Breast_Cancer_Detection

August 1, 2021

1 Breast Cancer Detection Using Artificial Neural Networks

1.1 Importing libraries

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

1.2 Importing dataset

```
[3]: dataset=pd.read_csv('breastcancer.csv')
```

1.3 Printing the dataset

```
[0]: dataset
```

```
[0]:           id diagnosis  radius_mean  texture_mean  perimeter_mean  area_mean  \
     0     842302         M       17.990         10.38          122.80     1001.0
     1     842517         M       20.570         17.77          132.90     1326.0
     2   84300903         M       19.690         21.25          130.00     1203.0
     3   84348301         M       11.420         20.38           77.58      386.1
     4   84358402         M       20.290         14.34          135.10     1297.0
     5     843786         M       12.450         15.70           82.57      477.1
     6     844359         M       18.250         19.98          119.60     1040.0
     7   84458202         M       13.710         20.83           90.20      577.9
     8     844981         M       13.000         21.82           87.50      519.8
     9   84501001         M       12.460         24.04           83.97      475.9
     10    845636         M       16.020         23.24          102.70      797.8
     11  84610002         M       15.780         17.89          103.60      781.0
     12    846226         M       19.170         24.80          132.40     1123.0
     13    846381         M       15.850         23.95          103.70      782.7
     14  84667401         M       13.730         22.61           93.60      578.3
     15  84799002         M       14.540         27.54           96.73      658.8
     16    848406         M       14.680         20.13           94.74      684.5
     17  84862001         M       16.130         20.68          108.10      798.8
     18    849014         M       19.810         22.15          130.00     1260.0
     19   8510426         B       13.540         14.36           87.46      566.3
```

20	8510653	B	13.080	15.71	85.63	520.0
21	8510824	B	9.504	12.44	60.34	273.9
22	8511133	M	15.340	14.26	102.50	704.4
23	851509	M	21.160	23.04	137.20	1404.0
24	852552	M	16.650	21.38	110.00	904.6
25	852631	M	17.140	16.40	116.00	912.7
26	852763	M	14.580	21.53	97.41	644.8
27	852781	M	18.610	20.25	122.10	1094.0
28	852973	M	15.300	25.27	102.40	732.4
29	853201	M	17.570	15.05	115.00	955.1
..	…	…	…	…	…	…
539	921362	B	7.691	25.44	48.34	170.4
540	921385	B	11.540	14.44	74.65	402.9
541	921386	B	14.470	24.99	95.81	656.4
542	921644	B	14.740	25.42	94.70	668.6
543	922296	B	13.210	28.06	84.88	538.4
544	922297	B	13.870	20.70	89.77	584.8
545	922576	B	13.620	23.23	87.19	573.2
546	922577	B	10.320	16.35	65.31	324.9
547	922840	B	10.260	16.58	65.85	320.8
548	923169	B	9.683	19.34	61.05	285.7
549	923465	B	10.820	24.21	68.89	361.6
550	923748	B	10.860	21.48	68.51	360.5
551	923780	B	11.130	22.44	71.49	378.4
552	924084	B	12.770	29.43	81.35	507.9
553	924342	B	9.333	21.94	59.01	264.0
554	924632	B	12.880	28.92	82.50	514.3
555	924934	B	10.290	27.61	65.67	321.4
556	924964	B	10.160	19.59	64.73	311.7
557	925236	B	9.423	27.88	59.26	271.3
558	925277	B	14.590	22.68	96.39	657.1
559	925291	B	11.510	23.93	74.52	403.5
560	925292	B	14.050	27.15	91.38	600.4
561	925311	B	11.200	29.37	70.67	386.0
562	925622	M	15.220	30.62	103.40	716.9
563	926125	M	20.920	25.09	143.00	1347.0
564	926424	M	21.560	22.39	142.00	1479.0
565	926682	M	20.130	28.25	131.20	1261.0
566	926954	M	16.600	28.08	108.30	858.1
567	927241	M	20.600	29.33	140.10	1265.0
568	92751	B	7.760	24.54	47.92	181.0

	smoothness_mean	compactness_mean	concavity_mean	concave points_mean \
0	0.11840	0.27760	0.300100	0.147100
1	0.08474	0.07864	0.086900	0.070170
2	0.10960	0.15990	0.197400	0.127900
3	0.14250	0.28390	0.241400	0.105200

4	0.10030	0.13280	0.198000	0.104300
5	0.12780	0.17000	0.157800	0.080890
6	0.09463	0.10900	0.112700	0.074000
7	0.11890	0.16450	0.093660	0.059850
8	0.12730	0.19320	0.185900	0.093530
9	0.11860	0.23960	0.227300	0.085430
10	0.08206	0.06669	0.032990	0.033230
11	0.09710	0.12920	0.099540	0.066060
12	0.09740	0.24580	0.206500	0.111800
13	0.08401	0.10020	0.099380	0.053640
14	0.11310	0.22930	0.212800	0.080250
15	0.11390	0.15950	0.163900	0.073640
16	0.09867	0.07200	0.073950	0.052590
17	0.11700	0.20220	0.172200	0.102800
18	0.09831	0.10270	0.147900	0.094980
19	0.09779	0.08129	0.066640	0.047810
20	0.10750	0.12700	0.045680	0.031100
21	0.10240	0.06492	0.029560	0.020760
22	0.10730	0.21350	0.207700	0.097560
23	0.09428	0.10220	0.109700	0.086320
24	0.11210	0.14570	0.152500	0.091700
25	0.11860	0.22760	0.222900	0.140100
26	0.10540	0.18680	0.142500	0.087830
27	0.09440	0.10660	0.149000	0.077310
28	0.10820	0.16970	0.168300	0.087510
29	0.09847	0.11570	0.098750	0.079530
..	…	…	…	…
539	0.08668	0.11990	0.092520	0.013640
540	0.09984	0.11200	0.067370	0.025940
541	0.08837	0.12300	0.100900	0.038900
542	0.08275	0.07214	0.041050	0.030270
543	0.08671	0.06877	0.029870	0.032750
544	0.09578	0.10180	0.036880	0.023690
545	0.09246	0.06747	0.029740	0.024430
546	0.09434	0.04994	0.010120	0.005495
547	0.08877	0.08066	0.043580	0.024380
548	0.08491	0.05030	0.023370	0.009615
549	0.08192	0.06602	0.015480	0.008160
550	0.07431	0.04227	0.000000	0.000000
551	0.09566	0.08194	0.048240	0.022570
552	0.08276	0.04234	0.019970	0.014990
553	0.09240	0.05605	0.039960	0.012820
554	0.08123	0.05824	0.061950	0.023430
555	0.09030	0.07658	0.059990	0.027380
556	0.10030	0.07504	0.005025	0.011160
557	0.08123	0.04971	0.000000	0.000000
558	0.08473	0.13300	0.102900	0.037360

```
559        0.09261          0.10210          0.111200          0.041050
560        0.09929          0.11260          0.044620          0.043040
561        0.07449          0.03558          0.000000          0.000000
562        0.10480          0.20870          0.255000          0.094290
563        0.10990          0.22360          0.317400          0.147400
564        0.11100          0.11590          0.243900          0.138900
565        0.09780          0.10340          0.144000          0.097910
566        0.08455          0.10230          0.092510          0.053020
567        0.11780          0.27700          0.351400          0.152000
568        0.05263          0.04362          0.000000          0.000000
```

		texture_worst	perimeter_worst	area_worst	smoothness_worst	\
0	…	17.33	184.60	2019.0	0.16220	
1	…	23.41	158.80	1956.0	0.12380	
2	…	25.53	152.50	1709.0	0.14440	
3	…	26.50	98.87	567.7	0.20980	
4	…	16.67	152.20	1575.0	0.13740	
5	…	23.75	103.40	741.6	0.17910	
6	…	27.66	153.20	1606.0	0.14420	
7	…	28.14	110.60	897.0	0.16540	
8	…	30.73	106.20	739.3	0.17030	
9	…	40.68	97.65	711.4	0.18530	
10	…	33.88	123.80	1150.0	0.11810	
11	…	27.28	136.50	1299.0	0.13960	
12	…	29.94	151.70	1332.0	0.10370	
13	…	27.66	112.00	876.5	0.11310	
14	…	32.01	108.80	697.7	0.16510	
15	…	37.13	124.10	943.2	0.16780	
16	…	30.88	123.40	1138.0	0.14640	
17	…	31.48	136.80	1315.0	0.17890	
18	…	30.88	186.80	2398.0	0.15120	
19	…	19.26	99.70	711.2	0.14400	
20	…	20.49	96.09	630.5	0.13120	
21	…	15.66	65.13	314.9	0.13240	
22	…	19.08	125.10	980.9	0.13900	
23	…	35.59	188.00	2615.0	0.14010	
24	…	31.56	177.00	2215.0	0.18050	
25	…	21.40	152.40	1461.0	0.15450	
26	…	33.21	122.40	896.9	0.15250	
27	…	27.26	139.90	1403.0	0.13380	
28	…	36.71	149.30	1269.0	0.16410	
29	…	19.52	134.90	1227.0	0.12550	
..	…	…	…	…	…	
539	…	31.89	54.49	223.6	0.15960	
540	…	19.68	78.78	457.8	0.13450	
541	…	31.73	113.50	808.9	0.13400	
542	…	32.29	107.40	826.4	0.10600	

543	…	37.17	92.48	629.6	0.10720
544	…	24.75	99.17	688.6	0.12640
545	…	29.09	97.58	729.8	0.12160
546	…	21.77	71.12	384.9	0.12850
547	…	22.04	71.08	357.4	0.14610
548	…	25.59	69.10	364.2	0.11990
549	…	31.45	83.90	505.6	0.12040
550	…	24.77	74.08	412.3	0.10010
551	…	28.26	77.80	436.6	0.10870
552	…	36.00	88.10	594.7	0.12340
553	…	25.05	62.86	295.8	0.11030
554	…	35.74	88.84	595.7	0.12270
555	…	34.91	69.57	357.6	0.13840
556	…	22.88	67.88	347.3	0.12650
557	…	34.24	66.50	330.6	0.10730
558	…	27.27	105.90	733.5	0.10260
559	…	37.16	82.28	474.2	0.12980
560	…	33.17	100.20	706.7	0.12410
561	…	38.30	75.19	439.6	0.09267
562	…	42.79	128.70	915.0	0.14170
563	…	29.41	179.10	1819.0	0.14070
564	…	26.40	166.10	2027.0	0.14100
565	…	38.25	155.00	1731.0	0.11660
566	…	34.12	126.70	1124.0	0.11390
567	…	39.42	184.60	1821.0	0.16500
568	…	30.37	59.16	268.6	0.08996

	compactness_worst	concavity_worst	concave points_worst	symmetry_worst \
0	0.66560	0.71190	0.26540	0.4601
1	0.18660	0.24160	0.18600	0.2750
2	0.42450	0.45040	0.24300	0.3613
3	0.86630	0.68690	0.25750	0.6638
4	0.20500	0.40000	0.16250	0.2364
5	0.52490	0.53550	0.17410	0.3985
6	0.25760	0.37840	0.19320	0.3063
7	0.36820	0.26780	0.15560	0.3196
8	0.54010	0.53900	0.20600	0.4378
9	1.05800	1.10500	0.22100	0.4366
10	0.15510	0.14590	0.09975	0.2948
11	0.56090	0.39650	0.18100	0.3792
12	0.39030	0.36390	0.17670	0.3176
13	0.19240	0.23220	0.11190	0.2809
14	0.77250	0.69430	0.22080	0.3596
15	0.65770	0.70260	0.17120	0.4218
16	0.18710	0.29140	0.16090	0.3029
17	0.42330	0.47840	0.20730	0.3706
18	0.31500	0.53720	0.23880	0.2768

19	0.17730	0.23900	0.12880	0.2977
20	0.27760	0.18900	0.07283	0.3184
21	0.11480	0.08867	0.06227	0.2450
22	0.59540	0.63050	0.23930	0.4667
23	0.26000	0.31550	0.20090	0.2822
24	0.35780	0.46950	0.20950	0.3613
25	0.39490	0.38530	0.25500	0.4066
26	0.66430	0.55390	0.27010	0.4264
27	0.21170	0.34460	0.14900	0.2341
28	0.61100	0.63350	0.20240	0.4027
29	0.28120	0.24890	0.14560	0.2756
..	…	…	…	…
539	0.30640	0.33930	0.05000	0.2790
540	0.21180	0.17970	0.06918	0.2329
541	0.42020	0.40400	0.12050	0.3187
542	0.13760	0.16110	0.10950	0.2722
543	0.13810	0.10620	0.07958	0.2473
544	0.20370	0.13770	0.06845	0.2249
545	0.15170	0.10490	0.07174	0.2642
546	0.08842	0.04384	0.02381	0.2681
547	0.22460	0.17830	0.08333	0.2691
548	0.09546	0.09350	0.03846	0.2552
549	0.16330	0.06194	0.03264	0.3059
550	0.07348	0.00000	0.00000	0.2458
551	0.17820	0.15640	0.06413	0.3169
552	0.10640	0.08653	0.06498	0.2407
553	0.08298	0.07993	0.02564	0.2435
554	0.16200	0.24390	0.06493	0.2372
555	0.17100	0.20000	0.09127	0.2226
556	0.12000	0.01005	0.02232	0.2262
557	0.07158	0.00000	0.00000	0.2475
558	0.31710	0.36620	0.11050	0.2258
559	0.25170	0.36300	0.09653	0.2112
560	0.22640	0.13260	0.10480	0.2250
561	0.05494	0.00000	0.00000	0.1566
562	0.79170	1.17000	0.23560	0.4089
563	0.41860	0.65990	0.25420	0.2929
564	0.21130	0.41070	0.22160	0.2060
565	0.19220	0.32150	0.16280	0.2572
566	0.30940	0.34030	0.14180	0.2218
567	0.86810	0.93870	0.26500	0.4087
568	0.06444	0.00000	0.00000	0.2871

