Breast Cancer Detection

December 30, 2019

1 Breast Cancer Detection

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

[ ]:

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

[ ]:

1.1 Obtain Data

[3]:
```
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

[ ]:

[5]:
```
df.shape
```

[5]:
```
(569, 33)
```

[ ]:

[99]:
```
df.head()
```

[99]:
```
         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]
```

[ ]:

[100]:
```
df.describe()
```

[100]:

	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]
```

[ ]:

[6]:
```
# id column has no use for machine learning
df.drop(['id'], 1, inplace=True)
```

[7]:
```
df.isnull().sum()
```

[7]:
```
diagnosis                 0
radius_mean               0
texture_mean              0
perimeter_mean            0
area_mean                 0
smoothness_mean           0
compactness_mean          0
concavity_mean            0
concave points_mean       0
symmetry_mean             0
fractal_dimension_mean    0
radius_se                 0
texture_se                0
perimeter_se              0
area_se                   0
smoothness_se             0
compactness_se            0
concavity_se              0
concave points_se         0
symmetry_se               0
fractal_dimension_se      0
radius_worst              0
texture_worst             0
perimeter_worst           0
area_worst                0
```

```
smoothness_worst             0
compactness_worst            0
concavity_worst              0
concave points_worst         0
symmetry_worst               0
fractal_dimension_worst      0
Unnamed: 32                569
dtype: int64
```

[ ]:

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

[ ]:

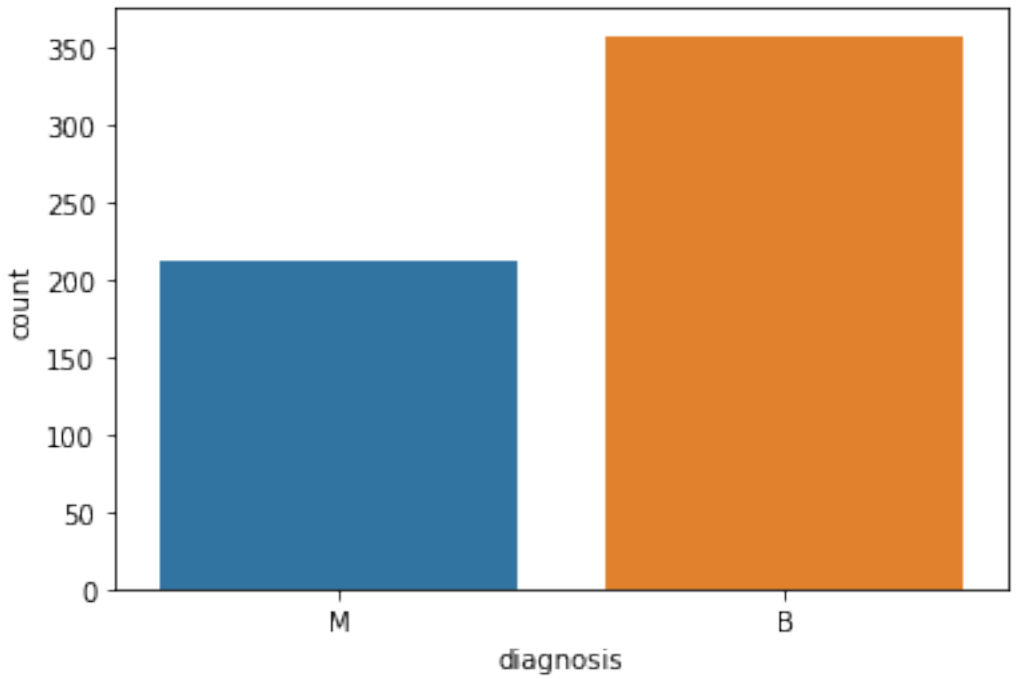
[9]:
```
df.shape
```

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

[ ]:

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

[10]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x1241090b8>
```



[ ]:

[11]:
```
df['diagnosis'].value_counts()
```

[11]:
```
B    357
M    212
Name: diagnosis, dtype: int64
```

[ ]:
```

```

[12]:
```
#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]
```

[ ]:
```

```

[13]:
```
df.head()
```

[13]:

	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]
```

[ ]:

[14]:
```
#Get the correlation of the columns
df.corr()
```

[14]:

	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

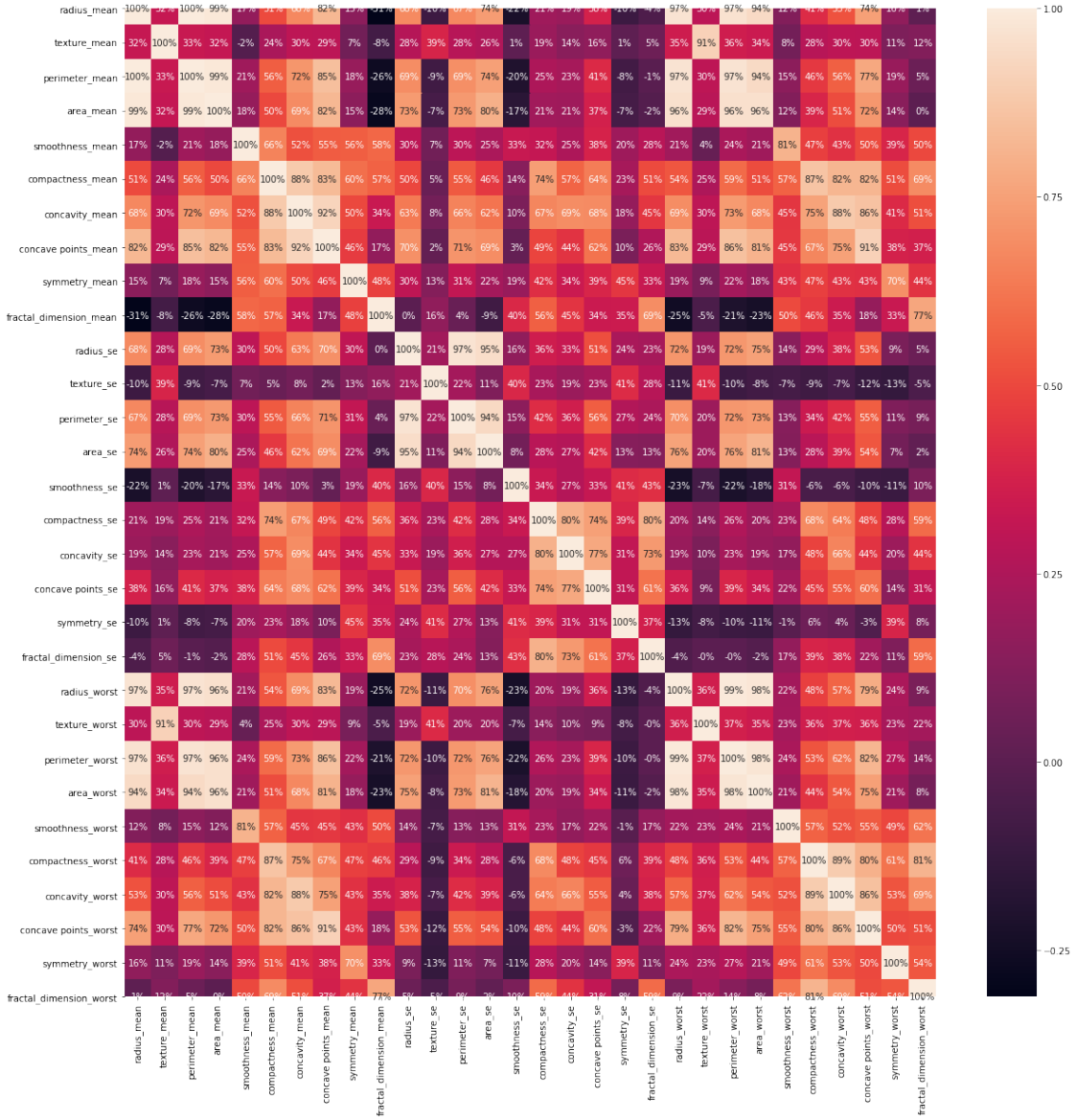
```
concave points_worst          0.502528                0.511114
symmetry_worst                1.000000                0.537848
fractal_dimension_worst       0.537848                1.000000

[31 rows x 31 columns]
```

[ ]:

[15]:
```
plt.figure(figsize=(20,20))
sns.heatmap(df.iloc[:,1:].corr(), annot=True, fmt='.0%')
```

[15]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x1096c5828>
```



[ ]:

[ ]:

1.3 Build a Machine Learning Model

[16]:
```
#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
```

[ ]:

[17]:
```
# Scale the data to bring all features to the same level of magnitude
# This means the data will be within a specific range for example 0 -100 or 0 -␣
 ↪1

#Feature Scaling
from sklearn.preprocessing import MinMaxScaler
sc = MinMaxScaler()
X = sc.fit_transform(X)
```

[ ]:

[18]:
```
# 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)
```

[ ]:

1.4 Train/Test Your Model

[19]:
```
#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)
```

[19]:
```
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)
```

[ ]:

[20]:
```
print('Random Forest Classifier Training Accuracy:', forest.score(X_train,␣
↪Y_train))
```

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

[ ]:
```

```

1.5 Predict

[21]:
```
#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
```

[ ]:
```

```