301036       24.298981  351.914129
min       6.981000      9.710000       43.790000  143.500000
25%      11.700000     16.170000       75.170000  420.300000
50%      13.370000     18.840000       86.240000  551.100000
```

```
75%      15.780000    21.800000      104.100000   782.700000
max      28.110000    39.280000      188.500000  2501.000000

       smoothness_mean  compactness_mean  concavity_mean  concave points_mean  \
count       569.000000        569.000000      569.000000           569.000000
mean          0.096360          0.104341        0.088799             0.048919
std           0.014064          0.052813        0.079720             0.038803
min           0.052630          0.019380        0.000000             0.000000
25%           0.086370          0.064920        0.029560             0.020310
50%           0.095870          0.092630        0.061540             0.033500
75%           0.105300          0.130400        0.130700             0.074000
max           0.163400          0.345400        0.426800             0.201200

       symmetry_mean  fractal_dimension_mean  …  radius_worst  \
count     569.000000              569.000000  …    569.000000
mean        0.181162                0.062798  …     16.269190
std         0.027414                0.007060  …      4.833242
min         0.106000                0.049960  …      7.930000
25%         0.161900                0.057700  …     13.010000
50%         0.179200                0.061540  …     14.970000
75%         0.195700                0.066120  …     18.790000
max         0.304000                0.097440  …     36.040000

       texture_worst  perimeter_worst   area_worst  smoothness_worst  \
count     569.000000       569.000000   569.000000        569.000000
mean       25.677223       107.261213   880.583128          0.132369
std         6.146258        33.602542   569.356993          0.022832
min        12.020000        50.410000   185.200000          0.071170
25%        21.080000        84.110000   515.300000          0.116600
50%        25.410000        97.660000   686.500000          0.131300
75%        29.720000       125.400000  1084.000000          0.146000
max        49.540000       251.200000  4254.000000          0.222600

       compactness_worst  concavity_worst  concave points_worst  \
count         569.000000       569.000000            569.000000
mean            0.254265         0.272188              0.114606
std             0.157336         0.208624              0.065732
min             0.027290         0.000000              0.000000
25%             0.147200         0.114500              0.064930
50%             0.211900         0.226700              0.099930
75%             0.339100         0.382900              0.161400
max             1.058000         1.252000              0.291000

       symmetry_worst  fractal_dimension_worst
count      569.000000               569.000000
mean         0.290076                 0.083946
std          0.061867                 0.018061
```

```
min          0.156500                0.055040
25%          0.250400                0.071460
50%          0.282200                0.080040
75%          0.317900                0.092080
max          0.663800                0.207500

[8 rows x 30 columns]
```

[25]:

```
len(df.columns)
```

[25]:

```
31
```

[26]:

```
# Correlation Plot
corr = df.corr()
corr
```

[26]:

```
                         radius_mean  texture_mean  perimeter_mean  area_mean  \
radius_mean                 1.000000      0.323782        0.997855   0.987357
texture_mean                0.323782      1.000000        0.329533   0.321086
perimeter_mean              0.997855      0.329533        1.000000   0.986507
area_mean                   0.987357      0.321086        0.986507   1.000000
smoothness_mean             0.170581     -0.023389        0.207278   0.177028
compactness_mean            0.506124      0.236702        0.556936   0.498502
concavity_mean              0.676764      0.302418        0.716136   0.685983
concave points_mean         0.822529      0.293464        0.850977   0.823269
symmetry_mean               0.147741      0.071401        0.183027   0.151293
fractal_dimension_mean     -0.311631     -0.076437       -0.261477  -0.283110
radius_se                   0.679090      0.275869        0.691765   0.732562
texture_se                 -0.097317      0.386358       -0.086761  -0.066280
perimeter_se                0.674172      0.281673        0.693135   0.726628
area_se                     0.735864      0.259845        0.744983   0.800086
smoothness_se              -0.222600      0.006614       -0.202694  -0.166777
compactness_se              0.206000      0.191975        0.250744   0.212583
concavity_se                0.194204      0.143293        0.228082   0.207660
concave points_se           0.376169      0.163851        0.407217   0.372320
symmetry_se                -0.104321      0.009127       -0.081629  -0.072497
fractal_dimension_se       -0.042641      0.054458       -0.005523  -0.019887
radius_worst                0.969539      0.352573        0.969476   0.962746
texture_worst               0.297008      0.912045        0.303038   0.287489
perimeter_worst             0.965137      0.358040        0.970387   0.959120
area_worst                  0.941082      0.343546        0.941550   0.959213
smoothness_worst            0.119616      0.077503        0.150549   0.123523
compactness_worst           0.413463      0.277830        0.455774   0.390410
concavity_worst             0.526911      0.301025        0.563879   0.512606
concave points_worst        0.744214      0.295316        0.771241   0.722017
symmetry_worst              0.163953      0.105008        0.189115   0.143570
fractal_dimension_worst     0.007066      0.119205        0.051019   0.003738
```

