# Breast Cancer Detection

December 22, 2020

## 1 Breast Cancer Detection

Sample machine learning application, which predicts whether a patient has breast cancer.

[ ]:

[1]:
```
from sklearn import preprocessing
from sklearn.model_selection import train_test_split
from sklearn.metrics import classification_report
from sklearn.metrics import accuracy_score
from pandas.plotting import scatter_matrix
%matplotlib inline
import matplotlib.pyplot as plt
import pandas as pd
import numpy as np
import seaborn as sns
```

[ ]:

[ ]:

### 1.1 Obtain Data

[2]:
```
url = "https://archive.ics.uci.edu/ml/machine-learning-databases/
 ↪breast-cancer-wisconsin/wdbc.data"
names = ['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']
df = pd.read_csv(url, names=names)
```

[ ]:

[ ]:

## 1.2 Understand, Clean and Transform Data

[4]:
```
df.shape
```

[4]:
```
(569, 33)
```

[ ]:
```

```

[ ]:
```

```

[5]:
```
df.head()
```

[5]:
```
         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]
```

[ ]:
```

```

[ ]:

[6]:
```
df.describe()
```

[6]:
```
                id  radius_mean  texture_mean  perimeter_mean    area_mean  \
count  5.690000e+02   569.000000    569.000000      569.000000   569.000000
mean   3.037183e+07    14.127292     19.289649       91.969033   654.889104
std    1.250206e+08     3.524049      4.301036       24.298981   351.914129
min    8.670000e+03     6.981000      9.710000       43.790000   143.500000
25%    8.692180e+05    11.700000     16.170000       75.170000   420.300000
50%    9.060240e+05    13.370000     18.840000       86.240000   551.100000
75%    8.813129e+06    15.780000     21.800000      104.100000   782.700000
max    9.113205e+08    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  ...  texture_worst  perimeter_worst   area_worst  \
count     569.000000  ...     569.000000       569.000000   569.000000
mean        0.181162  ...      25.677223       107.261213   880.583128
std         0.027414  ...       6.146258        33.602542   569.356993
min         0.106000  ...      12.020000        50.410000   185.200000
25%         0.161900  ...      21.080000        84.110000   515.300000
50%         0.179200  ...      25.410000        97.660000   686.500000
75%         0.195700  ...      29.720000       125.400000  1084.000000
max         0.304000  ...      49.540000       251.200000  4254.000000

       smoothness_worst  compactness_worst  concavity_worst  \
count        569.000000         569.000000       569.000000
mean           0.132369           0.254265         0.272188
std            0.022832           0.157336         0.208624
min            0.071170           0.027290         0.000000
25%            0.116600           0.147200         0.114500
50%            0.131300           0.211900         0.226700
75%            0.146000           0.339100         0.382900
max            0.222600           1.058000         1.252000

       concave points_worst  symmetry_worst  fractal_dimension_worst  \
count            569.000000      569.000000               569.000000
mean               0.114606        0.290076                 0.083946
std                0.065732        0.061867                 0.018061
```

```
min                 0.000000        0.156500                 0.055040
25%                 0.064930        0.250400                 0.071460
50%                 0.099930        0.282200                 0.080040
75%                 0.161400        0.317900                 0.092080
max                 0.291000        0.663800                 0.207500

       Unnamed: 32
count          0.0
mean           NaN
std            NaN
min            NaN
25%            NaN
50%            NaN
75%            NaN
max            NaN

[8 rows x 32 columns]
```

[ ]:

[ ]:

[7]:
```
# id column has no use for machine learning
df.drop(['id'], 1, inplace=True)
```

[ ]:

[8]:
```
#Drop the column with all missing values (na, NAN, NaN)
df = df.dropna(axis=1)
```

[ ]:

[9]:
```
df.shape
```

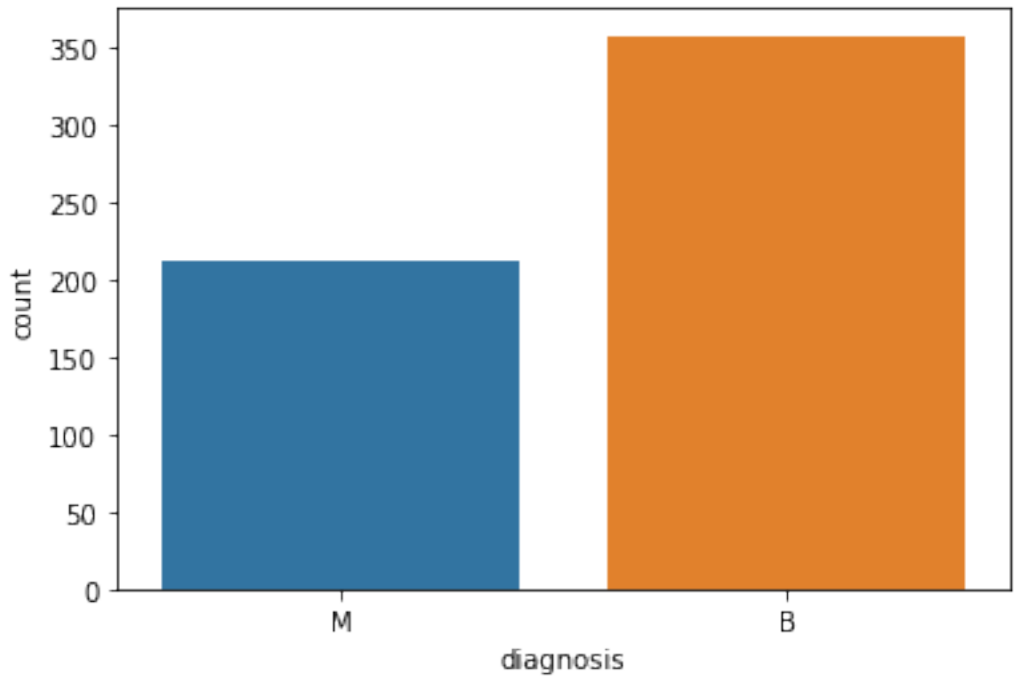
[9]:
```
(569, 31)
```

[ ]:

[ ]:

[10]:
```
#Visualize diagnosis counts
sns.countplot(df['diagnosis'], label="Count")
```

[10]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x1092035c0>
```




[ ]:

[48]:
```
df['diagnosis'].value_counts()
```

[48]:
```
B    357
M    212
Name: diagnosis, dtype: int64
```

[ ]:

[11]:
```
#Transform/Encode the column diagnosis
#Change all 'M' to 1 and all 'B' to 0 in the diagnosis col
dictionary = {'M':1, 'B':0}
df.diagnosis = [dictionary[item] for item in df.diagnosis]
```

[ ]:

[ ]:

[50]:
```
df.head()
```

[50]:
```
   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  \
0         0.2419           ...                    25.38          17.33
1         0.1812           ...                    24.99          23.41
2         0.2069           ...                    23.57          25.53
3         0.2597           ...                    14.91          26.50
4         0.1809           ...                    22.54          16.67

   perimeter_worst  area_worst  smoothness_worst  compactness_worst  \
0           184.60      2019.0            0.1622             0.6656
1           158.80      1956.0            0.1238             0.1866
2           152.50      1709.0            0.1444             0.4245
3            98.87       567.7            0.2098             0.8663
4           152.20      1575.0            0.1374             0.2050

   concavity_worst  concave points_worst  symmetry_worst  \
0           0.7119                0.2654          0.4601
1           0.2416                0.1860          0.2750
2           0.4504                0.2430          0.3613
3           0.6869                0.2575          0.6638
4           0.4000                0.1625          0.2364

   fractal_dimension_worst
0                  0.11890
1                  0.08902
2                  0.08758
3                  0.17300
4                  0.07678