	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	0.12440	NaN
6	0.08368	NaN
7	0.11510	NaN
8	0.10720	NaN
9	0.20750	NaN
10	0.08452	NaN
11	0.10480	NaN
12	0.10230	NaN
13	0.06287	NaN
14	0.14310	NaN
15	0.13410	NaN
16	0.08216	NaN
17	0.11420	NaN
18	0.07615	NaN
19	0.07259	NaN
20	0.08183	NaN
21	0.07773	NaN
22	0.09946	NaN
23	0.07526	NaN
24	0.09564	NaN
25	0.10590	NaN
26	0.12750	NaN
27	0.07421	NaN
28	0.09876	NaN
29	0.07919	NaN
..	…	…
539	0.10660	NaN
540	0.08134	NaN
541	0.10230	NaN
542	0.06956	NaN
543	0.06443	NaN
544	0.08492	NaN
545	0.06953	NaN
546	0.07399	NaN
547	0.09479	NaN
548	0.07920	NaN
549	0.07626	NaN
550	0.06592	NaN
551	0.08032	NaN
552	0.06484	NaN
553	0.07393	NaN
554	0.07242	NaN
555	0.08283	NaN
556	0.06742	NaN
557	0.06969	NaN

```
558              0.08004        NaN
559              0.08732        NaN
560              0.08321        NaN
561              0.05905        NaN
562              0.14090        NaN
563              0.09873        NaN
564              0.07115        NaN
565              0.06637        NaN
566              0.07820        NaN
567              0.12400        NaN
568              0.07039        NaN

[569 rows x 33 columns]
```

1.4 Encoding the 'diagnosis' column into 0s and 1s

```python
[0]: from sklearn.preprocessing import LabelEncoder
     encoder=LabelEncoder()
     dataset['diagnosis']=encoder.fit_transform(dataset['diagnosis'])
     dataset
```

```
[0]:          id  diagnosis  radius_mean  texture_mean  perimeter_mean  \
     0     842302          1       17.990         10.38          122.80
     1     842517          1       20.570         17.77          132.90
     2   84300903          1       19.690         21.25          130.00
     3   84348301          1       11.420         20.38           77.58
     4   84358402          1       20.290         14.34          135.10
     5     843786          1       12.450         15.70           82.57
     6     844359          1       18.250         19.98          119.60
     7   84458202          1       13.710         20.83           90.20
     8     844981          1       13.000         21.82           87.50
     9   84501001          1       12.460         24.04           83.97
     10    845636          1       16.020         23.24          102.70
     11  84610002          1       15.780         17.89          103.60
     12    846226          1       19.170         24.80          132.40
     13    846381          1       15.850         23.95          103.70
     14  84667401          1       13.730         22.61           93.60
     15  84799002          1       14.540         27.54           96.73
     16    848406          1       14.680         20.13           94.74
     17  84862001          1       16.130         20.68          108.10
     18    849014          1       19.810         22.15          130.00
     19   8510426          0       13.540         14.36           87.46
     20   8510653          0       13.080         15.71           85.63
     21   8510824          0        9.504         12.44           60.34
     22   8511133          1       15.340         14.26          102.50
     23    851509          1       21.160         23.04          137.20
     24    852552          1       16.650         21.38          110.00
```

8

25	852631	1	17.140	16.40	116.00
26	852763	1	14.580	21.53	97.41
27	852781	1	18.610	20.25	122.10
28	852973	1	15.300	25.27	102.40
29	853201	1	17.570	15.05	115.00
..	…	…	…	…	…
539	921362	0	7.691	25.44	48.34
540	921385	0	11.540	14.44	74.65
541	921386	0	14.470	24.99	95.81
542	921644	0	14.740	25.42	94.70
543	922296	0	13.210	28.06	84.88
544	922297	0	13.870	20.70	89.77
545	922576	0	13.620	23.23	87.19
546	922577	0	10.320	16.35	65.31
547	922840	0	10.260	16.58	65.85
548	923169	0	9.683	19.34	61.05
549	923465	0	10.820	24.21	68.89
550	923748	0	10.860	21.48	68.51
551	923780	0	11.130	22.44	71.49
552	924084	0	12.770	29.43	81.35
553	924342	0	9.333	21.94	59.01
554	924632	0	12.880	28.92	82.50
555	924934	0	10.290	27.61	65.67
556	924964	0	10.160	19.59	64.73
557	925236	0	9.423	27.88	59.26
558	925277	0	14.590	22.68	96.39
559	925291	0	11.510	23.93	74.52
560	925292	0	14.050	27.15	91.38
561	925311	0	11.200	29.37	70.67
562	925622	1	15.220	30.62	103.40
563	926125	1	20.920	25.09	143.00
564	926424	1	21.560	22.39	142.00
565	926682	1	20.130	28.25	131.20
566	926954	1	16.600	28.08	108.30
567	927241	1	20.600	29.33	140.10
568	92751	0	7.760	24.54	47.92

	area_mean	smoothness_mean	compactness_mean	concavity_mean \
0	1001.0	0.11840	0.27760	0.300100
1	1326.0	0.08474	0.07864	0.086900
2	1203.0	0.10960	0.15990	0.197400
3	386.1	0.14250	0.28390	0.241400
4	1297.0	0.10030	0.13280	0.198000
5	477.1	0.12780	0.17000	0.157800
6	1040.0	0.09463	0.10900	0.112700
7	577.9	0.11890	0.16450	0.093660
8	519.8	0.12730	0.19320	0.185900

9	475.9	0.11860	0.23960	0.227300
10	797.8	0.08206	0.06669	0.032990
11	781.0	0.09710	0.12920	0.099540
12	1123.0	0.09740	0.24580	0.206500
13	782.7	0.08401	0.10020	0.099380
14	578.3	0.11310	0.22930	0.212800
15	658.8	0.11390	0.15950	0.163900
16	684.5	0.09867	0.07200	0.073950
17	798.8	0.11700	0.20220	0.172200
18	1260.0	0.09831	0.10270	0.147900
19	566.3	0.09779	0.08129	0.066640
20	520.0	0.10750	0.12700	0.045680
21	273.9	0.10240	0.06492	0.029560
22	704.4	0.10730	0.21350	0.207700
23	1404.0	0.09428	0.10220	0.109700
24	904.6	0.11210	0.14570	0.152500
25	912.7	0.11860	0.22760	0.222900
26	644.8	0.10540	0.18680	0.142500
27	1094.0	0.09440	0.10660	0.149000
28	732.4	0.10820	0.16970	0.168300
29	955.1	0.09847	0.11570	0.098750
..	...	...	...	...
539	170.4	0.08668	0.11990	0.092520
540	402.9	0.09984	0.11200	0.067370
541	656.4	0.08837	0.12300	0.100900
542	668.6	0.08275	0.07214	0.041050
543	538.4	0.08671	0.06877	0.029870
544	584.8	0.09578	0.10180	0.036880
545	573.2	0.09246	0.06747	0.029740
546	324.9	0.09434	0.04994	0.010120
547	320.8	0.08877	0.08066	0.043580
548	285.7	0.08491	0.05030	0.023370
549	361.6	0.08192	0.06602	0.015480
550	360.5	0.07431	0.04227	0.000000
551	378.4	0.09566	0.08194	0.048240
552	507.9	0.08276	0.04234	0.019970
553	264.0	0.09240	0.05605	0.039960
554	514.3	0.08123	0.05824	0.061950
555	321.4	0.09030	0.07658	0.059990
556	311.7	0.10030	0.07504	0.005025
557	271.3	0.08123	0.04971	0.000000
558	657.1	0.08473	0.13300	0.102900
559	403.5	0.09261	0.10210	0.111200
560	600.4	0.09929	0.11260	0.044620
561	386.0	0.07449	0.03558	0.000000
562	716.9	0.10480	0.20870	0.255000
563	1347.0	0.10990	0.22360	0.317400

564	1479.0	0.11100	0.11590	0.243900
565	1261.0	0.09780	0.10340	0.144000
566	858.1	0.08455	0.10230	0.092510
567	1265.0	0.11780	0.27700	0.351400
568	181.0	0.05263	0.04362	0.000000

	concave points_mean	…	texture_worst	perimeter_worst	area_worst \
0	0.147100	…	17.33	184.60	2019.0
1	0.070170	…	23.41	158.80	1956.0
2	0.127900	…	25.53	152.50	1709.0
3	0.105200	…	26.50	98.87	567.7
4	0.104300	…	16.67	152.20	1575.0
5	0.080890	…	23.75	103.40	741.6
6	0.074000	…	27.66	153.20	1606.0
7	0.059850	…	28.14	110.60	897.0
8	0.093530	…	30.73	106.20	739.3
9	0.085430	…	40.68	97.65	711.4
10	0.033230	…	33.88	123.80	1150.0
11	0.066060	…	27.28	136.50	1299.0
12	0.111800	…	29.94	151.70	1332.0
13	0.053640	…	27.66	112.00	876.5
14	0.080250	…	32.01	108.80	697.7
15	0.073640	…	37.13	124.10	943.2
16	0.052590	…	30.88	123.40	1138.0
17	0.102800	…	31.48	136.80	1315.0
18	0.094980	…	30.88	186.80	2398.0
19	0.047810	…	19.26	99.70	711.2
20	0.031100	…	20.49	96.09	630.5
21	0.020760	…	15.66	65.13	314.9
22	0.097560	…	19.08	125.10	980.9
23	0.086320	…	35.59	188.00	2615.0
24	0.091700	…	31.56	177.00	2215.0
25	0.140100	…	21.40	152.40	1461.0
26	0.087830	…	33.21	122.40	896.9
27	0.077310	…	27.26	139.90	1403.0
28	0.087510	…	36.71	149.30	1269.0
29	0.079530	…	19.52	134.90	1227.0
..	…	…	…	…	…
539	0.013640	…	31.89	54.49	223.6
540	0.025940	…	19.68	78.78	457.8
541	0.038900	…	31.73	113.50	808.9
542	0.030270	…	32.29	107.40	826.4
543	0.032750	…	37.17	92.48	629.6
544	0.023690	…	24.75	99.17	688.6
545	0.024430	…	29.09	97.58	729.8
546	0.005495	…	21.77	71.12	384.9
547	0.024380	…	22.04	71.08	357.4

548	0.009615	…	25.59	69.10	364.2
549	0.008160	…	31.45	83.90	505.6
550	0.000000	…	24.77	74.08	412.3
551	0.022570	…	28.26	77.80	436.6
552	0.014990	…	36.00	88.10	594.7
553	0.012820	…	25.05	62.86	295.8
554	0.023430	…	35.74	88.84	595.7
555	0.027380	…	34.91	69.57	357.6
556	0.011160	…	22.88	67.88	347.3
557	0.000000	…	34.24	66.50	330.6
558	0.037360	…	27.27	105.90	733.5
559	0.041050	…	37.16	82.28	474.2
560	0.043040	…	33.17	100.20	706.7
561	0.000000	…	38.30	75.19	439.6
562	0.094290	…	42.79	128.70	915.0
563	0.147400	…	29.41	179.10	1819.0
564	0.138900	…	26.40	166.10	2027.0
565	0.097910	…	38.25	155.00	1731.0
566	0.053020	…	34.12	126.70	1124.0
567	0.152000	…	39.42	184.60	1821.0
568	0.000000	…	30.37	59.16	268.6

	smoothness_worst	compactness_worst	concavity_worst \
0	0.16220	0.66560	0.71190
1	0.12380	0.18660	0.24160
2	0.14440	0.42450	0.45040
3	0.20980	0.86630	0.68690
4	0.13740	0.20500	0.40000
5	0.17910	0.52490	0.53550
6	0.14420	0.25760	0.37840
7	0.16540	0.36820	0.26780
8	0.17030	0.54010	0.53900
9	0.18530	1.05800	1.10500
10	0.11810	0.15510	0.14590
11	0.13960	0.56090	0.39650
12	0.10370	0.39030	0.36390
13	0.11310	0.19240	0.23220
14	0.16510	0.77250	0.69430
15	0.16780	0.65770	0.70260
16	0.14640	0.18710	0.29140
17	0.17890	0.42330	0.47840
18	0.15120	0.31500	0.53720
19	0.14400	0.17730	0.23900
20	0.13120	0.27760	0.18900
21	0.13240	0.11480	0.08867
22	0.13900	0.59540	0.63050
23	0.14010	0.26000	0.31550

24	0.18050	0.35780	0.46950
25	0.15450	0.39490	0.38530
26	0.15250	0.66430	0.55390
27	0.13380	0.21170	0.34460
28	0.16410	0.61100	0.63350
29	0.12550	0.28120	0.24890
..	...	...	...
539	0.15960	0.30640	0.33930
540	0.13450	0.21180	0.17970
541	0.13400	0.42020	0.40400
542	0.10600	0.13760	0.16110
543	0.10720	0.13810	0.10620
544	0.12640	0.20370	0.13770
545	0.12160	0.15170	0.10490
546	0.12850	0.08842	0.04384
547	0.14610	0.22460	0.17830
548	0.11990	0.09546	0.09350
549	0.12040	0.16330	0.06194
550	0.10010	0.07348	0.00000
551	0.10870	0.17820	0.15640
552	0.12340	0.10640	0.08653
553	0.11030	0.08298	0.07993
554	0.12270	0.16200	0.24390
555	0.13840	0.17100	0.20000
556	0.12650	0.12000	0.01005
557	0.10730	0.07158	0.00000
558	0.10260	0.31710	0.36620
559	0.12980	0.25170	0.36300
560	0.12410	0.22640	0.13260
561	0.09267	0.05494	0.00000
562	0.14170	0.79170	1.17000
563	0.14070	0.41860	0.65990
564	0.14100	0.21130	0.41070
565	0.11660	0.19220	0.32150
566	0.11390	0.30940	0.34030
567	0.16500	0.86810	0.93870
568	0.08996	0.06444	0.00000

	concave points_worst	symmetry_worst	fractal_dimension_worst \
0	0.26540	0.4601	0.11890
1	0.18600	0.2750	0.08902
2	0.24300	0.3613	0.08758
3	0.25750	0.6638	0.17300
4	0.16250	0.2364	0.07678
5	0.17410	0.3985	0.12440
6	0.19320	0.3063	0.08368
7	0.15560	0.3196	0.11510