```
                         smoothness_mean  compactness_mean  concavity_mean  \
radius_mean                     0.170581          0.506124        0.676764
texture_mean                   -0.023389          0.236702        0.302418
perimeter_mean                  0.207278          0.556936        0.716136
area_mean                       0.177028          0.498502        0.685983
smoothness_mean                 1.000000          0.659123        0.521984
compactness_mean                0.659123          1.000000        0.883121
concavity_mean                  0.521984          0.883121        1.000000
concave points_mean             0.553695          0.831135        0.921391
symmetry_mean                   0.557775          0.602641        0.500667
fractal_dimension_mean          0.584792          0.565369        0.336783
radius_se                       0.301467          0.497473        0.631925
texture_se                      0.068406          0.046205        0.076218
perimeter_se                    0.296092          0.548905        0.660391
area_se                         0.246552          0.455653        0.617427
smoothness_se                   0.332375          0.135299        0.098564
compactness_se                  0.318943          0.738722        0.670279
concavity_se                    0.248396          0.570517        0.691270
concave points_se               0.380676          0.642262        0.683260
symmetry_se                     0.200774          0.229977        0.178009
fractal_dimension_se            0.283607          0.507318        0.449301
radius_worst                    0.213120          0.535315        0.688236
texture_worst                   0.036072          0.248133        0.299879
perimeter_worst                 0.238853          0.590210        0.729565
area_worst                      0.206718          0.509604        0.675987
smoothness_worst                0.805324          0.565541        0.448822
compactness_worst               0.472468          0.865809        0.754968
concavity_worst                 0.434926          0.816275        0.884103
concave points_worst            0.503053          0.815573        0.861323
symmetry_worst                  0.394309          0.510223        0.409464
fractal_dimension_worst         0.499316          0.687382        0.514930

                         concave points_mean  symmetry_mean  \
radius_mean                         0.822529       0.147741
texture_mean                        0.293464       0.071401
perimeter_mean                      0.850977       0.183027
area_mean                           0.823269       0.151293
smoothness_mean                     0.553695       0.557775
compactness_mean                    0.831135       0.602641
concavity_mean                      0.921391       0.500667
concave points_mean                 1.000000       0.462497
symmetry_mean                       0.462497       1.000000
fractal_dimension_mean              0.166917       0.479921
radius_se                           0.698050       0.303379
texture_se                          0.021480       0.128053
perimeter_se                        0.710650       0.313893
```

```
area_se                             0.690299       0.223970
smoothness_se                       0.027653       0.187321
compactness_se                      0.490424       0.421659
concavity_se                        0.439167       0.342627
concave points_se                   0.615634       0.393298
symmetry_se                         0.095351       0.449137
fractal_dimension_se                0.257584       0.331786
radius_worst                        0.830318       0.185728
texture_worst                       0.292752       0.090651
perimeter_worst                     0.855923       0.219169
area_worst                          0.809630       0.177193
smoothness_worst                    0.452753       0.426675
compactness_worst                   0.667454       0.473200
concavity_worst                     0.752399       0.433721
concave points_worst                0.910155       0.430297
symmetry_worst                      0.375744       0.699826
fractal_dimension_worst             0.368661       0.438413

                         fractal_dimension_mean  …  radius_worst  \
radius_mean                           -0.311631  …      0.969539
texture_mean                          -0.076437  …      0.352573
perimeter_mean                        -0.261477  …      0.969476
area_mean                             -0.283110  …      0.962746
smoothness_mean                        0.584792  …      0.213120
compactness_mean                       0.565369  …      0.535315
concavity_mean                         0.336783  …      0.688236
concave points_mean                    0.166917  …      0.830318
symmetry_mean                          0.479921  …      0.185728
fractal_dimension_mean                 1.000000  …     -0.253691
radius_se                              0.000111  …      0.715065
texture_se                             0.164174  …     -0.111690
perimeter_se                           0.039830  …      0.697201
area_se                               -0.090170  …      0.757373
smoothness_se                          0.401964  …     -0.230691
compactness_se                         0.559837  …      0.204607
concavity_se                           0.446630  …      0.186904
concave points_se                      0.341198  …      0.358127
symmetry_se                            0.345007  …     -0.128121
fractal_dimension_se                   0.688132  …     -0.037488
radius_worst                          -0.253691  …      1.000000
texture_worst                         -0.051269  …      0.359921
perimeter_worst                       -0.205151  …      0.993708
area_worst                            -0.231854  …      0.984015
smoothness_worst                       0.504942  …      0.216574
compactness_worst                      0.458798  …      0.475820
concavity_worst                        0.346234  …      0.573975
concave points_worst                   0.175325  …      0.787424
```