[5 rows x 31 columns]
```

[ ]:

```
```

[12]:

```
#Get the correlation of the columns
df.corr()
```

[12]:

```
                         diagnosis  radius_mean  texture_mean  perimeter_mean  \
diagnosis                 1.000000     0.730029      0.415185        0.742636
radius_mean               0.730029     1.000000      0.323782        0.997855
texture_mean              0.415185     0.323782      1.000000        0.329533
perimeter_mean            0.742636     0.997855      0.329533        1.000000
area_mean                 0.708984     0.987357      0.321086        0.986507
smoothness_mean           0.358560     0.170581     -0.023389        0.207278
```

| | | | | |
|---|---|---|---|---|
| compactness_mean | 0.596534 | 0.506124 | 0.236702 | 0.556936 |
| concavity_mean | 0.696360 | 0.676764 | 0.302418 | 0.716136 |
| concave points_mean | 0.776614 | 0.822529 | 0.293464 | 0.850977 |
| symmetry_mean | 0.330499 | 0.147741 | 0.071401 | 0.183027 |
| fractal_dimension_mean | -0.012838 | -0.311631 | -0.076437 | -0.261477 |
| radius_se | 0.567134 | 0.679090 | 0.275869 | 0.691765 |
| texture_se | -0.008303 | -0.097317 | 0.386358 | -0.086761 |
| perimeter_se | 0.556141 | 0.674172 | 0.281673 | 0.693135 |
| area_se | 0.548236 | 0.735864 | 0.259845 | 0.744983 |
| smoothness_se | -0.067016 | -0.222600 | 0.006614 | -0.202694 |
| compactness_se | 0.292999 | 0.206000 | 0.191975 | 0.250744 |
| concavity_se | 0.253730 | 0.194204 | 0.143293 | 0.228082 |
| concave points_se | 0.408042 | 0.376169 | 0.163851 | 0.407217 |
| symmetry_se | -0.006522 | -0.104321 | 0.009127 | -0.081629 |
| fractal_dimension_se | 0.077972 | -0.042641 | 0.054458 | -0.005523 |
| radius_worst | 0.776454 | 0.969539 | 0.352573 | 0.969476 |
| texture_worst | 0.456903 | 0.297008 | 0.912045 | 0.303038 |
| perimeter_worst | 0.782914 | 0.965137 | 0.358040 | 0.970387 |
| area_worst | 0.733825 | 0.941082 | 0.343546 | 0.941550 |
| smoothness_worst | 0.421465 | 0.119616 | 0.077503 | 0.150549 |
| compactness_worst | 0.590998 | 0.413463 | 0.277830 | 0.455774 |
| concavity_worst | 0.659610 | 0.526911 | 0.301025 | 0.563879 |
| concave points_worst | 0.793566 | 0.744214 | 0.295316 | 0.771241 |
| symmetry_worst | 0.416294 | 0.163953 | 0.105008 | 0.189115 |
| fractal_dimension_worst | 0.323872 | 0.007066 | 0.119205 | 0.051019 |

| | area_mean | smoothness_mean | compactness_mean | \ |
|---|---|---|---|---|
| diagnosis | 0.708984 | 0.358560 | 0.596534 | |
| radius_mean | 0.987357 | 0.170581 | 0.506124 | |
| texture_mean | 0.321086 | -0.023389 | 0.236702 | |
| perimeter_mean | 0.986507 | 0.207278 | 0.556936 | |
| area_mean | 1.000000 | 0.177028 | 0.498502 | |
| smoothness_mean | 0.177028 | 1.000000 | 0.659123 | |
| compactness_mean | 0.498502 | 0.659123 | 1.000000 | |