8	0.20600	0.4378	0.10720
9	0.22100	0.4366	0.20750
10	0.09975	0.2948	0.08452
11	0.18100	0.3792	0.10480
12	0.17670	0.3176	0.10230
13	0.11190	0.2809	0.06287
14	0.22080	0.3596	0.14310
15	0.17120	0.4218	0.13410
16	0.16090	0.3029	0.08216
17	0.20730	0.3706	0.11420
18	0.23880	0.2768	0.07615
19	0.12880	0.2977	0.07259
20	0.07283	0.3184	0.08183
21	0.06227	0.2450	0.07773
22	0.23930	0.4667	0.09946
23	0.20090	0.2822	0.07526
24	0.20950	0.3613	0.09564
25	0.25500	0.4066	0.10590
26	0.27010	0.4264	0.12750
27	0.14900	0.2341	0.07421
28	0.20240	0.4027	0.09876
29	0.14560	0.2756	0.07919
..	...	...	...
539	0.05000	0.2790	0.10660
540	0.06918	0.2329	0.08134
541	0.12050	0.3187	0.10230
542	0.10950	0.2722	0.06956
543	0.07958	0.2473	0.06443
544	0.06845	0.2249	0.08492
545	0.07174	0.2642	0.06953
546	0.02381	0.2681	0.07399
547	0.08333	0.2691	0.09479
548	0.03846	0.2552	0.07920
549	0.03264	0.3059	0.07626
550	0.00000	0.2458	0.06592
551	0.06413	0.3169	0.08032
552	0.06498	0.2407	0.06484
553	0.02564	0.2435	0.07393
554	0.06493	0.2372	0.07242
555	0.09127	0.2226	0.08283
556	0.02232	0.2262	0.06742
557	0.00000	0.2475	0.06969
558	0.11050	0.2258	0.08004
559	0.09653	0.2112	0.08732
560	0.10480	0.2250	0.08321
561	0.00000	0.1566	0.05905
562	0.23560	0.4089	0.14090

563	0.25420	0.2929	0.09873
564	0.22160	0.2060	0.07115
565	0.16280	0.2572	0.06637
566	0.14180	0.2218	0.07820
567	0.26500	0.4087	0.12400
568	0.00000	0.2871	0.07039

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```
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565          NaN
566          NaN
567          NaN
568          NaN

[569 rows x 33 columns]
```

1.5   Dropping the unnecessary columns

```
[0]: dataset=dataset.drop(['Unnamed: 32','id'],axis=1)
```

```
[0]: dataset
```

```
[0]:     diagnosis  radius_mean  texture_mean  perimeter_mean  area_mean  \
    0           1       17.990         10.38          122.80     1001.0
    1           1       20.570         17.77          132.90     1326.0
    2           1       19.690         21.25          130.00     1203.0
    3           1       11.420         20.38           77.58      386.1
    4           1       20.290         14.34          135.10     1297.0
    5           1       12.450         15.70           82.57      477.1
    6           1       18.250         19.98          119.60     1040.0
    7           1       13.710         20.83           90.20      577.9
    8           1       13.000         21.82           87.50      519.8
    9           1       12.460         24.04           83.97      475.9
    10          1       16.020         23.24          102.70      797.8
    11          1       15.780         17.89          103.60      781.0
    12          1       19.170         24.80          132.40     1123.0
    13          1       15.850         23.95          103.70      782.7
    14          1       13.730         22.61           93.60      578.3
```

15	1	14.540	27.54	96.73	658.8
16	1	14.680	20.13	94.74	684.5
17	1	16.130	20.68	108.10	798.8
18	1	19.810	22.15	130.00	1260.0
19	0	13.540	14.36	87.46	566.3
20	0	13.080	15.71	85.63	520.0
21	0	9.504	12.44	60.34	273.9
22	1	15.340	14.26	102.50	704.4
23	1	21.160	23.04	137.20	1404.0
24	1	16.650	21.38	110.00	904.6
25	1	17.140	16.40	116.00	912.7
26	1	14.580	21.53	97.41	644.8
27	1	18.610	20.25	122.10	1094.0
28	1	15.300	25.27	102.40	732.4
29	1	17.570	15.05	115.00	955.1
..	...	...	...	...	...
539	0	7.691	25.44	48.34	170.4
540	0	11.540	14.44	74.65	402.9
541	0	14.470	24.99	95.81	656.4
542	0	14.740	25.42	94.70	668.6
543	0	13.210	28.06	84.88	538.4
544	0	13.870	20.70	89.77	584.8
545	0	13.620	23.23	87.19	573.2
546	0	10.320	16.35	65.31	324.9
547	0	10.260	16.58	65.85	320.8
548	0	9.683	19.34	61.05	285.7
549	0	10.820	24.21	68.89	361.6
550	0	10.860	21.48	68.51	360.5
551	0	11.130	22.44	71.49	378.4
552	0	12.770	29.43	81.35	507.9
553	0	9.333	21.94	59.01	264.0
554	0	12.880	28.92	82.50	514.3
555	0	10.290	27.61	65.67	321.4
556	0	10.160	19.59	64.73	311.7
557	0	9.423	27.88	59.26	271.3
558	0	14.590	22.68	96.39	657.1
559	0	11.510	23.93	74.52	403.5
560	0	14.050	27.15	91.38	600.4
561	0	11.200	29.37	70.67	386.0
562	1	15.220	30.62	103.40	716.9
563	1	20.920	25.09	143.00	1347.0
564	1	21.560	22.39	142.00	1479.0
565	1	20.130	28.25	131.20	1261.0
566	1	16.600	28.08	108.30	858.1
567	1	20.600	29.33	140.10	1265.0
568	0	7.760	24.54	47.92	181.0

	smoothness_mean	compactness_mean	concavity_mean	concave points_mean \
0	0.11840	0.27760	0.300100	0.147100
1	0.08474	0.07864	0.086900	0.070170
2	0.10960	0.15990	0.197400	0.127900
3	0.14250	0.28390	0.241400	0.105200
4	0.10030	0.13280	0.198000	0.104300
5	0.12780	0.17000	0.157800	0.080890
6	0.09463	0.10900	0.112700	0.074000
7	0.11890	0.16450	0.093660	0.059850
8	0.12730	0.19320	0.185900	0.093530
9	0.11860	0.23960	0.227300	0.085430
10	0.08206	0.06669	0.032990	0.033230
11	0.09710	0.12920	0.099540	0.066060
12	0.09740	0.24580	0.206500	0.111800
13	0.08401	0.10020	0.099380	0.053640
14	0.11310	0.22930	0.212800	0.080250
15	0.11390	0.15950	0.163900	0.073640
16	0.09867	0.07200	0.073950	0.052590
17	0.11700	0.20220	0.172200	0.102800
18	0.09831	0.10270	0.147900	0.094980
19	0.09779	0.08129	0.066640	0.047810
20	0.10750	0.12700	0.045680	0.031100
21	0.10240	0.06492	0.029560	0.020760
22	0.10730	0.21350	0.207700	0.097560
23	0.09428	0.10220	0.109700	0.086320
24	0.11210	0.14570	0.152500	0.091700
25	0.11860	0.22760	0.222900	0.140100
26	0.10540	0.18680	0.142500	0.087830
27	0.09440	0.10660	0.149000	0.077310
28	0.10820	0.16970	0.168300	0.087510
29	0.09847	0.11570	0.098750	0.079530
..	...	...	...	...
539	0.08668	0.11990	0.092520	0.013640
540	0.09984	0.11200	0.067370	0.025940
541	0.08837	0.12300	0.100900	0.038900
542	0.08275	0.07214	0.041050	0.030270
543	0.08671	0.06877	0.029870	0.032750
544	0.09578	0.10180	0.036880	0.023690
545	0.09246	0.06747	0.029740	0.024430
546	0.09434	0.04994	0.010120	0.005495
547	0.08877	0.08066	0.043580	0.024380
548	0.08491	0.05030	0.023370	0.009615
549	0.08192	0.06602	0.015480	0.008160
550	0.07431	0.04227	0.000000	0.000000
551	0.09566	0.08194	0.048240	0.022570
552	0.08276	0.04234	0.019970	0.014990
553	0.09240	0.05605	0.039960	0.012820

554	0.08123	0.05824	0.061950	0.023430
555	0.09030	0.07658	0.059990	0.027380
556	0.10030	0.07504	0.005025	0.011160
557	0.08123	0.04971	0.000000	0.000000
558	0.08473	0.13300	0.102900	0.037360
559	0.09261	0.10210	0.111200	0.041050
560	0.09929	0.11260	0.044620	0.043040
561	0.07449	0.03558	0.000000	0.000000
562	0.10480	0.20870	0.255000	0.094290
563	0.10990	0.22360	0.317400	0.147400
564	0.11100	0.11590	0.243900	0.138900
565	0.09780	0.10340	0.144000	0.097910
566	0.08455	0.10230	0.092510	0.053020
567	0.11780	0.27700	0.351400	0.152000
568	0.05263	0.04362	0.000000	0.000000

	symmetry_mean	…	radius_worst	texture_worst	perimeter_worst	\
0	0.2419	…	25.380	17.33	184.60
1	0.1812	…	24.990	23.41	158.80
2	0.2069	…	23.570	25.53	152.50
3	0.2597	…	14.910	26.50	98.87
4	0.1809	…	22.540	16.67	152.20
5	0.2087	…	15.470	23.75	103.40
6	0.1794	…	22.880	27.66	153.20
7	0.2196	…	17.060	28.14	110.60
8	0.2350	…	15.490	30.73	106.20
9	0.2030	…	15.090	40.68	97.65
10	0.1528	…	19.190	33.88	123.80
11	0.1842	…	20.420	27.28	136.50
12	0.2397	…	20.960	29.94	151.70
13	0.1847	…	16.840	27.66	112.00
14	0.2069	…	15.030	32.01	108.80
15	0.2303	…	17.460	37.13	124.10
16	0.1586	…	19.070	30.88	123.40
17	0.2164	…	20.960	31.48	136.80
18	0.1582	…	27.320	30.88	186.80
19	0.1885	…	15.110	19.26	99.70
20	0.1967	…	14.500	20.49	96.09
21	0.1815	…	10.230	15.66	65.13
22	0.2521	…	18.070	19.08	125.10
23	0.1769	…	29.170	35.59	188.00
24	0.1995	…	26.460	31.56	177.00
25	0.3040	…	22.250	21.40	152.40
26	0.2252	…	17.620	33.21	122.40
27	0.1697	…	21.310	27.26	139.90
28	0.1926	…	20.270	36.71	149.30
29	0.1739	…	20.010	19.52	134.90

..		…	…	…	…
539	0.2037	…	8.678	31.89	54.49
540	0.1818	…	12.260	19.68	78.78
541	0.1872	…	16.220	31.73	113.50
542	0.1840	…	16.510	32.29	107.40
543	0.1628	…	14.370	37.17	92.48
544	0.1620	…	15.050	24.75	99.17
545	0.1664	…	15.350	29.09	97.58
546	0.1885	…	11.250	21.77	71.12
547	0.1669	…	10.830	22.04	71.08
548	0.1580	…	10.930	25.59	69.10
549	0.1976	…	13.030	31.45	83.90
550	0.1661	…	11.660	24.77	74.08
551	0.2030	…	12.020	28.26	77.80
552	0.1539	…	13.870	36.00	88.10
553	0.1692	…	9.845	25.05	62.86
554	0.1566	…	13.890	35.74	88.84
555	0.1593	…	10.840	34.91	69.57
556	0.1791	…	10.650	22.88	67.88
557	0.1742	…	10.490	34.24	66.50
558	0.1454	…	15.480	27.27	105.90
559	0.1388	…	12.480	37.16	82.28
560	0.1537	…	15.300	33.17	100.20
561	0.1060	…	11.920	38.30	75.19
562	0.2128	…	17.520	42.79	128.70
563	0.2149	…	24.290	29.41	179.10
564	0.1726	…	25.450	26.40	166.10
565	0.1752	…	23.690	38.25	155.00
566	0.1590	…	18.980	34.12	126.70
567	0.2397	…	25.740	39.42	184.60
568	0.1587	…	9.456	30.37	59.16

	area_worst	smoothness_worst	compactness_worst	concavity_worst \
0	2019.0	0.16220	0.66560	0.71190
1	1956.0	0.12380	0.18660	0.24160
2	1709.0	0.14440	0.42450	0.45040
3	567.7	0.20980	0.86630	0.68690
4	1575.0	0.13740	0.20500	0.40000
5	741.6	0.17910	0.52490	0.53550
6	1606.0	0.14420	0.25760	0.37840
7	897.0	0.16540	0.36820	0.26780
8	739.3	0.17030	0.54010	0.53900
9	711.4	0.18530	1.05800	1.10500
10	1150.0	0.11810	0.15510	0.14590
11	1299.0	0.13960	0.56090	0.39650
12	1332.0	0.10370	0.39030	0.36390
13	876.5	0.11310	0.19240	0.23220

14	697.7	0.16510	0.77250	0.69430
15	943.2	0.16780	0.65770	0.70260
16	1138.0	0.14640	0.18710	0.29140
17	1315.0	0.17890	0.42330	0.47840
18	2398.0	0.15120	0.31500	0.53720
19	711.2	0.14400	0.17730	0.23900
20	630.5	0.13120	0.27760	0.18900
21	314.9	0.13240	0.11480	0.08867
22	980.9	0.13900	0.59540	0.63050
23	2615.0	0.14010	0.26000	0.31550
24	2215.0	0.18050	0.35780	0.46950
25	1461.0	0.15450	0.39490	0.38530
26	896.9	0.15250	0.66430	0.55390
27	1403.0	0.13380	0.21170	0.34460
28	1269.0	0.16410	0.61100	0.63350
29	1227.0	0.12550	0.28120	0.24890
..	...	...	...	...
539	223.6	0.15960	0.30640	0.33930
540	457.8	0.13450	0.21180	0.17970
541	808.9	0.13400	0.42020	0.40400
542	826.4	0.10600	0.13760	0.16110
543	629.6	0.10720	0.13810	0.10620
544	688.6	0.12640	0.20370	0.13770
545	729.8	0.12160	0.15170	0.10490
546	384.9	0.12850	0.08842	0.04384
547	357.4	0.14610	0.22460	0.17830
548	364.2	0.11990	0.09546	0.09350
549	505.6	0.12040	0.16330	0.06194
550	412.3	0.10010	0.07348	0.00000
551	436.6	0.10870	0.17820	0.15640
552	594.7	0.12340	0.10640	0.08653
553	295.8	0.11030	0.08298	0.07993
554	595.7	0.12270	0.16200	0.24390
555	357.6	0.13840	0.17100	0.20000
556	347.3	0.12650	0.12000	0.01005
557	330.6	0.10730	0.07158	0.00000
558	733.5	0.10260	0.31710	0.36620
559	474.2	0.12980	0.25170	0.36300
560	706.7	0.12410	0.22640	0.13260
561	439.6	0.09267	0.05494	0.00000
562	915.0	0.14170	0.79170	1.17000
563	1819.0	0.14070	0.41860	0.65990
564	2027.0	0.14100	0.21130	0.41070
565	1731.0	0.11660	0.19220	0.32150
566	1124.0	0.11390	0.30940	0.34030
567	1821.0	0.16500	0.86810	0.93870
568	268.6	0.08996	0.06444	0.00000

	concave points_worst	symmetry_worst	fractal_dimension_worst
0	0.26540	0.4601	0.11890
1	0.18600	0.2750	0.08902
2	0.24300	0.3613	0.08758
3	0.25750	0.6638	0.17300
4	0.16250	0.2364	0.07678
5	0.17410	0.3985	0.12440
6	0.19320	0.3063	0.08368
7	0.15560	0.3196	0.11510
8	0.20600	0.4378	0.10720
9	0.22100	0.4366	0.20750
10	0.09975	0.2948	0.08452
11	0.18100	0.3792	0.10480
12	0.17670	0.3176	0.10230
13	0.11190	0.2809	0.06287
14	0.22080	0.3596	0.14310
15	0.17120	0.4218	0.13410
16	0.16090	0.3029	0.08216
17	0.20730	0.3706	0.11420
18	0.23880	0.2768	0.07615
19	0.12880	0.2977	0.07259
20	0.07283	0.3184	0.08183
21	0.06227	0.2450	0.07773
22	0.23930	0.4667	0.09946
23	0.20090	0.2822	0.07526
24	0.20950	0.3613	0.09564
25	0.25500	0.4066	0.10590
26	0.27010	0.4264	0.12750
27	0.14900	0.2341	0.07421
28	0.20240	0.4027	0.09876
29	0.14560	0.2756	0.07919
..	...	...	...
539	0.05000	0.2790	0.10660
540	0.06918	0.2329	0.08134
541	0.12050	0.3187	0.10230
542	0.10950	0.2722	0.06956
543	0.07958	0.2473	0.06443
544	0.06845	0.2249	0.08492
545	0.07174	0.2642	0.06953
546	0.02381	0.2681	0.07399
547	0.08333	0.2691	0.09479
548	0.03846	0.2552	0.07920
549	0.03264	0.3059	0.07626
550	0.00000	0.2458	0.06592
551	0.06413	0.3169	0.08032
552	0.06498	0.2407	0.06484