```
symmetry_worst                         0.334019  …      0.243529
fractal_dimension_worst                0.767297  …      0.093492

                         texture_worst  perimeter_worst  area_worst  \
radius_mean                   0.297008         0.965137    0.941082
texture_mean                  0.912045         0.358040    0.343546
perimeter_mean                0.303038         0.970387    0.941550
area_mean                     0.287489         0.959120    0.959213
smoothness_mean               0.036072         0.238853    0.206718
compactness_mean              0.248133         0.590210    0.509604
concavity_mean                0.299879         0.729565    0.675987
concave points_mean           0.292752         0.855923    0.809630
symmetry_mean                 0.090651         0.219169    0.177193
fractal_dimension_mean       -0.051269        -0.205151   -0.231854
radius_se                     0.194799         0.719684    0.751548
texture_se                    0.409003        -0.102242   -0.083195
perimeter_se                  0.200371         0.721031    0.730713
area_se                       0.196497         0.761213    0.811408
smoothness_se                -0.074743        -0.217304   -0.182195
compactness_se                0.143003         0.260516    0.199371
concavity_se                  0.100241         0.226680    0.188353
concave points_se             0.086741         0.394999    0.342271
symmetry_se                  -0.077473        -0.103753   -0.110343
fractal_dimension_se         -0.003195        -0.001000   -0.022736
radius_worst                  0.359921         0.993708    0.984015
texture_worst                 1.000000         0.365098    0.345842
perimeter_worst               0.365098         1.000000    0.977578
area_worst                    0.345842         0.977578    1.000000
smoothness_worst              0.225429         0.236775    0.209145
compactness_worst             0.360832         0.529408    0.438296
concavity_worst               0.368366         0.618344    0.543331
concave points_worst          0.359755         0.816322    0.747419
symmetry_worst                0.233027         0.269493    0.209146
fractal_dimension_worst       0.219122         0.138957    0.079647

                         smoothness_worst  compactness_worst  concavity_worst  \
radius_mean                      0.119616           0.413463         0.526911
texture_mean                     0.077503           0.277830         0.301025
perimeter_mean                   0.150549           0.455774         0.563879
area_mean                        0.123523           0.390410         0.512606
smoothness_mean                  0.805324           0.472468         0.434926
compactness_mean                 0.565541           0.865809         0.816275
concavity_mean                   0.448822           0.754968         0.884103
concave points_mean              0.452753           0.667454         0.752399
symmetry_mean                    0.426675           0.473200         0.433721
fractal_dimension_mean           0.504942           0.458798         0.346234
radius_se                        0.141919           0.287103         0.380585
```

```
texture_se                      -0.073658          -0.092439        -0.068956
perimeter_se                     0.130054           0.341919         0.418899
area_se                          0.125389           0.283257         0.385100
smoothness_se                    0.314457          -0.055558        -0.058298
compactness_se                   0.227394           0.678780         0.639147
concavity_se                     0.168481           0.484858         0.662564
concave points_se                0.215351           0.452888         0.549592
symmetry_se                     -0.012662           0.060255         0.037119
fractal_dimension_se             0.170568           0.390159         0.379975
radius_worst                     0.216574           0.475820         0.573975
texture_worst                    0.225429           0.360832         0.368366
perimeter_worst                  0.236775           0.529408         0.618344
area_worst                       0.209145           0.438296         0.543331
smoothness_worst                 1.000000           0.568187         0.518523
compactness_worst                0.568187           1.000000         0.892261
concavity_worst                  0.518523           0.892261         1.000000
concave points_worst             0.547691           0.801080         0.855434
symmetry_worst                   0.493838           0.614441         0.532520
fractal_dimension_worst          0.617624           0.810455         0.686511

                         concave points_worst  symmetry_worst  \
radius_mean                          0.744214        0.163953
texture_mean                         0.295316        0.105008
perimeter_mean                       0.771241        0.189115
area_mean                            0.722017        0.143570
smoothness_mean                      0.503053        0.394309
compactness_mean                     0.815573        0.510223
concavity_mean                       0.861323        0.409464
concave points_mean                  0.910155        0.375744
symmetry_mean                        0.430297        0.699826
fractal_dimension_mean               0.175325        0.334019
radius_se                            0.531062        0.094543
texture_se                          -0.119638       -0.128215
perimeter_se                         0.554897        0.109930
area_se                              0.538166        0.074126
smoothness_se                       -0.102007       -0.107342
compactness_se                       0.483208        0.277878
concavity_se                         0.440472        0.197788
concave points_se                    0.602450        0.143116
symmetry_se                         -0.030413        0.389402
fractal_dimension_se                 0.215204        0.111094
radius_worst                         0.787424        0.243529
texture_worst                        0.359755        0.233027
perimeter_worst                      0.816322        0.269493
area_worst                           0.747419        0.209146
smoothness_worst                     0.547691        0.493838
compactness_worst                    0.801080        0.614441
```