| concavity_mean | 0.685983 | 0.521984 | 0.883121 | |
| concave points_mean | 0.823269 | 0.553695 | 0.831135 | |
| symmetry_mean | 0.151293 | 0.557775 | 0.602641 | |
| fractal_dimension_mean | -0.283110 | 0.584792 | 0.565369 | |
| radius_se | 0.732562 | 0.301467 | 0.497473 | |
| texture_se | -0.066280 | 0.068406 | 0.046205 | |
| perimeter_se | 0.726628 | 0.296092 | 0.548905 | |
| area_se | 0.800086 | 0.246552 | 0.455653 | |
| smoothness_se | -0.166777 | 0.332375 | 0.135299 | |
| compactness_se | 0.212583 | 0.318943 | 0.738722 | |
| concavity_se | 0.207660 | 0.248396 | 0.570517 | |
| concave points_se | 0.372320 | 0.380676 | 0.642262 | |
| symmetry_se | -0.072497 | 0.200774 | 0.229977 | |

| | | | |
|---|---|---|---|
| fractal_dimension_se | -0.019887 | 0.283607 | 0.507318 |
| radius_worst | 0.962746 | 0.213120 | 0.535315 |
| texture_worst | 0.287489 | 0.036072 | 0.248133 |
| perimeter_worst | 0.959120 | 0.238853 | 0.590210 |
| area_worst | 0.959213 | 0.206718 | 0.509604 |
| smoothness_worst | 0.123523 | 0.805324 | 0.565541 |
| compactness_worst | 0.390410 | 0.472468 | 0.865809 |
| concavity_worst | 0.512606 | 0.434926 | 0.816275 |
| concave points_worst | 0.722017 | 0.503053 | 0.815573 |
| symmetry_worst | 0.143570 | 0.394309 | 0.510223 |
| fractal_dimension_worst | 0.003738 | 0.499316 | 0.687382 |

| | concavity_mean | concave points_mean | symmetry_mean | \ |
|---|---|---|---|---|
| diagnosis | 0.696360 | 0.776614 | 0.330499 | |
| radius_mean | 0.676764 | 0.822529 | 0.147741 | |
| texture_mean | 0.302418 | 0.293464 | 0.071401 | |
| perimeter_mean | 0.716136 | 0.850977 | 0.183027 | |
| area_mean | 0.685983 | 0.823269 | 0.151293 | |
| smoothness_mean | 0.521984 | 0.553695 | 0.557775 | |
| compactness_mean | 0.883121 | 0.831135 | 0.602641 | |
| concavity_mean | 1.000000 | 0.921391 | 0.500667 | |
| concave points_mean | 0.921391 | 1.000000 | 0.462497 | |
| symmetry_mean | 0.500667 | 0.462497 | 1.000000 | |
| fractal_dimension_mean | 0.336783 | 0.166917 | 0.479921 | |
| radius_se | 0.631925 | 0.698050 | 0.303379 | |
| texture_se | 0.076218 | 0.021480 | 0.128053 | |
| perimeter_se | 0.660391 | 0.710650 | 0.313893 | |
| area_se | 0.617427 | 0.690299 | 0.223970 | |
| smoothness_se | 0.098564 | 0.027653 | 0.187321 | |
| compactness_se | 0.670279 | 0.490424 | 0.421659 | |
| concavity_se | 0.691270 | 0.439167 | 0.342627 | |
| concave points_se | 0.683260 | 0.615634 | 0.393298 | |
| symmetry_se | 0.178009 | 0.095351 | 0.449137 | |
| fractal_dimension_se | 0.449301 | 0.257584 | 0.331786 | |
| radius_worst | 0.688236 | 0.830318 | 0.185728 | |
| texture_worst | 0.299879 | 0.292752 | 0.090651 | |
| perimeter_worst | 0.729565 | 0.855923 | 0.219169 | |
| area_worst | 0.675987 | 0.809630 | 0.177193 | |