```
553              0.02564              0.2435                0.07393
554              0.06493              0.2372                0.07242
555              0.09127              0.2226                0.08283
556              0.02232              0.2262                0.06742
557              0.00000              0.2475                0.06969
558              0.11050              0.2258                0.08004
559              0.09653              0.2112                0.08732
560              0.10480              0.2250                0.08321
561              0.00000              0.1566                0.05905
562              0.23560              0.4089                0.14090
563              0.25420              0.2929                0.09873
564              0.22160              0.2060                0.07115
565              0.16280              0.2572                0.06637
566              0.14180              0.2218                0.07820
567              0.26500              0.4087                0.12400
568              0.00000              0.2871                0.07039

[569 rows x 31 columns]
```

1.6 Description of dataset

```
[0]: dataset.describe()
```

```
[0]:          diagnosis   radius_mean   texture_mean   perimeter_mean     area_mean  \
     count   569.000000    569.000000     569.000000       569.000000    569.000000
     mean      0.372583     14.127292      19.289649        91.969033    654.889104
     std       0.483918      3.524049       4.301036        24.298981    351.914129
     min       0.000000      6.981000       9.710000        43.790000    143.500000
     25%       0.000000     11.700000      16.170000        75.170000    420.300000
     50%       0.000000     13.370000      18.840000        86.240000    551.100000
     75%       1.000000     15.780000      21.800000       104.100000    782.700000
     max       1.000000     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   …   radius_worst   texture_worst   perimeter_worst  \
     count      569.000000   …     569.000000      569.000000        569.000000
     mean         0.181162   …      16.269190       25.677223        107.261213
     std          0.027414   …       4.833242        6.146258         33.602542
```

```
min           0.106000    …      7.930000        12.020000          50.410000
25%           0.161900    …     13.010000        21.080000          84.110000
50%           0.179200    …     14.970000        25.410000          97.660000
75%           0.195700    …     18.790000        29.720000         125.400000
max           0.304000    …     36.040000        49.540000         251.200000


          area_worst    smoothness_worst    compactness_worst    concavity_worst  \
count     569.000000          569.000000           569.000000         569.000000
mean      880.583128            0.132369             0.254265           0.272188
std       569.356993            0.022832             0.157336           0.208624
min       185.200000            0.071170             0.027290           0.000000
25%       515.300000            0.116600             0.147200           0.114500
50%       686.500000            0.131300             0.211900           0.226700
75%      1084.000000            0.146000             0.339100           0.382900
max      4254.000000            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


[8 rows x 31 columns]
```

1.7 Information of dataset

[0]: `dataset.info()`

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 569 entries, 0 to 568
Data columns (total 31 columns):
diagnosis                569 non-null int32
radius_mean              569 non-null float64
texture_mean             569 non-null float64
perimeter_mean           569 non-null float64
area_mean                569 non-null float64
smoothness_mean          569 non-null float64
compactness_mean         569 non-null float64
concavity_mean           569 non-null float64
concave points_mean      569 non-null float64
symmetry_mean            569 non-null float64
fractal_dimension_mean   569 non-null float64
radius_se                569 non-null float64
texture_se               569 non-null float64
```

```
perimeter_se                569 non-null float64
area_se                     569 non-null float64
smoothness_se               569 non-null float64
compactness_se              569 non-null float64
concavity_se                569 non-null float64
concave points_se           569 non-null float64
symmetry_se                 569 non-null float64
fractal_dimension_se        569 non-null float64
radius_worst                569 non-null float64
texture_worst               569 non-null float64
perimeter_worst             569 non-null float64
area_worst                  569 non-null float64
smoothness_worst            569 non-null float64
compactness_worst           569 non-null float64
concavity_worst             569 non-null float64
concave points_worst        569 non-null float64
symmetry_worst              569 non-null float64
fractal_dimension_worst     569 non-null float64
dtypes: float64(30), int32(1)
memory usage: 135.7 KB
```

1.8 Checking for any null values

```
[0]: dataset.isnull().sum()
```

```
[0]: 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
dtype: int64
```

1.9 Heatmap showing the correlation values

```python
[0]: plt.figure(figsize=(30,15))
     sns.heatmap(dataset.corr(),annot=True)
```

```
[0]: <matplotlib.axes._subplots.AxesSubplot at 0x1381ca30e80>
```
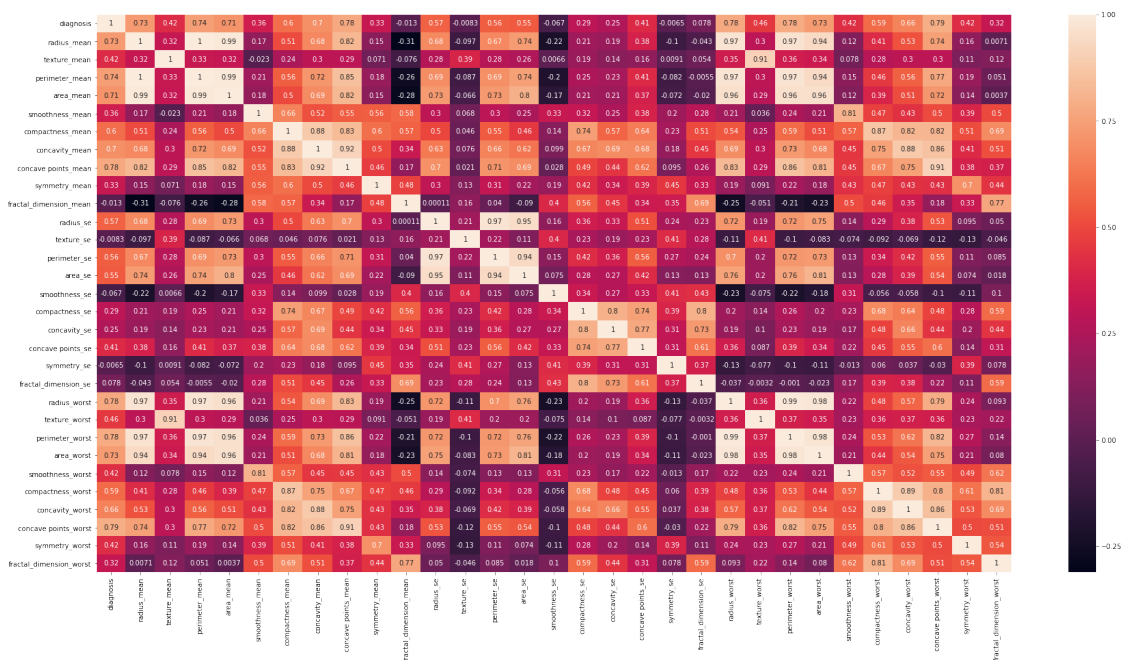

1.10 Pairplots showing the values of different attributes contributing towards the presence/absence of breast cancer

```python
[0]: sns.
     ↪pairplot(dataset,hue='diagnosis',vars=['radius_mean','texture_mean','perimeter_mean','area_
```

```
[0]: <seaborn.axisgrid.PairGrid at 0x1381d2a3940>
```
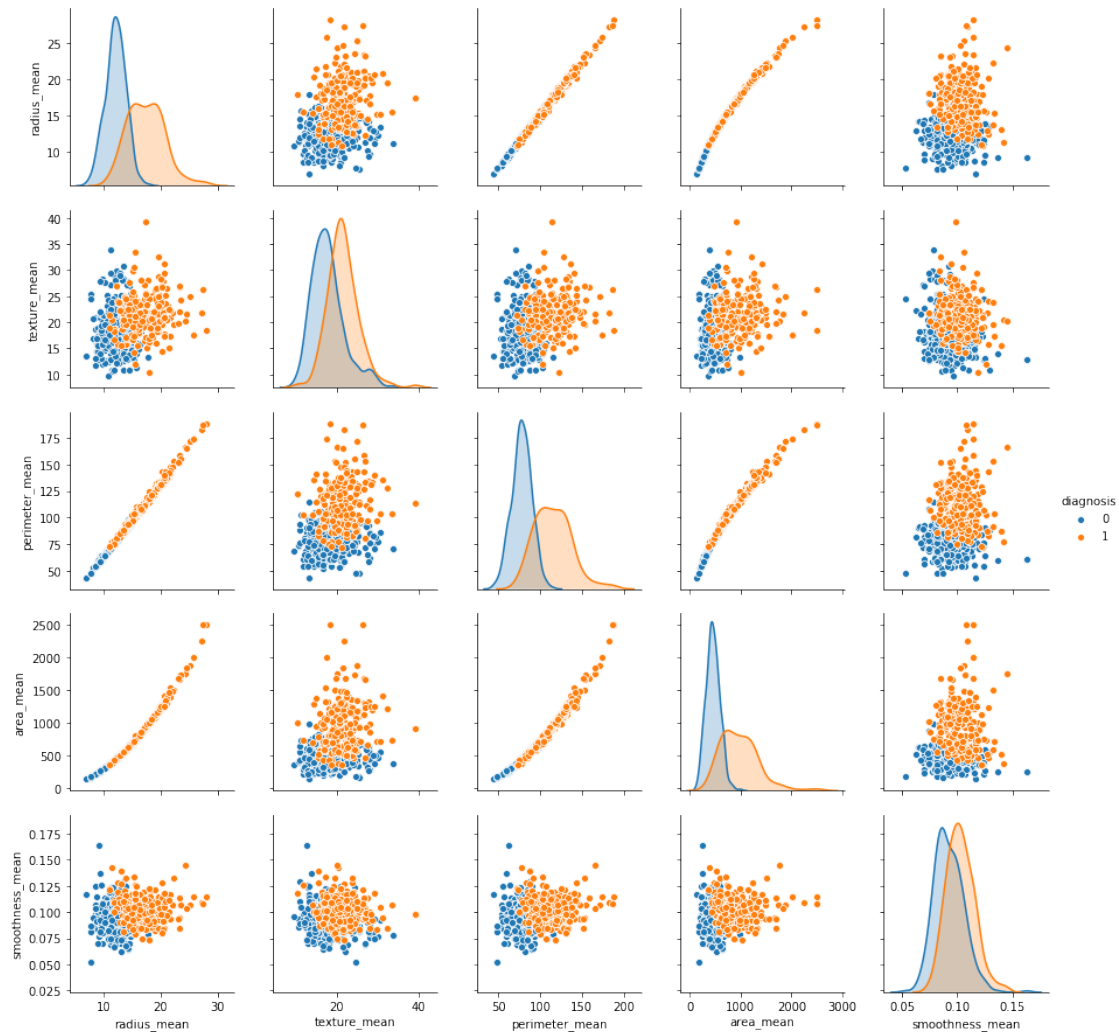
1.11 Getting independent and dependent variables from the dataset

```
[0]: X=dataset.iloc[:,1:]
     X
```

```
[0]:      radius_mean   texture_mean   perimeter_mean   area_mean   smoothness_mean  \
     0         17.990          10.38           122.80      1001.0           0.11840
     1         20.570          17.77           132.90      1326.0           0.08474
     2         19.690          21.25           130.00      1203.0           0.10960
     3         11.420          20.38            77.58       386.1           0.14250
     4         20.290          14.34           135.10      1297.0           0.10030
     5         12.450          15.70            82.57       477.1           0.12780
     6         18.250          19.98           119.60      1040.0           0.09463
     7         13.710          20.83            90.20       577.9           0.11890
     8         13.000          21.82            87.50       519.8           0.12730
```