```
concavity_worst                      0.855434        0.532520
concave points_worst                 1.000000        0.502528
symmetry_worst                       0.502528        1.000000
fractal_dimension_worst              0.511114        0.537848

                         fractal_dimension_worst
radius_mean                             0.007066
texture_mean                            0.119205
perimeter_mean                          0.051019
area_mean                               0.003738
smoothness_mean                         0.499316
compactness_mean                        0.687382
concavity_mean                          0.514930
concave points_mean                     0.368661
symmetry_mean                           0.438413
fractal_dimension_mean                  0.767297
radius_se                               0.049559
texture_se                             -0.045655
perimeter_se                            0.085433
area_se                                 0.017539
smoothness_se                           0.101480
compactness_se                          0.590973
concavity_se                            0.439329
concave points_se                       0.310655
symmetry_se                             0.078079
fractal_dimension_se                    0.591328
radius_worst                            0.093492
texture_worst                           0.219122
perimeter_worst                         0.138957
area_worst                              0.079647
smoothness_worst                        0.617624
compactness_worst                       0.810455
concavity_worst                         0.686511
concave points_worst                    0.511114
symmetry_worst                          0.537848
fractal_dimension_worst                 1.000000

[30 rows x 30 columns]
```

[27]:

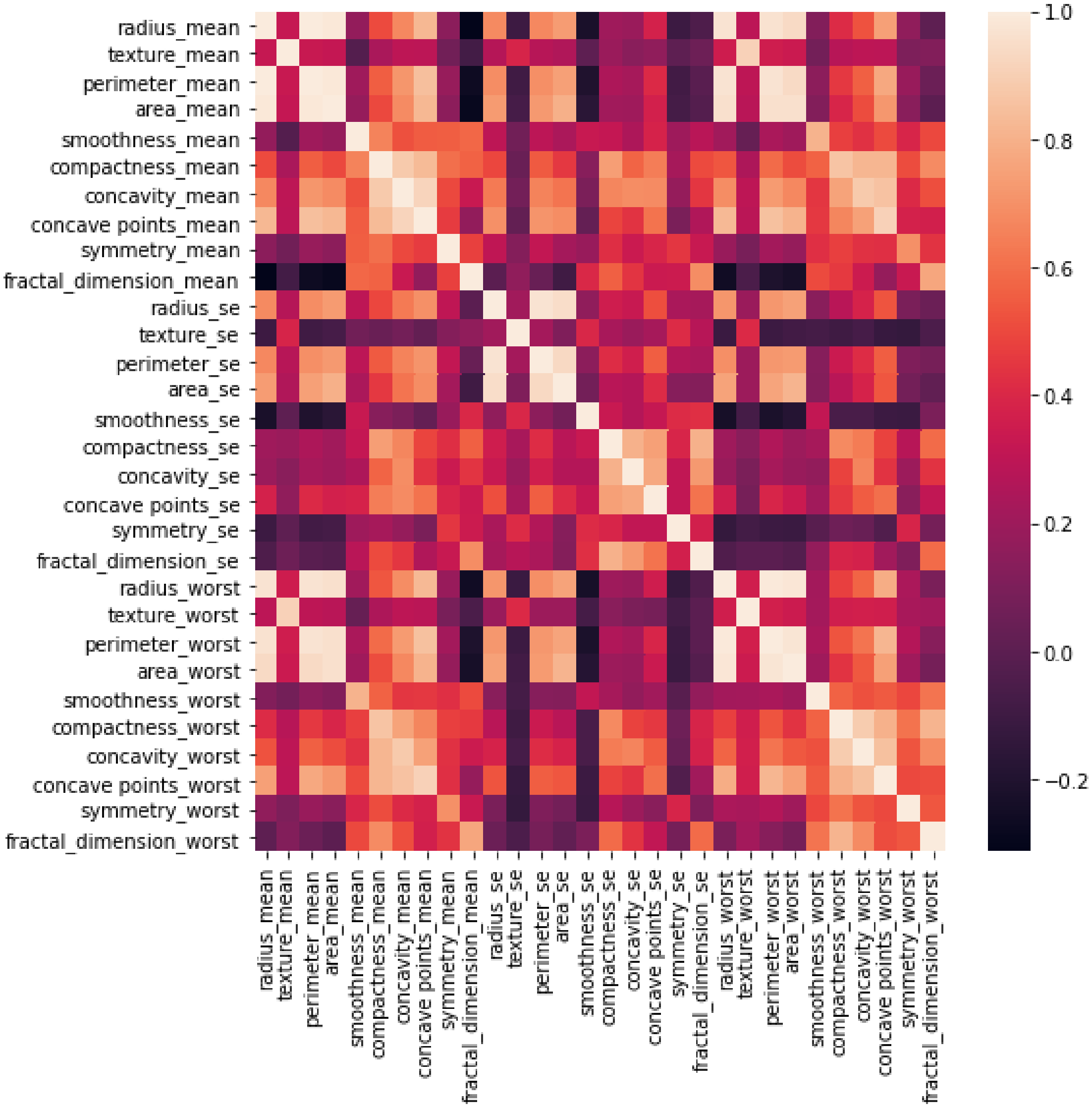
```
corr.shape
```

[27]:

```
(30, 30)
```

[31]:

```
plt.figure(figsize=(8,8))
sns.heatmap(corr);
```



[33]:
```
df.head()
```

[33]:
```
  diagnosis  radius_mean  texture_mean  perimeter_mean  area_mean  \
0         M        17.99         10.38          122.80     1001.0
1         M        20.57         17.77          132.90     1326.0
2         M        19.69         21.25          130.00     1203.0
3         M        11.42         20.38           77.58      386.1
4         M        20.29         14.34          135.10     1297.0

   smoothness_mean  compactness_mean  concavity_mean  concave points_mean  \
0          0.11840           0.27760          0.3001              0.14710
1          0.08474           0.07864          0.0869              0.07017
```

```
2          0.10960           0.15990          0.1974              0.12790
3          0.14250           0.28390          0.2414              0.10520
4          0.10030           0.13280          0.1980              0.10430

   symmetry_mean  …  radius_worst  texture_worst  perimeter_worst  \
0         0.2419  …         25.38          17.33           184.60
1         0.1812  …         24.99          23.41           158.80
2         0.2069  …         23.57          25.53           152.50
3         0.2597  …         14.91          26.50            98.87
4         0.1809  …         22.54          16.67           152.20

   area_worst  smoothness_worst  compactness_worst  concavity_worst  \
0      2019.0            0.1622             0.6656           0.7119
1      1956.0            0.1238             0.1866           0.2416
2      1709.0            0.1444             0.4245           0.4504
3       567.7            0.2098             0.8663           0.6869
4      1575.0            0.1374             0.2050           0.4000

   concave points_worst  symmetry_worst  fractal_dimension_worst
0                0.2654          0.4601                  0.11890
1                0.1860          0.2750                  0.08902
2                0.2430          0.3613                  0.08758
3                0.2575          0.6638                  0.17300
4                0.1625          0.2364                  0.07678

[5 rows x 31 columns]
```

[34]:

```python
df['diagnosis'] = df['diagnosis'].map({'M':1, 'B':0})
```

[35]:

```python
df.head()
```

[35]:

```
   diagnosis  radius_mean  texture_mean  perimeter_mean  area_mean  \
0          1        17.99         10.38          122.80     1001.0
1          1        20.57         17.77          132.90     1326.0
2          1        19.69         21.25          130.00     1203.0
3          1        11.42         20.38           77.58      386.1
4          1        20.29         14.34          135.10     1297.0

   smoothness_mean  compactness_mean  concavity_mean  concave points_mean  \
0          0.11840           0.27760          0.3001              0.14710
1          0.08474           0.07864          0.0869              0.07017
2          0.10960           0.15990          0.1974              0.12790
3          0.14250           0.28390          0.2414              0.10520
4          0.10030           0.13280          0.1980              0.10430

   symmetry_mean  …  radius_worst  texture_worst  perimeter_worst  \
0         0.2419  …         25.38          17.33           184.60
```

```
1         0.1812  …         24.99          23.41           158.80
2         0.2069  …         23.57          25.53           152.50
3         0.2597  …         14.91          26.50            98.87
4         0.1809  …         22.54          16.67           152.20

   area_worst  smoothness_worst  compactness_worst  concavity_worst  \
0      2019.0            0.1622             0.6656           0.7119
1      1956.0            0.1238             0.1866           0.2416
2      1709.0            0.1444             0.4245           0.4504
3       567.7            0.2098             0.8663           0.6869
4      1575.0            0.1374             0.2050           0.4000

   concave points_worst  symmetry_worst  fractal_dimension_worst
0                0.2654          0.4601                  0.11890
1                0.1860          0.2750                  0.08902
2                0.2430          0.3613                  0.08758
3                0.2575          0.6638                  0.17300
4                0.1625          0.2364                  0.07678