| smoothness_worst | 0.448822 | 0.452753 | 0.426675 | |
| compactness_worst | 0.754968 | 0.667454 | 0.473200 | |
| concavity_worst | 0.884103 | 0.752399 | 0.433721 | |
| concave points_worst | 0.861323 | 0.910155 | 0.430297 | |
| symmetry_worst | 0.409464 | 0.375744 | 0.699826 | |
| fractal_dimension_worst | 0.514930 | 0.368661 | 0.438413 | |

| | ... | radius_worst | texture_worst | perimeter_worst | \ |
|---|---|---|---|---|---|
| diagnosis | ... | 0.776454 | 0.456903 | 0.782914 | |

| | | | | |
|---|---|---|---|---|
| radius_mean | ... | 0.969539 | 0.297008 | 0.965137 |
| texture_mean | ... | 0.352573 | 0.912045 | 0.358040 |
| perimeter_mean | ... | 0.969476 | 0.303038 | 0.970387 |
| area_mean | ... | 0.962746 | 0.287489 | 0.959120 |
| smoothness_mean | ... | 0.213120 | 0.036072 | 0.238853 |
| compactness_mean | ... | 0.535315 | 0.248133 | 0.590210 |
| concavity_mean | ... | 0.688236 | 0.299879 | 0.729565 |
| concave points_mean | ... | 0.830318 | 0.292752 | 0.855923 |
| symmetry_mean | ... | 0.185728 | 0.090651 | 0.219169 |
| fractal_dimension_mean | ... | -0.253691 | -0.051269 | -0.205151 |
| radius_se | ... | 0.715065 | 0.194799 | 0.719684 |
| texture_se | ... | -0.111690 | 0.409003 | -0.102242 |
| perimeter_se | ... | 0.697201 | 0.200371 | 0.721031 |
| area_se | ... | 0.757373 | 0.196497 | 0.761213 |
| smoothness_se | ... | -0.230691 | -0.074743 | -0.217304 |
| compactness_se | ... | 0.204607 | 0.143003 | 0.260516 |
| concavity_se | ... | 0.186904 | 0.100241 | 0.226680 |
| concave points_se | ... | 0.358127 | 0.086741 | 0.394999 |
| symmetry_se | ... | -0.128121 | -0.077473 | -0.103753 |
| fractal_dimension_se | ... | -0.037488 | -0.003195 | -0.001000 |
| radius_worst | ... | 1.000000 | 0.359921 | 0.993708 |
| texture_worst | ... | 0.359921 | 1.000000 | 0.365098 |
| perimeter_worst | ... | 0.993708 | 0.365098 | 1.000000 |
| area_worst | ... | 0.984015 | 0.345842 | 0.977578 |
| smoothness_worst | ... | 0.216574 | 0.225429 | 0.236775 |
| compactness_worst | ... | 0.475820 | 0.360832 | 0.529408 |
| concavity_worst | ... | 0.573975 | 0.368366 | 0.618344 |
| concave points_worst | ... | 0.787424 | 0.359755 | 0.816322 |
| symmetry_worst | ... | 0.243529 | 0.233027 | 0.269493 |
| fractal_dimension_worst | ... | 0.093492 | 0.219122 | 0.138957 |

| | area_worst | smoothness_worst | compactness_worst | \ |
|---|---|---|---|---|
| diagnosis | 0.733825 | 0.421465 | 0.590998 | |
| radius_mean | 0.941082 | 0.119616 | 0.413463 | |
| texture_mean | 0.343546 | 0.077503 | 0.277830 | |
| perimeter_mean | 0.941550 | 0.150549 | 0.455774 | |
| area_mean | 0.959213 | 0.123523 | 0.390410 | |
| smoothness_mean | 0.206718 | 0.805324 | 0.472468 | |
| compactness_mean | 0.509604 | 0.565541 | 0.865809 | |
| concavity_mean | 0.675987 | 0.448822 | 0.754968 | |