9	12.460	24.04	83.97	475.9	0.11860
10	16.020	23.24	102.70	797.8	0.08206
11	15.780	17.89	103.60	781.0	0.09710
12	19.170	24.80	132.40	1123.0	0.09740
13	15.850	23.95	103.70	782.7	0.08401
14	13.730	22.61	93.60	578.3	0.11310
15	14.540	27.54	96.73	658.8	0.11390
16	14.680	20.13	94.74	684.5	0.09867
17	16.130	20.68	108.10	798.8	0.11700
18	19.810	22.15	130.00	1260.0	0.09831
19	13.540	14.36	87.46	566.3	0.09779
20	13.080	15.71	85.63	520.0	0.10750
21	9.504	12.44	60.34	273.9	0.10240
22	15.340	14.26	102.50	704.4	0.10730
23	21.160	23.04	137.20	1404.0	0.09428
24	16.650	21.38	110.00	904.6	0.11210
25	17.140	16.40	116.00	912.7	0.11860
26	14.580	21.53	97.41	644.8	0.10540
27	18.610	20.25	122.10	1094.0	0.09440
28	15.300	25.27	102.40	732.4	0.10820
29	17.570	15.05	115.00	955.1	0.09847
..	...	...	...	...	...
539	7.691	25.44	48.34	170.4	0.08668
540	11.540	14.44	74.65	402.9	0.09984
541	14.470	24.99	95.81	656.4	0.08837
542	14.740	25.42	94.70	668.6	0.08275
543	13.210	28.06	84.88	538.4	0.08671
544	13.870	20.70	89.77	584.8	0.09578
545	13.620	23.23	87.19	573.2	0.09246
546	10.320	16.35	65.31	324.9	0.09434
547	10.260	16.58	65.85	320.8	0.08877
548	9.683	19.34	61.05	285.7	0.08491
549	10.820	24.21	68.89	361.6	0.08192
550	10.860	21.48	68.51	360.5	0.07431
551	11.130	22.44	71.49	378.4	0.09566
552	12.770	29.43	81.35	507.9	0.08276
553	9.333	21.94	59.01	264.0	0.09240
554	12.880	28.92	82.50	514.3	0.08123
555	10.290	27.61	65.67	321.4	0.09030
556	10.160	19.59	64.73	311.7	0.10030
557	9.423	27.88	59.26	271.3	0.08123
558	14.590	22.68	96.39	657.1	0.08473
559	11.510	23.93	74.52	403.5	0.09261
560	14.050	27.15	91.38	600.4	0.09929
561	11.200	29.37	70.67	386.0	0.07449
562	15.220	30.62	103.40	716.9	0.10480
563	20.920	25.09	143.00	1347.0	0.10990

564	21.560	22.39	142.00	1479.0	0.11100
565	20.130	28.25	131.20	1261.0	0.09780
566	16.600	28.08	108.30	858.1	0.08455
567	20.600	29.33	140.10	1265.0	0.11780
568	7.760	24.54	47.92	181.0	0.05263

	compactness_mean	concavity_mean	concave points_mean	symmetry_mean \
0	0.27760	0.300100	0.147100	0.2419
1	0.07864	0.086900	0.070170	0.1812
2	0.15990	0.197400	0.127900	0.2069
3	0.28390	0.241400	0.105200	0.2597
4	0.13280	0.198000	0.104300	0.1809
5	0.17000	0.157800	0.080890	0.2087
6	0.10900	0.112700	0.074000	0.1794
7	0.16450	0.093660	0.059850	0.2196
8	0.19320	0.185900	0.093530	0.2350
9	0.23960	0.227300	0.085430	0.2030
10	0.06669	0.032990	0.033230	0.1528
11	0.12920	0.099540	0.066060	0.1842
12	0.24580	0.206500	0.111800	0.2397
13	0.10020	0.099380	0.053640	0.1847
14	0.22930	0.212800	0.080250	0.2069
15	0.15950	0.163900	0.073640	0.2303
16	0.07200	0.073950	0.052590	0.1586
17	0.20220	0.172200	0.102800	0.2164
18	0.10270	0.147900	0.094980	0.1582
19	0.08129	0.066640	0.047810	0.1885
20	0.12700	0.045680	0.031100	0.1967
21	0.06492	0.029560	0.020760	0.1815
22	0.21350	0.207700	0.097560	0.2521
23	0.10220	0.109700	0.086320	0.1769
24	0.14570	0.152500	0.091700	0.1995
25	0.22760	0.222900	0.140100	0.3040
26	0.18680	0.142500	0.087830	0.2252
27	0.10660	0.149000	0.077310	0.1697
28	0.16970	0.168300	0.087510	0.1926
29	0.11570	0.098750	0.079530	0.1739
..	...	...	...	...
539	0.11990	0.092520	0.013640	0.2037
540	0.11200	0.067370	0.025940	0.1818
541	0.12300	0.100900	0.038900	0.1872
542	0.07214	0.041050	0.030270	0.1840
543	0.06877	0.029870	0.032750	0.1628
544	0.10180	0.036880	0.023690	0.1620
545	0.06747	0.029740	0.024430	0.1664
546	0.04994	0.010120	0.005495	0.1885
547	0.08066	0.043580	0.024380	0.1669

548	0.05030	0.023370	0.009615	0.1580
549	0.06602	0.015480	0.008160	0.1976
550	0.04227	0.000000	0.000000	0.1661
551	0.08194	0.048240	0.022570	0.2030
552	0.04234	0.019970	0.014990	0.1539
553	0.05605	0.039960	0.012820	0.1692
554	0.05824	0.061950	0.023430	0.1566
555	0.07658	0.059990	0.027380	0.1593
556	0.07504	0.005025	0.011160	0.1791
557	0.04971	0.000000	0.000000	0.1742
558	0.13300	0.102900	0.037360	0.1454
559	0.10210	0.111200	0.041050	0.1388
560	0.11260	0.044620	0.043040	0.1537
561	0.03558	0.000000	0.000000	0.1060
562	0.20870	0.255000	0.094290	0.2128
563	0.22360	0.317400	0.147400	0.2149
564	0.11590	0.243900	0.138900	0.1726
565	0.10340	0.144000	0.097910	0.1752
566	0.10230	0.092510	0.053020	0.1590
567	0.27700	0.351400	0.152000	0.2397
568	0.04362	0.000000	0.000000	0.1587

	fractal_dimension_mean	…	radius_worst	texture_worst \
0	0.07871	…	25.380	17.33
1	0.05667	…	24.990	23.41
2	0.05999	…	23.570	25.53
3	0.09744	…	14.910	26.50
4	0.05883	…	22.540	16.67
5	0.07613	…	15.470	23.75
6	0.05742	…	22.880	27.66
7	0.07451	…	17.060	28.14
8	0.07389	…	15.490	30.73
9	0.08243	…	15.090	40.68
10	0.05697	…	19.190	33.88
11	0.06082	…	20.420	27.28
12	0.07800	…	20.960	29.94
13	0.05338	…	16.840	27.66
14	0.07682	…	15.030	32.01
15	0.07077	…	17.460	37.13
16	0.05922	…	19.070	30.88
17	0.07356	…	20.960	31.48
18	0.05395	…	27.320	30.88
19	0.05766	…	15.110	19.26
20	0.06811	…	14.500	20.49
21	0.06905	…	10.230	15.66
22	0.07032	…	18.070	19.08
23	0.05278	…	29.170	35.59

24	0.06330	...	26.460	31.56
25	0.07413	...	22.250	21.40
26	0.06924	...	17.620	33.21
27	0.05699	...	21.310	27.26
28	0.06540	...	20.270	36.71
29	0.06149	...	20.010	19.52
..	...	...	...	...
539	0.07751	...	8.678	31.89
540	0.06782	...	12.260	19.68
541	0.06341	...	16.220	31.73
542	0.05680	...	16.510	32.29
543	0.05781	...	14.370	37.17
544	0.06688	...	15.050	24.75
545	0.05801	...	15.350	29.09
546	0.06201	...	11.250	21.77
547	0.06714	...	10.830	22.04
548	0.06235	...	10.930	25.59
549	0.06328	...	13.030	31.45
550	0.05948	...	11.660	24.77
551	0.06552	...	12.020	28.26
552	0.05637	...	13.870	36.00
553	0.06576	...	9.845	25.05
554	0.05708	...	13.890	35.74
555	0.06127	...	10.840	34.91
556	0.06331	...	10.650	22.88
557	0.06059	...	10.490	34.24
558	0.06147	...	15.480	27.27
559	0.06570	...	12.480	37.16
560	0.06171	...	15.300	33.17
561	0.05502	...	11.920	38.30
562	0.07152	...	17.520	42.79
563	0.06879	...	24.290	29.41
564	0.05623	...	25.450	26.40
565	0.05533	...	23.690	38.25
566	0.05648	...	18.980	34.12
567	0.07016	...	25.740	39.42
568	0.05884	...	9.456	30.37

	perimeter_worst	area_worst	smoothness_worst	compactness_worst	\
0	184.60	2019.0	0.16220	0.66560
1	158.80	1956.0	0.12380	0.18660
2	152.50	1709.0	0.14440	0.42450
3	98.87	567.7	0.20980	0.86630
4	152.20	1575.0	0.13740	0.20500
5	103.40	741.6	0.17910	0.52490
6	153.20	1606.0	0.14420	0.25760
7	110.60	897.0	0.16540	0.36820

8	106.20	739.3	0.17030	0.54010
9	97.65	711.4	0.18530	1.05800
10	123.80	1150.0	0.11810	0.15510
11	136.50	1299.0	0.13960	0.56090
12	151.70	1332.0	0.10370	0.39030
13	112.00	876.5	0.11310	0.19240
14	108.80	697.7	0.16510	0.77250
15	124.10	943.2	0.16780	0.65770
16	123.40	1138.0	0.14640	0.18710
17	136.80	1315.0	0.17890	0.42330
18	186.80	2398.0	0.15120	0.31500
19	99.70	711.2	0.14400	0.17730
20	96.09	630.5	0.13120	0.27760
21	65.13	314.9	0.13240	0.11480
22	125.10	980.9	0.13900	0.59540
23	188.00	2615.0	0.14010	0.26000
24	177.00	2215.0	0.18050	0.35780
25	152.40	1461.0	0.15450	0.39490
26	122.40	896.9	0.15250	0.66430
27	139.90	1403.0	0.13380	0.21170
28	149.30	1269.0	0.16410	0.61100
29	134.90	1227.0	0.12550	0.28120
..	...	...	...	...
539	54.49	223.6	0.15960	0.30640
540	78.78	457.8	0.13450	0.21180
541	113.50	808.9	0.13400	0.42020
542	107.40	826.4	0.10600	0.13760
543	92.48	629.6	0.10720	0.13810
544	99.17	688.6	0.12640	0.20370
545	97.58	729.8	0.12160	0.15170
546	71.12	384.9	0.12850	0.08842
547	71.08	357.4	0.14610	0.22460
548	69.10	364.2	0.11990	0.09546
549	83.90	505.6	0.12040	0.16330
550	74.08	412.3	0.10010	0.07348
551	77.80	436.6	0.10870	0.17820
552	88.10	594.7	0.12340	0.10640
553	62.86	295.8	0.11030	0.08298
554	88.84	595.7	0.12270	0.16200
555	69.57	357.6	0.13840	0.17100
556	67.88	347.3	0.12650	0.12000
557	66.50	330.6	0.10730	0.07158
558	105.90	733.5	0.10260	0.31710
559	82.28	474.2	0.12980	0.25170
560	100.20	706.7	0.12410	0.22640
561	75.19	439.6	0.09267	0.05494
562	128.70	915.0	0.14170	0.79170

563	179.10	1819.0	0.14070	0.41860
564	166.10	2027.0	0.14100	0.21130
565	155.00	1731.0	0.11660	0.19220
566	126.70	1124.0	0.11390	0.30940
567	184.60	1821.0	0.16500	0.86810
568	59.16	268.6	0.08996	0.06444

	concavity_worst	concave points_worst	symmetry_worst	\
0	0.71190	0.26540	0.4601
1	0.24160	0.18600	0.2750
2	0.45040	0.24300	0.3613
3	0.68690	0.25750	0.6638
4	0.40000	0.16250	0.2364
5	0.53550	0.17410	0.3985
6	0.37840	0.19320	0.3063
7	0.26780	0.15560	0.3196
8	0.53900	0.20600	0.4378
9	1.10500	0.22100	0.4366
10	0.14590	0.09975	0.2948
11	0.39650	0.18100	0.3792
12	0.36390	0.17670	0.3176
13	0.23220	0.11190	0.2809
14	0.69430	0.22080	0.3596
15	0.70260	0.17120	0.4218
16	0.29140	0.16090	0.3029
17	0.47840	0.20730	0.3706
18	0.53720	0.23880	0.2768
19	0.23900	0.12880	0.2977
20	0.18900	0.07283	0.3184
21	0.08867	0.06227	0.2450
22	0.63050	0.23930	0.4667
23	0.31550	0.20090	0.2822
24	0.46950	0.20950	0.3613
25	0.38530	0.25500	0.4066
26	0.55390	0.27010	0.4264
27	0.34460	0.14900	0.2341
28	0.63350	0.20240	0.4027
29	0.24890	0.14560	0.2756
..	…	…	…
539	0.33930	0.05000	0.2790
540	0.17970	0.06918	0.2329
541	0.40400	0.12050	0.3187
542	0.16110	0.10950	0.2722
543	0.10620	0.07958	0.2473
544	0.13770	0.06845	0.2249
545	0.10490	0.07174	0.2642
546	0.04384	0.02381	0.2681

547	0.17830	0.08333	0.2691
548	0.09350	0.03846	0.2552
549	0.06194	0.03264	0.3059
550	0.00000	0.00000	0.2458
551	0.15640	0.06413	0.3169
552	0.08653	0.06498	0.2407
553	0.07993	0.02564	0.2435
554	0.24390	0.06493	0.2372
555	0.20000	0.09127	0.2226
556	0.01005	0.02232	0.2262
557	0.00000	0.00000	0.2475
558	0.36620	0.11050	0.2258
559	0.36300	0.09653	0.2112
560	0.13260	0.10480	0.2250
561	0.00000	0.00000	0.1566
562	1.17000	0.23560	0.4089
563	0.65990	0.25420	0.2929
564	0.41070	0.22160	0.2060
565	0.32150	0.16280	0.2572
566	0.34030	0.14180	0.2218
567	0.93870	0.26500	0.4087
568	0.00000	0.00000	0.2871

	fractal_dimension_worst
0	0.11890
1	0.08902
2	0.08758
3	0.17300
4	0.07678
5	0.12440
6	0.08368
7	0.11510
8	0.10720
9	0.20750
10	0.08452
11	0.10480
12	0.10230
13	0.06287
14	0.14310
15	0.13410
16	0.08216
17	0.11420
18	0.07615
19	0.07259
20	0.08183
21	0.07773
22	0.09946

```
23                  0.07526
24                  0.09564
25                  0.10590
26                  0.12750
27                  0.07421
28                  0.09876
29                  0.07919
..                     …
539                 0.10660
540                 0.08134
541                 0.10230
542                 0.06956
543                 0.06443
544                 0.08492
545                 0.06953
546                 0.07399
547                 0.09479
548                 0.07920
549                 0.07626
550                 0.06592
551                 0.08032
552                 0.06484
553                 0.07393
554                 0.07242
555                 0.08283
556                 0.06742
557                 0.06969
558                 0.08004
559                 0.08732
560                 0.08321
561                 0.05905
562                 0.14090
563                 0.09873
564                 0.07115
565                 0.06637
566                 0.07820
567                 0.12400
568                 0.07039

[569 rows x 30 columns]
```

```
[0]: y=dataset.iloc[:,0]
     y
```

```
[0]: 0        1
     1        1
     2        1
```