[5 rows x 31 columns]
```

[36]:

```python
df['diagnosis'].unique()
```

[36]:

```
array([1, 0], dtype=int64)
```

[37]:

```python
X = df.drop('diagnosis', axis=1)
X.head()
```

[37]:

```
   radius_mean  texture_mean  perimeter_mean  area_mean  smoothness_mean  \
0        17.99         10.38          122.80     1001.0          0.11840
1        20.57         17.77          132.90     1326.0          0.08474
2        19.69         21.25          130.00     1203.0          0.10960
3        11.42         20.38           77.58      386.1          0.14250
4        20.29         14.34          135.10     1297.0          0.10030

   compactness_mean  concavity_mean  concave points_mean  symmetry_mean  \
0           0.27760          0.3001              0.14710         0.2419
1           0.07864          0.0869              0.07017         0.1812
2           0.15990          0.1974              0.12790         0.2069
3           0.28390          0.2414              0.10520         0.2597
4           0.13280          0.1980              0.10430         0.1809

   fractal_dimension_mean  …  radius_worst  texture_worst  perimeter_worst  \
0                 0.07871  …         25.38          17.33           184.60
1                 0.05667  …         24.99          23.41           158.80
2                 0.05999  …         23.57          25.53           152.50
3                 0.09744  …         14.91          26.50            98.87
```

```
4                 0.05883  …         22.54          16.67           152.20

   area_worst  smoothness_worst  compactness_worst  concavity_worst  \
0      2019.0            0.1622             0.6656           0.7119
1      1956.0            0.1238             0.1866           0.2416
2      1709.0            0.1444             0.4245           0.4504
3       567.7            0.2098             0.8663           0.6869
4      1575.0            0.1374             0.2050           0.4000

   concave points_worst  symmetry_worst  fractal_dimension_worst
0                0.2654          0.4601                  0.11890
1                0.1860          0.2750                  0.08902
2                0.2430          0.3613                  0.08758
3                0.2575          0.6638                  0.17300
4                0.1625          0.2364                  0.07678

[5 rows x 30 columns]
```

[38]:

```
y = df['diagnosis']
y.head()
```

[38]:

```
0    1
1    1
2    1
3    1
4    1
Name: diagnosis, dtype: int64
```

[39]:

```
from sklearn.model_selection import train_test_split
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.3)
```

[43]:

```
df.shape
```

[43]:

```
(569, 31)
```

[41]:

```
X_train.shape
```

[41]:

```
(398, 30)
```

[42]:

```
X_test.shape
```

[42]:

```
(171, 30)
```

[44]:

```
y_train.shape
```

[44]:

```
(398,)
```

```
[45]: y_test.shape
```

```
[45]: (171,)
```

```
[46]: X_train.head(1)
```

```
[46]:      radius_mean  texture_mean  perimeter_mean  area_mean  smoothness_mean  \
347        14.76         14.74           94.87      668.7          0.08875

     compactness_mean  concavity_mean  concave points_mean  symmetry_mean  \
347            0.0778         0.04608              0.03528         0.1521

     fractal_dimension_mean  …  radius_worst  texture_worst  \
347                 0.05912  …         17.27          17.93

     perimeter_worst  area_worst  smoothness_worst  compactness_worst  \
347            114.2       880.8             0.122             0.2009

     concavity_worst  concave points_worst  symmetry_worst  \
347           0.2151                0.1251          0.3109

     fractal_dimension_worst
347                  0.08187

[1 rows x 30 columns]
```

```
[47]: from sklearn.preprocessing import StandardScaler
      ss = StandardScaler()
      X_train = ss.fit_transform(X_train)
      X_test = ss.transform(X_test)
```

```
[48]: X_train
```

```
[48]: array([[ 0.18305557, -1.06191772,  0.12373402, …,  0.20236068,
               0.40015948, -0.07470951],
             [ 0.2747421 ,  1.46055891,  0.25370283, …,  0.629684  ,
              -0.36737939,  0.65877068],
             [-0.81690059, -1.4701003 , -0.77774297, …,  0.30647218,
               0.79489376,  0.52802241],
             …,
             [ 1.06840358, -1.40818497,  0.94299431, …, -0.44546146,
              -1.8366681 , -1.43261527],
             [ 0.83918727, -0.06668603,  0.89316601, …,  2.2100033 ,
               0.40015948,  0.43772989],
             [ 1.13430327,  0.56622629,  1.05926034, …, -0.31493361,
              -0.8481455 , -1.0298168 ]])
```

2 Machine Learning Models

3 Logistic Regression