| concave points_mean | 0.809630 | 0.452753 | 0.667454 | |
| symmetry_mean | 0.177193 | 0.426675 | 0.473200 | |
| fractal_dimension_mean | -0.231854 | 0.504942 | 0.458798 | |
| radius_se | 0.751548 | 0.141919 | 0.287103 | |
| texture_se | -0.083195 | -0.073658 | -0.092439 | |
| perimeter_se | 0.730713 | 0.130054 | 0.341919 | |
| area_se | 0.811408 | 0.125389 | 0.283257 | |

| | | | |
|---|---|---|---|
| smoothness_se | -0.182195 | 0.314457 | -0.055558 |
| compactness_se | 0.199371 | 0.227394 | 0.678780 |
| concavity_se | 0.188353 | 0.168481 | 0.484858 |
| concave points_se | 0.342271 | 0.215351 | 0.452888 |
| symmetry_se | -0.110343 | -0.012662 | 0.060255 |
| fractal_dimension_se | -0.022736 | 0.170568 | 0.390159 |
| radius_worst | 0.984015 | 0.216574 | 0.475820 |
| texture_worst | 0.345842 | 0.225429 | 0.360832 |
| perimeter_worst | 0.977578 | 0.236775 | 0.529408 |
| area_worst | 1.000000 | 0.209145 | 0.438296 |
| smoothness_worst | 0.209145 | 1.000000 | 0.568187 |
| compactness_worst | 0.438296 | 0.568187 | 1.000000 |
| concavity_worst | 0.543331 | 0.518523 | 0.892261 |
| concave points_worst | 0.747419 | 0.547691 | 0.801080 |
| symmetry_worst | 0.209146 | 0.493838 | 0.614441 |
| fractal_dimension_worst | 0.079647 | 0.617624 | 0.810455 |

| | concavity_worst | concave points_worst | \ |
|---|---|---|---|
| diagnosis | 0.659610 | 0.793566 | |
| radius_mean | 0.526911 | 0.744214 | |
| texture_mean | 0.301025 | 0.295316 | |
| perimeter_mean | 0.563879 | 0.771241 | |
| area_mean | 0.512606 | 0.722017 | |
| smoothness_mean | 0.434926 | 0.503053 | |
| compactness_mean | 0.816275 | 0.815573 | |
| concavity_mean | 0.884103 | 0.861323 | |
| concave points_mean | 0.752399 | 0.910155 | |
| symmetry_mean | 0.433721 | 0.430297 | |
| fractal_dimension_mean | 0.346234 | 0.175325 | |
| radius_se | 0.380585 | 0.531062 | |
| texture_se | -0.068956 | -0.119638 | |
| perimeter_se | 0.418899 | 0.554897 | |
| area_se | 0.385100 | 0.538166 | |
| smoothness_se | -0.058298 | -0.102007 | |
| compactness_se | 0.639147 | 0.483208 | |
| concavity_se | 0.662564 | 0.440472 | |
| concave points_se | 0.549592 | 0.602450 | |
| symmetry_se | 0.037119 | -0.030413 | |
| fractal_dimension_se | 0.379975 | 0.215204 | |
| radius_worst | 0.573975 | 0.787424 | |
| texture_worst | 0.368366 | 0.359755 | |
| perimeter_worst | 0.618344 | 0.816322 | |
| area_worst | 0.543331 | 0.747419 | |
| smoothness_worst | 0.518523 | 0.547691 | |
| compactness_worst | 0.892261 | 0.801080 | |
| concavity_worst | 1.000000 | 0.855434 | |
| concave points_worst | 0.855434 | 1.000000 | |

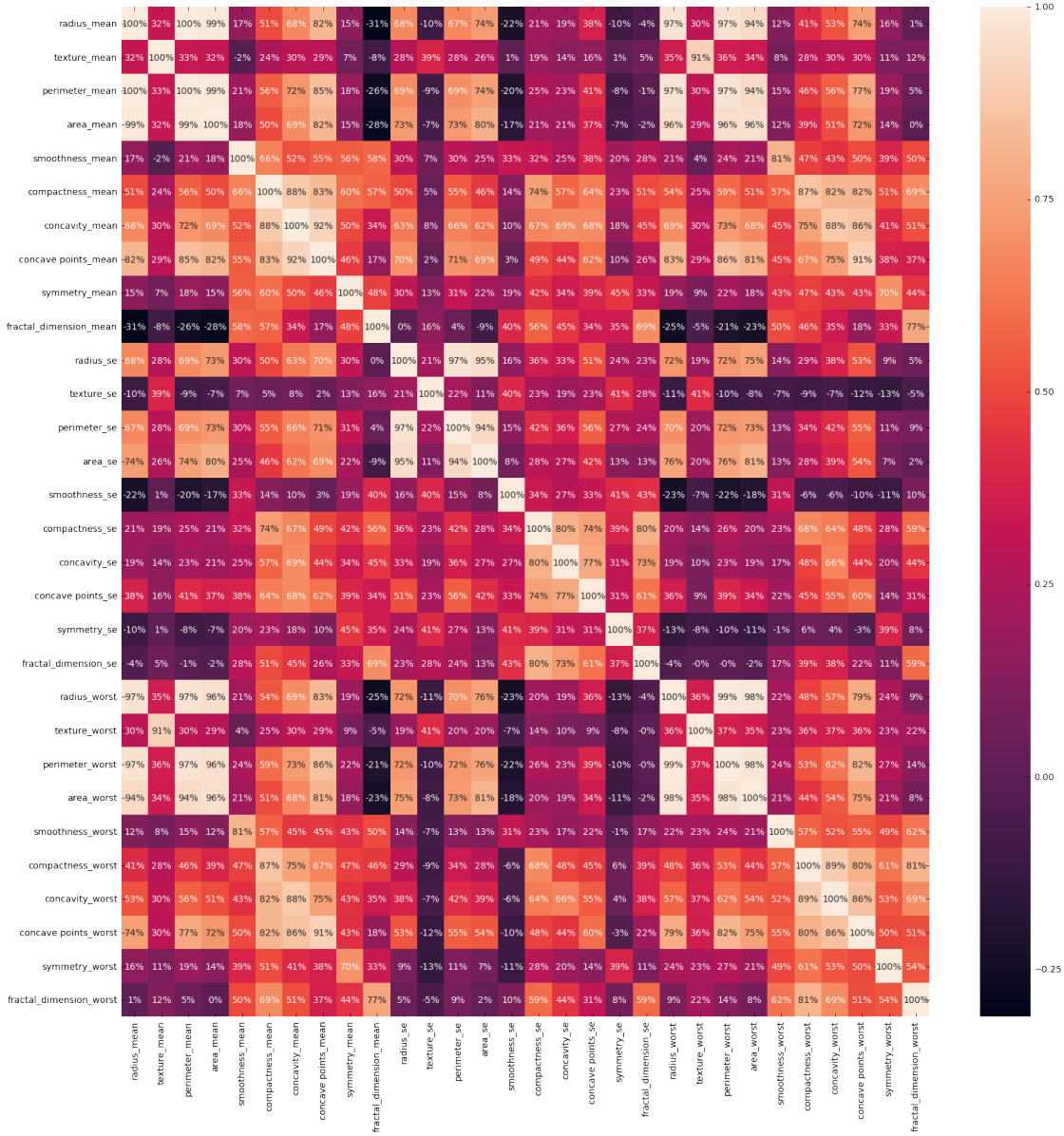
```
symmetry_worst                  0.532520              0.502528
fractal_dimension_worst         0.686511              0.511114