3	1
4	1
5	1
6	1
7	1
8	1
9	1
10	1
11	1
12	1
13	1
14	1
15	1
16	1
17	1
18	1
19	0
20	0
21	0
22	1
23	1
24	1
25	1
26	1
27	1
28	1
29	1
	..
539	0
540	0
541	0
542	0
543	0
544	0
545	0
546	0
547	0
548	0
549	0
550	0
551	0
552	0
553	0
554	0
555	0
556	0
557	0

```
558    0
559    0
560    0
561    0
562    1
563    1
564    1
565    1
566    1
567    1
568    0
Name: diagnosis, Length: 569, dtype: int32
```

[0]:
```python
X=X.values
y=y.values
```

1.12 Normalization (scaling all the values between 0 and 1)

[0]:
```python
from sklearn.preprocessing import MinMaxScaler
scaler=MinMaxScaler()
X=scaler.fit_transform(X)
```

1.13 Splitting into training and test set

[0]:
```python
from sklearn.model_selection import train_test_split
train_x,test_x,train_y,test_y=train_test_split(X,y,test_size=0.2,random_state=0)

test_x.shape
```

[0]: (114, 30)

1.14 Applying ANN and finding the best values for the hyperparameters

[0]:
```python
import keras
from keras.models import Sequential

from keras.layers import Dense
from keras.wrappers.scikit_learn import KerasClassifier
from sklearn.model_selection import GridSearchCV
def build_classifier():
    classifier = Sequential()
    classifier.add(Dense(units = 16, kernel_initializer = 'uniform', activation
 = 'relu', input_dim = 30))
    classifier.add(Dense(units = 16, kernel_initializer = 'uniform', activation
 = 'relu'))
    classifier.add(Dense(units = 1, kernel_initializer = 'uniform', activation
 = 'sigmoid'))
```

```python
    classifier.compile(optimizer ='adam', loss = 'binary_crossentropy', metrics↵
 ↪= ['accuracy'])
    return classifier


classifier = KerasClassifier(build_fn = build_classifier)

parameters={'batch_size': [10,20,30], 'epochs' : [100,200,300]}

#now we will implement gridsearch

grid_search=GridSearchCV(estimator=classifier,param_grid=parameters,scoring='accuracy',cv=5,n_

grid_search=grid_search.fit(train_x,train_y)
best_parameters=grid_search.best_params_
```

Using TensorFlow backend.
E:\Anaconda\lib\site-packages\joblib\externals\loky\process_executor.py:706:
UserWarning: A worker stopped while some jobs were given to the executor. This
can be caused by a too short worker timeout or by a memory leak.
  "timeout or by a memory leak.", UserWarning

WARNING:tensorflow:From E:\Anaconda\lib\site-
packages\tensorflow\python\ops\resource_variable_ops.py:435: colocate_with (from
tensorflow.python.framework.ops) is deprecated and will be removed in a future
version.
Instructions for updating:
Colocations handled automatically by placer.
WARNING:tensorflow:From E:\Anaconda\lib\site-
packages\tensorflow\python\ops\math_ops.py:3066: to_int32 (from
tensorflow.python.ops.math_ops) is deprecated and will be removed in a future
version.
Instructions for updating:
Use tf.cast instead.
Epoch 1/100
455/455 [==============================] - 1s 1ms/step - loss: 0.6905 -
accuracy: 0.6549
Epoch 2/100
455/455 [==============================] - 0s 286us/step - loss: 0.6668 -
accuracy: 0.9297
Epoch 3/100
455/455 [==============================] - 0s 308us/step - loss: 0.5843 -
accuracy: 0.8879
Epoch 4/100
455/455 [==============================] - 0s 356us/step - loss: 0.4644 -
accuracy: 0.9187
Epoch 5/100
455/455 [==============================] - 0s 340us/step - loss: 0.3557 -

```
accuracy: 0.9275
Epoch 6/100
455/455 [==============================] - 0s 321us/step - loss: 0.2733 -
accuracy: 0.9319
Epoch 7/100
455/455 [==============================] - 0s 180us/step - loss: 0.2203 -
accuracy: 0.9451
Epoch 8/100
455/455 [==============================] - 0s 351us/step - loss: 0.1910 -
accuracy: 0.9451
Epoch 9/100
455/455 [==============================] - 0s 338us/step - loss: 0.1664 -
accuracy: 0.9495
Epoch 10/100
455/455 [==============================] - 0s 279us/step - loss: 0.1518 -
accuracy: 0.9473
Epoch 11/100
455/455 [==============================] - 0s 213us/step - loss: 0.1400 -
accuracy: 0.9582
Epoch 12/100
455/455 [==============================] - 0s 215us/step - loss: 0.1279 -
accuracy: 0.9560
Epoch 13/100
455/455 [==============================] - 0s 332us/step - loss: 0.1213 -
accuracy: 0.9604
Epoch 14/100
455/455 [==============================] - 0s 259us/step - loss: 0.1135 -
accuracy: 0.9648
Epoch 15/100
455/455 [==============================] - 0s 277us/step - loss: 0.1068 -
accuracy: 0.9670
Epoch 16/100
455/455 [==============================] - 0s 334us/step - loss: 0.1033 -
accuracy: 0.9692
Epoch 17/100
455/455 [==============================] - 0s 314us/step - loss: 0.1030 -
accuracy: 0.9670
Epoch 18/100
455/455 [==============================] - 0s 189us/step - loss: 0.1024 -
accuracy: 0.9692
Epoch 19/100
455/455 [==============================] - 0s 248us/step - loss: 0.0891 -
accuracy: 0.9758
Epoch 20/100
455/455 [==============================] - 0s 220us/step - loss: 0.0860 -
accuracy: 0.9736
Epoch 21/100
455/455 [==============================] - 0s 258us/step - loss: 0.0821 -
```

```
accuracy: 0.9780
Epoch 22/100
455/455 [==============================] - 0s 266us/step - loss: 0.0794 -
accuracy: 0.9802
Epoch 23/100
455/455 [==============================] - 0s 214us/step - loss: 0.0785 -
accuracy: 0.9780
Epoch 24/100
455/455 [==============================] - 0s 292us/step - loss: 0.0774 -
accuracy: 0.9824
Epoch 25/100
455/455 [==============================] - 0s 301us/step - loss: 0.0875 -
accuracy: 0.9736
Epoch 26/100
455/455 [==============================] - 0s 320us/step - loss: 0.0763 -
accuracy: 0.9714
Epoch 27/100
455/455 [==============================] - 0s 201us/step - loss: 0.0708 -
accuracy: 0.9846
Epoch 28/100
455/455 [==============================] - 0s 258us/step - loss: 0.0694 -
accuracy: 0.9846
Epoch 29/100
455/455 [==============================] - 0s 214us/step - loss: 0.0711 -
accuracy: 0.9780
Epoch 30/100
455/455 [==============================] - 0s 169us/step - loss: 0.0685 -
accuracy: 0.9758
Epoch 31/100
455/455 [==============================] - 0s 202us/step - loss: 0.0686 -
accuracy: 0.9802
Epoch 32/100
455/455 [==============================] - 0s 195us/step - loss: 0.0660 -
accuracy: 0.9824
Epoch 33/100
455/455 [==============================] - 0s 279us/step - loss: 0.0657 -
accuracy: 0.9824
Epoch 34/100
455/455 [==============================] - 0s 373us/step - loss: 0.0648 -
accuracy: 0.9758
Epoch 35/100
455/455 [==============================] - 0s 264us/step - loss: 0.0669 -
accuracy: 0.9780
Epoch 36/100
455/455 [==============================] - 0s 239us/step - loss: 0.0626 -
accuracy: 0.9868
Epoch 37/100
455/455 [==============================] - 0s 297us/step - loss: 0.0618 -
```

```
accuracy: 0.9846
Epoch 38/100
455/455 [==============================] - 0s 259us/step - loss: 0.0611 -
accuracy: 0.9846
Epoch 39/100
455/455 [==============================] - 0s 222us/step - loss: 0.0649 -
accuracy: 0.9758
Epoch 40/100
455/455 [==============================] - 0s 141us/step - loss: 0.0606 -
accuracy: 0.9736
Epoch 41/100
455/455 [==============================] - 0s 156us/step - loss: 0.0604 -
accuracy: 0.9824
Epoch 42/100
455/455 [==============================] - 0s 198us/step - loss: 0.0632 -
accuracy: 0.9802
Epoch 43/100
455/455 [==============================] - 0s 198us/step - loss: 0.0598 -
accuracy: 0.9758
Epoch 44/100
455/455 [==============================] - 0s 213us/step - loss: 0.0611 -
accuracy: 0.9780
Epoch 45/100
455/455 [==============================] - 0s 297us/step - loss: 0.0587 -
accuracy: 0.9802
Epoch 46/100
455/455 [==============================] - 0s 270us/step - loss: 0.0568 -
accuracy: 0.9846
Epoch 47/100
455/455 [==============================] - 0s 242us/step - loss: 0.0577 -
accuracy: 0.9846
Epoch 48/100
455/455 [==============================] - 0s 204us/step - loss: 0.0596 -
accuracy: 0.9846
Epoch 49/100
455/455 [==============================] - 0s 217us/step - loss: 0.0609 -
accuracy: 0.9846
Epoch 50/100
455/455 [==============================] - 0s 222us/step - loss: 0.0551 -
accuracy: 0.9846
Epoch 51/100
455/455 [==============================] - 0s 255us/step - loss: 0.0601 -
accuracy: 0.9758
Epoch 52/100
455/455 [==============================] - 0s 316us/step - loss: 0.0632 -
accuracy: 0.9802
Epoch 53/100
455/455 [==============================] - 0s 299us/step - loss: 0.0599 -
```

```
accuracy: 0.9824
Epoch 54/100
455/455 [==============================] - 0s 314us/step - loss: 0.0572 -
accuracy: 0.9802
Epoch 55/100
455/455 [==============================] - 0s 369us/step - loss: 0.0599 -
accuracy: 0.9758
Epoch 56/100
455/455 [==============================] - 0s 226us/step - loss: 0.0609 -
accuracy: 0.9758
Epoch 57/100
455/455 [==============================] - 0s 325us/step - loss: 0.0574 -
accuracy: 0.9824
Epoch 58/100
455/455 [==============================] - 0s 286us/step - loss: 0.0556 -
accuracy: 0.9824
Epoch 59/100
455/455 [==============================] - 0s 347us/step - loss: 0.0539 -
accuracy: 0.9824
Epoch 60/100
455/455 [==============================] - 0s 233us/step - loss: 0.0608 -
accuracy: 0.9736
Epoch 61/100
455/455 [==============================] - 0s 231us/step - loss: 0.0574 -
accuracy: 0.9868
Epoch 62/100
455/455 [==============================] - 0s 244us/step - loss: 0.0533 -
accuracy: 0.9802
Epoch 63/100
455/455 [==============================] - 0s 257us/step - loss: 0.0565 -
accuracy: 0.9824
Epoch 64/100
455/455 [==============================] - 0s 329us/step - loss: 0.0552 -
accuracy: 0.9802
Epoch 65/100
455/455 [==============================] - 0s 220us/step - loss: 0.0530 -
accuracy: 0.9824
Epoch 66/100
455/455 [==============================] - 0s 191us/step - loss: 0.0526 -
accuracy: 0.9846
Epoch 67/100
455/455 [==============================] - 0s 185us/step - loss: 0.0540 -
accuracy: 0.9802
Epoch 68/100
455/455 [==============================] - 0s 259us/step - loss: 0.0580 -
accuracy: 0.9758
Epoch 69/100
455/455 [==============================] - 0s 200us/step - loss: 0.0573 -
```

```
accuracy: 0.9846
Epoch 70/100
455/455 [==============================] - 0s 187us/step - loss: 0.0566 -
accuracy: 0.9824
Epoch 71/100
455/455 [==============================] - 0s 316us/step - loss: 0.0598 -
accuracy: 0.9780
Epoch 72/100
455/455 [==============================] - 0s 136us/step - loss: 0.0561 -
accuracy: 0.9824
Epoch 73/100
455/455 [==============================] - 0s 204us/step - loss: 0.0532 -
accuracy: 0.9824
Epoch 74/100
455/455 [==============================] - 0s 204us/step - loss: 0.0539 -
accuracy: 0.9802
Epoch 75/100
455/455 [==============================] - 0s 235us/step - loss: 0.0564 -
accuracy: 0.9846
Epoch 76/100
455/455 [==============================] - 0s 380us/step - loss: 0.0534 -
accuracy: 0.9824
Epoch 77/100
455/455 [==============================] - 0s 185us/step - loss: 0.0543 -
accuracy: 0.9824
Epoch 78/100
455/455 [==============================] - 0s 305us/step - loss: 0.0535 -
accuracy: 0.9802
Epoch 79/100
455/455 [==============================] - 0s 316us/step - loss: 0.0511 -
accuracy: 0.9868
Epoch 80/100
455/455 [==============================] - 0s 215us/step - loss: 0.0557 -
accuracy: 0.9824
Epoch 81/100
455/455 [==============================] - 0s 193us/step - loss: 0.0574 -
accuracy: 0.9758
Epoch 82/100
455/455 [==============================] - 0s 217us/step - loss: 0.0523 -
accuracy: 0.9824
Epoch 83/100
455/455 [==============================] - 0s 277us/step - loss: 0.0547 -
accuracy: 0.9758
Epoch 84/100
455/455 [==============================] - 0s 191us/step - loss: 0.0592 -
accuracy: 0.9824
Epoch 85/100
455/455 [==============================] - 0s 213us/step - loss: 0.0547 -
```

```
accuracy: 0.9824
Epoch 86/100
455/455 [==============================] - 0s 349us/step - loss: 0.0563 -
accuracy: 0.9802
Epoch 87/100
455/455 [==============================] - 0s 193us/step - loss: 0.0526 -
accuracy: 0.9824
Epoch 88/100
455/455 [==============================] - 0s 222us/step - loss: 0.0504 -
accuracy: 0.9846
Epoch 89/100
455/455 [==============================] - 0s 283us/step - loss: 0.0634 -
accuracy: 0.9846
Epoch 90/100
455/455 [==============================] - 0s 373us/step - loss: 0.0535 -
accuracy: 0.9758
Epoch 91/100
455/455 [==============================] - 0s 259us/step - loss: 0.0556 -
accuracy: 0.9824
Epoch 92/100
455/455 [==============================] - 0s 189us/step - loss: 0.0522 -
accuracy: 0.9824
Epoch 93/100
455/455 [==============================] - 0s 222us/step - loss: 0.0558 -
accuracy: 0.9824
Epoch 94/100
455/455 [==============================] - 0s 360us/step - loss: 0.0519 -
accuracy: 0.9802
Epoch 95/100
455/455 [==============================] - 0s 174us/step - loss: 0.0530 -
accuracy: 0.9846
Epoch 96/100
455/455 [==============================] - 0s 272us/step - loss: 0.0566 -
accuracy: 0.9802
Epoch 97/100
455/455 [==============================] - 0s 261us/step - loss: 0.0547 -
accuracy: 0.9824
Epoch 98/100
455/455 [==============================] - 0s 276us/step - loss: 0.0541 -
accuracy: 0.9802
Epoch 99/100
455/455 [==============================] - 0s 188us/step - loss: 0.0494 -
accuracy: 0.9824
Epoch 100/100
455/455 [==============================] - 0s 289us/step - loss: 0.0504 -
accuracy: 0.9780
```

```
[0]: best_parameters
```

```
[0]: {'batch_size': 10, 'epochs': 100}
```

1.15 Applying ANN with the optimized values of hyperparameters

```
[0]: from keras.models import Sequential
     from keras.layers import Dense
```

```
[0]: classifier=Sequential()
```

```
[0]: classifier.add(Dense(units = 16, kernel_initializer = 'uniform', activation =␣
     ↪'relu', input_dim = 30))
     classifier.add(Dense(units = 16, kernel_initializer = 'uniform', activation =␣
     ↪'relu'))
     classifier.add(Dense(units = 1, kernel_initializer = 'uniform', activation =␣
     ↪'sigmoid'))
     classifier.
     ↪compile(optimizer='adam',loss='binary_crossentropy',metrics=['accuracy'])
     history=classifier.fit(train_x,train_y,epochs=100,batch_size=30,validation_data␣
     ↪= (test_x,test_y))
```

```
Train on 455 samples, validate on 114 samples
Epoch 1/100
455/455 [==============================] - 1s 1ms/step - loss: 0.6918 -
accuracy: 0.6198 - val_loss: 0.6915 - val_accuracy: 0.5877
Epoch 2/100
455/455 [==============================] - 0s 152us/step - loss: 0.6892 -
accuracy: 0.6374 - val_loss: 0.6891 - val_accuracy: 0.5877
Epoch 3/100
455/455 [==============================] - 0s 123us/step - loss: 0.6855 -
accuracy: 0.6374 - val_loss: 0.6850 - val_accuracy: 0.5877
Epoch 4/100
455/455 [==============================] - 0s 119us/step - loss: 0.6789 -
accuracy: 0.6374 - val_loss: 0.6774 - val_accuracy: 0.5877
Epoch 5/100
455/455 [==============================] - 0s 88us/step - loss: 0.6670 -
accuracy: 0.6505 - val_loss: 0.6632 - val_accuracy: 0.6228
Epoch 6/100
455/455 [==============================] - 0s 99us/step - loss: 0.6476 -
accuracy: 0.7297 - val_loss: 0.6400 - val_accuracy: 0.6842
Epoch 7/100
455/455 [==============================] - 0s 125us/step - loss: 0.6184 -
accuracy: 0.7758 - val_loss: 0.6054 - val_accuracy: 0.7982
Epoch 8/100
455/455 [==============================] - 0s 127us/step - loss: 0.5785 -
accuracy: 0.8330 - val_loss: 0.5589 - val_accuracy: 0.8684
Epoch 9/100
```

```
455/455 [==============================] - 0s 64us/step - loss: 0.5284 -
accuracy: 0.8857 - val_loss: 0.5017 - val_accuracy: 0.9035
Epoch 10/100
455/455 [==============================] - 0s 92us/step - loss: 0.4722 -
accuracy: 0.8967 - val_loss: 0.4458 - val_accuracy: 0.9123
Epoch 11/100
455/455 [==============================] - 0s 103us/step - loss: 0.4151 -
accuracy: 0.9077 - val_loss: 0.3915 - val_accuracy: 0.9035
Epoch 12/100
455/455 [==============================] - 0s 187us/step - loss: 0.3643 -
accuracy: 0.9231 - val_loss: 0.3439 - val_accuracy: 0.9123
Epoch 13/100
455/455 [==============================] - 0s 81us/step - loss: 0.3211 -
accuracy: 0.9275 - val_loss: 0.3074 - val_accuracy: 0.9211
Epoch 14/100
455/455 [==============================] - 0s 59us/step - loss: 0.2883 -
accuracy: 0.9253 - val_loss: 0.2779 - val_accuracy: 0.9123
Epoch 15/100
455/455 [==============================] - 0s 57us/step - loss: 0.2599 -
accuracy: 0.9341 - val_loss: 0.2570 - val_accuracy: 0.9211
Epoch 16/100
455/455 [==============================] - 0s 125us/step - loss: 0.2386 -
accuracy: 0.9275 - val_loss: 0.2389 - val_accuracy: 0.9035
Epoch 17/100
455/455 [==============================] - 0s 202us/step - loss: 0.2195 -
accuracy: 0.9341 - val_loss: 0.2271 - val_accuracy: 0.9298
Epoch 18/100
455/455 [==============================] - 0s 81us/step - loss: 0.2056 -
accuracy: 0.9385 - val_loss: 0.2170 - val_accuracy: 0.9298
Epoch 19/100
455/455 [==============================] - 0s 191us/step - loss: 0.1951 -
accuracy: 0.9297 - val_loss: 0.2068 - val_accuracy: 0.9123
Epoch 20/100
455/455 [==============================] - 0s 103us/step - loss: 0.1845 -
accuracy: 0.9363 - val_loss: 0.1999 - val_accuracy: 0.9211
Epoch 21/100
455/455 [==============================] - 0s 55us/step - loss: 0.1764 -
accuracy: 0.9385 - val_loss: 0.1943 - val_accuracy: 0.9211
Epoch 22/100
455/455 [==============================] - 0s 81us/step - loss: 0.1679 -
accuracy: 0.9407 - val_loss: 0.1894 - val_accuracy: 0.9035
Epoch 23/100
455/455 [==============================] - 0s 132us/step - loss: 0.1650 -
accuracy: 0.9407 - val_loss: 0.1848 - val_accuracy: 0.9123
Epoch 24/100
455/455 [==============================] - 0s 116us/step - loss: 0.1556 -
accuracy: 0.9429 - val_loss: 0.1812 - val_accuracy: 0.9035
Epoch 25/100
```

```
455/455 [==============================] - 0s 125us/step - loss: 0.1520 -
accuracy: 0.9473 - val_loss: 0.1766 - val_accuracy: 0.9123
Epoch 26/100
455/455 [==============================] - 0s 136us/step - loss: 0.1485 -
accuracy: 0.9473 - val_loss: 0.1732 - val_accuracy: 0.9035
Epoch 27/100
455/455 [==============================] - 0s 187us/step - loss: 0.1435 -
accuracy: 0.9495 - val_loss: 0.1699 - val_accuracy: 0.9386
Epoch 28/100
455/455 [==============================] - 0s 99us/step - loss: 0.1399 -
accuracy: 0.9538 - val_loss: 0.1677 - val_accuracy: 0.9035
Epoch 29/100
455/455 [==============================] - 0s 187us/step - loss: 0.1334 -
accuracy: 0.9516 - val_loss: 0.1649 - val_accuracy: 0.9386
Epoch 30/100
455/455 [==============================] - 0s 167us/step - loss: 0.1300 -
accuracy: 0.9560 - val_loss: 0.1630 - val_accuracy: 0.9123
Epoch 31/100
455/455 [==============================] - 0s 88us/step - loss: 0.1276 -
accuracy: 0.9538 - val_loss: 0.1594 - val_accuracy: 0.9211
Epoch 32/100
455/455 [==============================] - 0s 64us/step - loss: 0.1227 -
accuracy: 0.9692 - val_loss: 0.1565 - val_accuracy: 0.9298
Epoch 33/100
455/455 [==============================] - 0s 59us/step - loss: 0.1220 -
accuracy: 0.9538 - val_loss: 0.1536 - val_accuracy: 0.9386
Epoch 34/100
455/455 [==============================] - 0s 59us/step - loss: 0.1198 -
accuracy: 0.9538 - val_loss: 0.1529 - val_accuracy: 0.9211
Epoch 35/100
455/455 [==============================] - 0s 64us/step - loss: 0.1152 -
accuracy: 0.9648 - val_loss: 0.1488 - val_accuracy: 0.9386
Epoch 36/100
455/455 [==============================] - 0s 81us/step - loss: 0.1120 -
accuracy: 0.9604 - val_loss: 0.1486 - val_accuracy: 0.9211
Epoch 37/100
455/455 [==============================] - 0s 134us/step - loss: 0.1104 -
accuracy: 0.9670 - val_loss: 0.1451 - val_accuracy: 0.9386
Epoch 38/100
455/455 [==============================] - 0s 81us/step - loss: 0.1087 -
accuracy: 0.9604 - val_loss: 0.1433 - val_accuracy: 0.9474
Epoch 39/100
455/455 [==============================] - 0s 59us/step - loss: 0.1047 -
accuracy: 0.9692 - val_loss: 0.1433 - val_accuracy: 0.9298
Epoch 40/100
455/455 [==============================] - 0s 81us/step - loss: 0.1022 -
accuracy: 0.9714 - val_loss: 0.1398 - val_accuracy: 0.9386
Epoch 41/100
```

```
455/455 [==============================] - 0s 158us/step - loss: 0.1015 -
accuracy: 0.9670 - val_loss: 0.1389 - val_accuracy: 0.9474
Epoch 42/100
455/455 [==============================] - 0s 99us/step - loss: 0.1003 -
accuracy: 0.9670 - val_loss: 0.1382 - val_accuracy: 0.9298
Epoch 43/100
455/455 [==============================] - 0s 143us/step - loss: 0.0978 -
accuracy: 0.9714 - val_loss: 0.1355 - val_accuracy: 0.9386
Epoch 44/100
455/455 [==============================] - 0s 141us/step - loss: 0.0969 -
accuracy: 0.9670 - val_loss: 0.1344 - val_accuracy: 0.9386
Epoch 45/100
455/455 [==============================] - 0s 156us/step - loss: 0.0942 -
accuracy: 0.9736 - val_loss: 0.1336 - val_accuracy: 0.9386
Epoch 46/100
455/455 [==============================] - 0s 110us/step - loss: 0.0918 -
accuracy: 0.9736 - val_loss: 0.1317 - val_accuracy: 0.9386
Epoch 47/100
455/455 [==============================] - 0s 149us/step - loss: 0.0946 -
accuracy: 0.9714 - val_loss: 0.1288 - val_accuracy: 0.9649
Epoch 48/100
455/455 [==============================] - 0s 86us/step - loss: 0.0921 -
accuracy: 0.9714 - val_loss: 0.1336 - val_accuracy: 0.9298
Epoch 49/100
455/455 [==============================] - 0s 132us/step - loss: 0.0886 -
accuracy: 0.9714 - val_loss: 0.1267 - val_accuracy: 0.9649
Epoch 50/100
455/455 [==============================] - 0s 72us/step - loss: 0.0876 -
accuracy: 0.9692 - val_loss: 0.1283 - val_accuracy: 0.9649
Epoch 51/100
455/455 [==============================] - 0s 59us/step - loss: 0.0844 -
accuracy: 0.9736 - val_loss: 0.1254 - val_accuracy: 0.9561
Epoch 52/100
455/455 [==============================] - 0s 59us/step - loss: 0.0834 -
accuracy: 0.9758 - val_loss: 0.1248 - val_accuracy: 0.9561
Epoch 53/100
455/455 [==============================] - 0s 160us/step - loss: 0.0826 -
accuracy: 0.9758 - val_loss: 0.1248 - val_accuracy: 0.9649
Epoch 54/100
455/455 [==============================] - 0s 101us/step - loss: 0.0813 -
accuracy: 0.9780 - val_loss: 0.1238 - val_accuracy: 0.9649
Epoch 55/100
455/455 [==============================] - 0s 167us/step - loss: 0.0799 -
accuracy: 0.9802 - val_loss: 0.1237 - val_accuracy: 0.9649
Epoch 56/100
455/455 [==============================] - 0s 143us/step - loss: 0.0801 -
accuracy: 0.9736 - val_loss: 0.1236 - val_accuracy: 0.9649
Epoch 57/100
```

```
455/455 [==============================] - 0s 59us/step - loss: 0.0781 -
accuracy: 0.9802 - val_loss: 0.1241 - val_accuracy: 0.9649
Epoch 58/100
455/455 [==============================] - 0s 59us/step - loss: 0.0781 -
accuracy: 0.9802 - val_loss: 0.1219 - val_accuracy: 0.9649
Epoch 59/100
455/455 [==============================] - 0s 57us/step - loss: 0.0769 -
accuracy: 0.9846 - val_loss: 0.1221 - val_accuracy: 0.9649
Epoch 60/100
455/455 [==============================] - 0s 64us/step - loss: 0.0759 -
accuracy: 0.9780 - val_loss: 0.1226 - val_accuracy: 0.9649
Epoch 61/100
455/455 [==============================] - 0s 81us/step - loss: 0.0760 -
accuracy: 0.9780 - val_loss: 0.1210 - val_accuracy: 0.9649
Epoch 62/100
455/455 [==============================] - 0s 66us/step - loss: 0.0735 -
accuracy: 0.9846 - val_loss: 0.1219 - val_accuracy: 0.9649
Epoch 63/100
455/455 [==============================] - 0s 97us/step - loss: 0.0758 -
accuracy: 0.9758 - val_loss: 0.1216 - val_accuracy: 0.9649
Epoch 64/100
455/455 [==============================] - 0s 70us/step - loss: 0.0796 -
accuracy: 0.9780 - val_loss: 0.1264 - val_accuracy: 0.9649
Epoch 65/100
455/455 [==============================] - 0s 116us/step - loss: 0.0723 -
accuracy: 0.9802 - val_loss: 0.1199 - val_accuracy: 0.9737
Epoch 66/100
455/455 [==============================] - 0s 121us/step - loss: 0.0726 -
accuracy: 0.9780 - val_loss: 0.1205 - val_accuracy: 0.9649
Epoch 67/100
455/455 [==============================] - 0s 64us/step - loss: 0.0703 -
accuracy: 0.9824 - val_loss: 0.1205 - val_accuracy: 0.9649
Epoch 68/100
455/455 [==============================] - 0s 75us/step - loss: 0.0706 -
accuracy: 0.9802 - val_loss: 0.1194 - val_accuracy: 0.9649
Epoch 69/100
455/455 [==============================] - 0s 59us/step - loss: 0.0688 -
accuracy: 0.9802 - val_loss: 0.1205 - val_accuracy: 0.9649
Epoch 70/100
455/455 [==============================] - 0s 81us/step - loss: 0.0690 -
accuracy: 0.9868 - val_loss: 0.1193 - val_accuracy: 0.9649
Epoch 71/100
455/455 [==============================] - 0s 130us/step - loss: 0.0675 -
accuracy: 0.9824 - val_loss: 0.1211 - val_accuracy: 0.9649
Epoch 72/100
455/455 [==============================] - 0s 64us/step - loss: 0.0681 -
accuracy: 0.9846 - val_loss: 0.1193 - val_accuracy: 0.9737
Epoch 73/100
```

```
455/455 [==============================] - 0s 57us/step - loss: 0.0668 -
accuracy: 0.9846 - val_loss: 0.1201 - val_accuracy: 0.9649
Epoch 74/100
455/455 [==============================] - 0s 130us/step - loss: 0.0670 -
accuracy: 0.9802 - val_loss: 0.1202 - val_accuracy: 0.9649
Epoch 75/100
455/455 [==============================] - 0s 66us/step - loss: 0.0663 -
accuracy: 0.9846 - val_loss: 0.1198 - val_accuracy: 0.9649
Epoch 76/100
455/455 [==============================] - 0s 77us/step - loss: 0.0651 -
accuracy: 0.9824 - val_loss: 0.1206 - val_accuracy: 0.9649
Epoch 77/100
455/455 [==============================] - 0s 64us/step - loss: 0.0654 -
accuracy: 0.9824 - val_loss: 0.1205 - val_accuracy: 0.9649
Epoch 78/100
455/455 [==============================] - 0s 163us/step - loss: 0.0654 -
accuracy: 0.9846 - val_loss: 0.1202 - val_accuracy: 0.9649
Epoch 79/100
455/455 [==============================] - 0s 119us/step - loss: 0.0660 -
accuracy: 0.9846 - val_loss: 0.1215 - val_accuracy: 0.9649
Epoch 80/100
455/455 [==============================] - 0s 88us/step - loss: 0.0650 -
accuracy: 0.9802 - val_loss: 0.1206 - val_accuracy: 0.9649
Epoch 81/100
455/455 [==============================] - 0s 145us/step - loss: 0.0666 -
accuracy: 0.9824 - val_loss: 0.1204 - val_accuracy: 0.9737
Epoch 82/100
455/455 [==============================] - 0s 156us/step - loss: 0.0651 -
accuracy: 0.9824 - val_loss: 0.1202 - val_accuracy: 0.9737
Epoch 83/100
455/455 [==============================] - 0s 134us/step - loss: 0.0624 -
accuracy: 0.9846 - val_loss: 0.1212 - val_accuracy: 0.9649
Epoch 84/100
455/455 [==============================] - 0s 178us/step - loss: 0.0638 -
accuracy: 0.9824 - val_loss: 0.1204 - val_accuracy: 0.9737
Epoch 85/100
455/455 [==============================] - 0s 66us/step - loss: 0.0642 -
accuracy: 0.9802 - val_loss: 0.1222 - val_accuracy: 0.9649
Epoch 86/100
455/455 [==============================] - 0s 57us/step - loss: 0.0648 -
accuracy: 0.9780 - val_loss: 0.1218 - val_accuracy: 0.9737
Epoch 87/100
455/455 [==============================] - 0s 86us/step - loss: 0.0643 -
accuracy: 0.9846 - val_loss: 0.1228 - val_accuracy: 0.9649
Epoch 88/100
455/455 [==============================] - 0s 132us/step - loss: 0.0728 -
accuracy: 0.9714 - val_loss: 0.1218 - val_accuracy: 0.9737
Epoch 89/100
```

```
455/455 [==============================] - 0s 152us/step - loss: 0.0623 -
accuracy: 0.9846 - val_loss: 0.1240 - val_accuracy: 0.9561
Epoch 90/100
455/455 [==============================] - 0s 154us/step - loss: 0.0604 -
accuracy: 0.9824 - val_loss: 0.1215 - val_accuracy: 0.9737
Epoch 91/100
455/455 [==============================] - 0s 61us/step - loss: 0.0611 -
accuracy: 0.9868 - val_loss: 0.1220 - val_accuracy: 0.9649
Epoch 92/100
455/455 [==============================] - 0s 59us/step - loss: 0.0606 -
accuracy: 0.9868 - val_loss: 0.1221 - val_accuracy: 0.9737
Epoch 93/100
455/455 [==============================] - 0s 59us/step - loss: 0.0605 -
accuracy: 0.9824 - val_loss: 0.1228 - val_accuracy: 0.9649
Epoch 94/100
455/455 [==============================] - 0s 101us/step - loss: 0.0618 -
accuracy: 0.9824 - val_loss: 0.1228 - val_accuracy: 0.9737
Epoch 95/100
455/455 [==============================] - 0s 72us/step - loss: 0.0585 -
accuracy: 0.9802 - val_loss: 0.1246 - val_accuracy: 0.9649
Epoch 96/100
455/455 [==============================] - 0s 62us/step - loss: 0.0595 -
accuracy: 0.9824 - val_loss: 0.1229 - val_accuracy: 0.9649
Epoch 97/100
455/455 [==============================] - 0s 124us/step - loss: 0.0589 -
accuracy: 0.9868 - val_loss: 0.1231 - val_accuracy: 0.9649
Epoch 98/100
455/455 [==============================] - ETA: 0s - loss: 0.0207 - accuracy:
1.00 - 0s 89us/step - loss: 0.0597 - accuracy: 0.9846 - val_loss: 0.1231 -
val_accuracy: 0.9649
Epoch 99/100
455/455 [==============================] - 0s 168us/step - loss: 0.0583 -
accuracy: 0.9868 - val_loss: 0.1231 - val_accuracy: 0.9649
Epoch 100/100
455/455 [==============================] - 0s 111us/step - loss: 0.0581 -
accuracy: 0.9868 - val_loss: 0.1242 - val_accuracy: 0.9649
```

```
[0]: history.history.keys()
```

```
[0]: dict_keys(['val_loss', 'val_accuracy', 'loss', 'accuracy'])
```

```
[0]: accuracy = history.history['accuracy']
     val_accuracy = history.history['val_accuracy']
     loss = history.history['loss']
     val_loss = history.history['val_loss']

     epochs = range(len(accuracy))
```

```python
plt.plot(epochs, accuracy, 'ro', label='Training Accuracy')
plt.plot(epochs, val_accuracy, 'b', label='Validation Accuracy')
plt.title('Training and Validation accuracy')
plt.legend()
```

[0]: <matplotlib.legend.Legend at 0x138271eaa20>
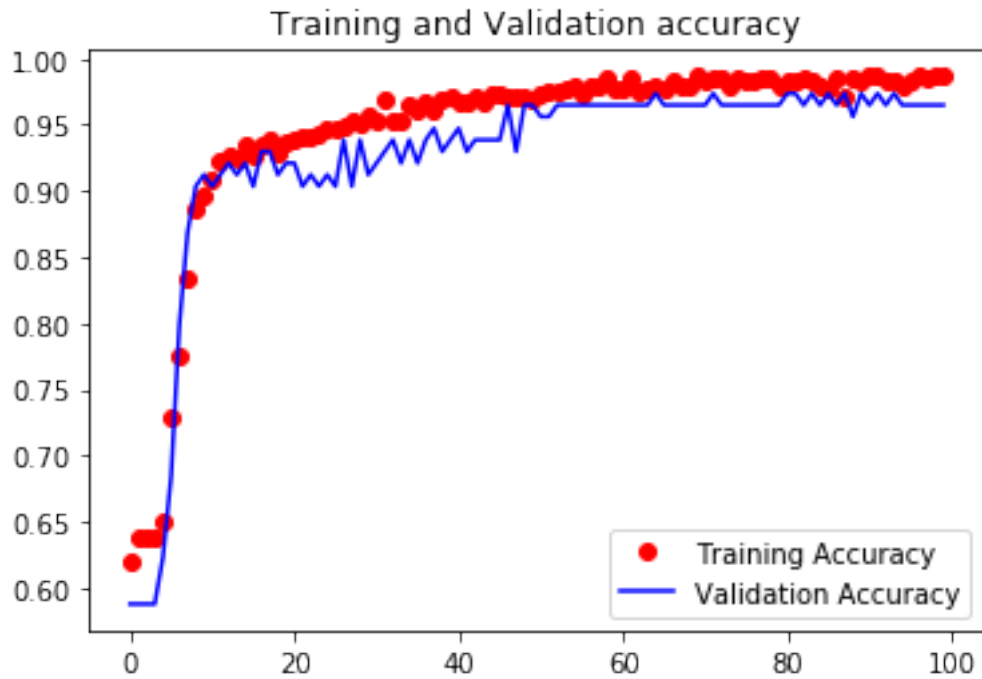
[0]:
```python
plt.plot(epochs, loss, 'ro', label='Training Loss')
plt.plot(epochs, val_loss, 'b', label='Validation Loss')
plt.title('Training and validation loss')
plt.legend()
plt.show()
```

Training and validation loss
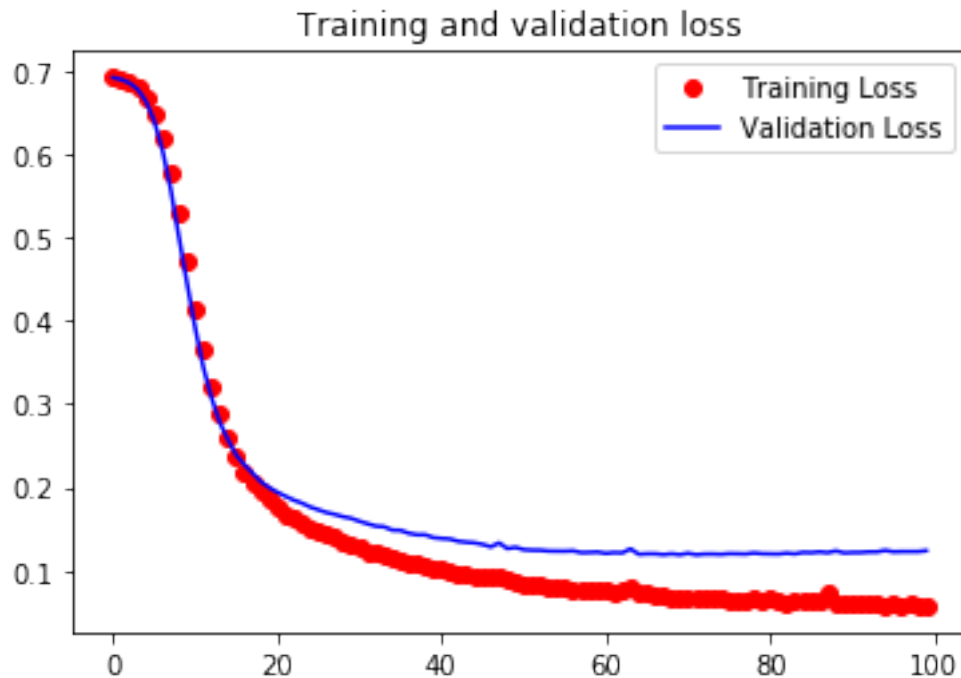
1.16 Predictions on test data

```
[0]: y_pred = classifier.predict(test_x)
     #probability showing the individual having breast cancer (Malignant)
     #probability over 50% would indicate the presence of breast cancer

     y_pred = (y_pred > 0.5)    #Converting the probabilities into 'true' and 'false'
```
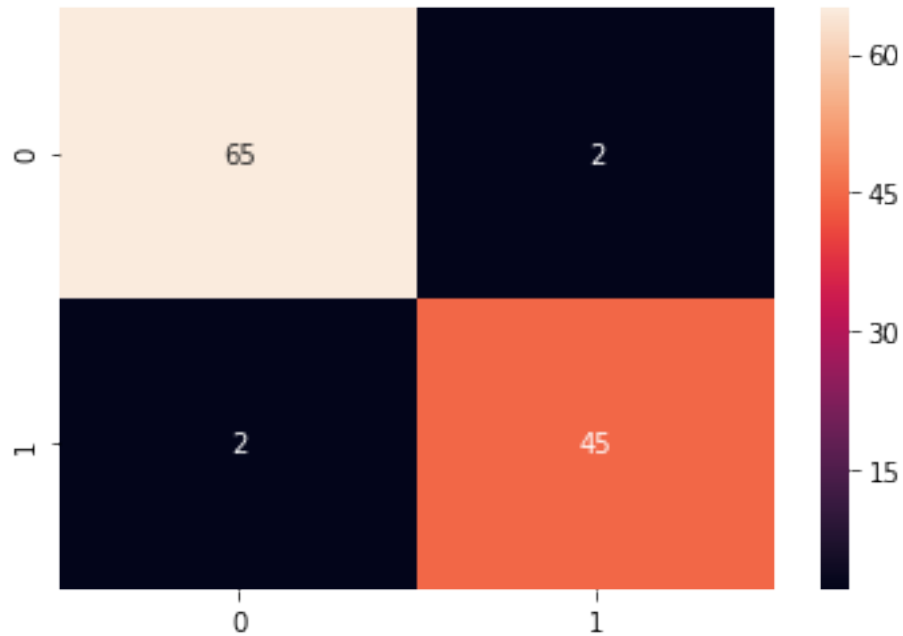
1.17 Confusion matrix and heatmap for visualizing the accuracy of ANN on test data

```
[0]: from sklearn.metrics import confusion_matrix
     cm = confusion_matrix(test_y, y_pred)
     cm
```

```
[0]: array([[65,  2],
            [ 2, 45]], dtype=int64)
```

```
[0]: sns.heatmap(cm,annot=True)
```

```
[0]: <matplotlib.axes._subplots.AxesSubplot at 0x1381ec89780>
```

1.18 Accuracy on test data

```
[0]: print("Accuracy Score:",round((cm[0,0]+cm[1,1])/
     ↪(cm[0,0]+cm[0,1]+cm[1,0]+cm[1,1])*100,2))
```

Accuracy Score: 96.49

2 End of Project.