```
[49]: from sklearn.linear_model import LogisticRegression
      lr = LogisticRegression()
      lr.fit(X_train, y_train)
```

```
[49]: LogisticRegression()
```

```
[50]: y_pred = lr.predict(X_test)
```

```
[51]: y_pred
```

```
[51]: array([0, 0, 1, 0, 1, 1, 0, 1, 0, 0, 0, 0, 1, 0, 0, 0, 1, 0, 0, 0, 1, 1,
             0, 1, 1, 1, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 1, 0, 0, 0, 0, 1, 0,
             1, 1, 0, 1, 0, 1, 0, 0, 0, 0, 0, 0, 1, 1, 0, 0, 0, 1, 1, 1, 0, 1,
             0, 0, 1, 1, 1, 0, 0, 1, 0, 1, 1, 0, 0, 0, 0, 1, 1, 1, 0, 0, 1, 0,
             0, 0, 1, 0, 0, 1, 0, 0, 1, 0, 1, 0, 0, 1, 1, 1, 0, 1, 0, 1, 0, 1,
             0, 1, 1, 1, 0, 0, 0, 0, 0, 1, 1, 1, 1, 1, 0, 0, 0, 0, 0, 1, 0, 1,
             0, 1, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 1, 1, 0,
             0, 1, 0, 1, 0, 1, 0, 1, 0, 0, 1, 1, 0, 0, 1, 0, 0], dtype=int64)
```

```
[53]: y_test
```

```
[53]: 378    0
      106    0
      567    1
      354    0
      521    1
            ..
      426    0
      312    0
      95     1
      232    0
      427    0
      Name: diagnosis, Length: 171, dtype: int64
```

```
[54]: from sklearn.metrics import accuracy_score
      print(accuracy_score(y_test, y_pred))
```

```
0.9824561403508771
```

```
[56]: lr_acc = accuracy_score(y_test, y_pred)
      print(lr_acc)
```

```
0.9824561403508771
```

```
[55]: results = pd.DataFrame()
      results
```

```
[55]: Empty DataFrame
      Columns: []
      Index: []
```

```
[57]: tempResults = pd.DataFrame({'Algorithm':['Logistic Regression Method'],␣
       ↪'Accuracy':[lr_acc]})
      results = pd.concat( [results, tempResults] )
      results = results[['Algorithm','Accuracy']]
      results
```

```
[57]:                     Algorithm  Accuracy
      0  Logistic Regression Method  0.982456
```

4 Decision Tree Classifier

```
[58]: from sklearn.tree import DecisionTreeClassifier
      dtc = DecisionTreeClassifier()
      dtc.fit(X_train, y_train)
```

```
[58]: DecisionTreeClassifier()
```

```
[59]: y_pred = dtc.predict(X_test)
      y_pred
```

```
[59]: array([0, 0, 1, 0, 1, 1, 0, 1, 0, 0, 0, 0, 1, 0, 0, 0, 1, 0, 0, 0, 1, 1,
             0, 1, 1, 1, 0, 0, 0, 0, 0, 1, 0, 0, 1, 0, 0, 1, 0, 1, 0, 0, 1, 0,
             1, 1, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 1, 1, 0, 0, 0, 0, 1, 0, 1, 1,
             1, 0, 0, 1, 1, 1, 0, 1, 0, 1, 1, 0, 0, 1, 0, 1, 1, 1, 0, 0, 1, 0,
             0, 0, 1, 0, 0, 1, 0, 0, 1, 0, 1, 0, 0, 1, 1, 1, 0, 1, 0, 1, 0, 1,
             0, 1, 1, 1, 0, 0, 1, 0, 0, 1, 1, 1, 1, 1, 0, 0, 0, 0, 1, 1, 0, 0,
             0, 1, 0, 0, 0, 0, 1, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 1, 0, 1, 1, 0,
             0, 1, 0, 1, 0, 1, 0, 1, 0, 0, 1, 1, 0, 0, 1, 0, 0], dtype=int64)
```

```
[60]: from sklearn.metrics import accuracy_score
      print(accuracy_score(y_test, y_pred))
```

```
0.9005847953216374
```

```
[61]: dtc_acc = accuracy_score(y_test, y_pred)
      print(dtc_acc)
```

```
0.9005847953216374
```

[62]:
```
tempResults = pd.DataFrame({'Algorithm':['Decision tree Classifier Method'],␣
 ↪'Accuracy':[dtc_acc]})
results = pd.concat( [results, tempResults] )
results = results[['Algorithm','Accuracy']]
results
```

[62]:
```
                         Algorithm  Accuracy
0       Logistic Regression Method  0.982456
0  Decision tree Classifier Method  0.900585
```

5 Random Forest Classifier

[63]:
```
from sklearn.ensemble import RandomForestClassifier
rfc = RandomForestClassifier()
rfc.fit(X_train, y_train)
```

[63]:
```
RandomForestClassifier()
```

[64]:
```
y_pred = rfc.predict(X_test)
y_pred
```

[64]:
```
array([0, 0, 1, 0, 1, 1, 0, 1, 0, 0, 0, 0, 1, 0, 0, 0, 1, 0, 0, 0, 1, 0,
       0, 1, 1, 1, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 1, 0, 1, 0, 0, 1, 0,
       1, 1, 1, 0, 0, 1, 0, 0, 0, 0, 0, 0, 1, 1, 0, 0, 0, 0, 1, 0, 0, 1,
       1, 0, 1, 1, 1, 0, 0, 1, 0, 1, 1, 0, 0, 0, 0, 1, 1, 1, 0, 0, 1, 0,
       0, 0, 1, 0, 0, 1, 0, 0, 1, 0, 1, 0, 0, 1, 1, 1, 0, 1, 0, 1, 0, 1,
       0, 1, 1, 1, 1, 0, 0, 0, 0, 1, 1, 1, 1, 1, 0, 0, 0, 0, 0, 1, 0, 1,
       0, 1, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 1, 1, 0,
       0, 1, 0, 1, 0, 1, 0, 1, 0, 0, 1, 1, 0, 0, 1, 0, 0], dtype=int64)
```

[65]:
```
from sklearn.metrics import accuracy_score
print(accuracy_score(y_test, y_pred))
```

```
0.9590643274853801
```

[66]:
```
rfc_acc = accuracy_score(y_test, y_pred)
print(rfc_acc)
```

```
0.9590643274853801
```

[67]:
```
tempResults = pd.DataFrame({'Algorithm':['Random Forest Classifier Method'],␣
 ↪'Accuracy':[rfc_acc]})
results = pd.concat( [results, tempResults] )
results = results[['Algorithm','Accuracy']]
results
```

```
[67]:                              Algorithm  Accuracy
      0        Logistic Regression Method  0.982456
      0  Decision tree Classifier Method  0.900585
      0  Random Forest Classifier Method  0.959064
```

6 Support Vector Classifier

```
[68]: from sklearn import svm
      svc = svm.SVC()
      svc.fit(X_train,y_train)
```

```
[68]: SVC()
```

```
[69]: y_pred = svc.predict(X_test)
      y_pred
```

```
[69]: array([0, 0, 1, 0, 1, 1, 0, 1, 0, 0, 0, 0, 1, 0, 0, 0, 1, 0, 0, 0, 1, 1,
             0, 1, 1, 1, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 1, 0, 0, 0, 0, 1, 0,
             1, 1, 1, 1, 0, 1, 0, 0, 0, 0, 0, 0, 1, 1, 0, 0, 0, 1, 1, 1, 0, 1,
             1, 0, 1, 1, 1, 0, 0, 1, 0, 1, 1, 0, 0, 0, 0, 1, 1, 1, 0, 0, 1, 0,
             0, 0, 1, 0, 0, 1, 0, 0, 1, 0, 1, 0, 0, 1, 1, 1, 0, 1, 0, 1, 0, 1,
             0, 1, 1, 0, 0, 0, 0, 0, 0, 1, 1, 1, 1, 1, 0, 0, 0, 0, 0, 1, 0, 1,
             0, 1, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 1, 1, 0,
             0, 1, 0, 1, 0, 1, 0, 1, 0, 0, 1, 1, 0, 0, 1, 0, 0], dtype=int64)
```

```
[70]: from sklearn.metrics import accuracy_score
      print(accuracy_score(y_test, y_pred))
```

```
0.9766081871345029
```

```
[71]: svc_acc = accuracy_score(y_test, y_pred)
      print(svc_acc)
```

```
0.9766081871345029
```

```
[72]: tempResults = pd.DataFrame({'Algorithm':['Support Vector Classifier Method'],␣
       ↪'Accuracy':[svc_acc]})
      results = pd.concat( [results, tempResults] )
      results = results[['Algorithm','Accuracy']]
      results
```

```
[72]:                              Algorithm  Accuracy
      0        Logistic Regression Method  0.982456
      0   Decision tree Classifier Method  0.900585
      0   Random Forest Classifier Method  0.959064
      0  Support Vector Classifier Method  0.976608
```

```
[ ]:
```