                         symmetry_worst  fractal_dimension_worst
diagnosis                      0.416294                 0.323872
radius_mean                    0.163953                 0.007066
texture_mean                   0.105008                 0.119205
perimeter_mean                 0.189115                 0.051019
area_mean                      0.143570                 0.003738
smoothness_mean                0.394309                 0.499316
compactness_mean               0.510223                 0.687382
concavity_mean                 0.409464                 0.514930
concave points_mean            0.375744                 0.368661
symmetry_mean                  0.699826                 0.438413
fractal_dimension_mean         0.334019                 0.767297
radius_se                      0.094543                 0.049559
texture_se                    -0.128215                -0.045655
perimeter_se                   0.109930                 0.085433
area_se                        0.074126                 0.017539
smoothness_se                 -0.107342                 0.101480
compactness_se                 0.277878                 0.590973
concavity_se                   0.197788                 0.439329
concave points_se              0.143116                 0.310655
symmetry_se                    0.389402                 0.078079
fractal_dimension_se           0.111094                 0.591328
radius_worst                   0.243529                 0.093492
texture_worst                  0.233027                 0.219122
perimeter_worst                0.269493                 0.138957
area_worst                     0.209146                 0.079647
smoothness_worst               0.493838                 0.617624
compactness_worst              0.614441                 0.810455
concavity_worst                0.532520                 0.686511
concave points_worst           0.502528                 0.511114
symmetry_worst                 1.000000                 0.537848
fractal_dimension_worst        0.537848                 1.000000

[31 rows x 31 columns]
```

[ ]:

[ ]:

[52]:
```
plt.figure(figsize=(20,20))
sns.heatmap(df.iloc[:,1:].corr(), annot=True, fmt='.0%')
```

[52]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x1a242b8d30>
```




[ ]:

```
```

## 1.3 Build a Machine Learning Model

[14]:

```
#Split the data into independent 'X' and dependent 'Y' variables
X = df.iloc[:, 1:].values
Y = df.iloc[:, 0].values  #Get the target variable 'diagnosis' located at␣
↪index=0
```

[ ]:

```
```

[15]:
```
# Split the dataset into 75% Training set and 25% Testing set
from sklearn.model_selection import train_test_split
X_train, X_test, Y_train, Y_test = train_test_split(X, Y, test_size = 0.25,␣
↪random_state = 0)
```

[ ]:
```

```

[16]:
```
#Feature Scaling
from sklearn.preprocessing import MinMaxScaler
scaler = MinMaxScaler()

scaler.fit(X_train)
X_train = scaler.transform(X_train)
X_test = scaler.transform(X_test)
```

[ ]:
```

```

### 1.4 Train/Test Your Model

[17]:
```
#Using RandomForestClassifier method of ensemble class to use Random Forest␣
↪Classification algorithm
from sklearn.ensemble import RandomForestClassifier
forest = RandomForestClassifier(n_estimators = 10, criterion = 'entropy',␣
↪random_state = 42)
forest.fit(X_train, Y_train)
```

[17]:
```
RandomForestClassifier(bootstrap=True, class_weight=None, criterion='entropy',
                       max_depth=None, max_features='auto', max_leaf_nodes=None,
                       min_impurity_decrease=0.0, min_impurity_split=None,
                       min_samples_leaf=1, min_samples_split=2,
                       min_weight_fraction_leaf=0.0, n_estimators=10,
                       n_jobs=None, oob_score=False, random_state=42, verbose=0,
                       warm_start=False)
```

[ ]:
```

```

[ ]:
```

```

[18]:
```
print('Random Forest Classifier Training Accuracy:', forest.score(X_train,␣
↪Y_train))
```

```
Random Forest Classifier Training Accuracy: 0.9953051643192489
```

[ ]:
```

```

### 1.5 Predict

[19]:
```
#Check precision, recall, f1-score
print( classification_report(Y_test, forest.predict(X_test)) )

#Another way to get the models accuracy on the test data
print( 'accuracy_score : ', accuracy_score(Y_test, forest.predict(X_test)))
```

```
              precision    recall  f1-score   support

           0       0.97      0.97      0.97        90
           1       0.94      0.94      0.94        53

    accuracy                           0.96       143
   macro avg       0.96      0.96      0.96       143
weighted avg       0.96      0.96      0.96       143

accuracy_score :  0.958041958041958
```

[ ]:

[ ]:

[ ]:

[ ]: