HW1_part2

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1 CS 84020 Neural Networks and Deep Learning

Homework 1

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2 PART2

3 Listing 6

Load libraries. Load the Wisconsin Diagnostic Breast Cancer dataset. Data Visualization. Analysis The list of pairwise Pearson correlation of data shows that 'perimeter_mean' and 'radius_mean' have the largest correlation among all the 30 attributes. From the correlation matrix, we conclude that the 'perimeter', 'radius' and 'area' are highly correlated because the mean, se and worst value of these three attributes have have large correlation. On the other hand, 'texture' is less related to all of the three. 'fractal_dimension', 'texture', 'symmetry' and 'smoothness' are four features that have the least correlation with other features. The skew of data shows that 'area_se' has the most positive skew. This means 'area_se' has some extreme larger data. We can also conclude this from the density plot: For 'area_se', the tail on the right is longer than the tail on the left, because there are a few variables that have large values, which makes the tail on the right side of the curve longer.

a) Load libraries.

[1]:

```
# Load libraries
from pandas import read_csv, set_option
from pandas.plotting import scatter_matrix
from matplotlib import pyplot as plt
import seaborn as sns
import pandas as pd
import numpy as np
from google.colab import data_table
from sklearn.model_selection import train_test_split
from sklearn.model_selection import KFold
from sklearn.model_selection import cross_val_score
from sklearn.metrics import classification_report
from sklearn.metrics import confusion_matrix
from sklearn.metrics import accuracy_score
from sklearn.linear_model import LogisticRegression
from sklearn.tree import DecisionTreeClassifier
from sklearn.neighbors import KNeighborsClassifier
from sklearn.discriminant_analysis import LinearDiscriminantAnalysis
from sklearn.naive_bayes import GaussianNB
from sklearn.svm import SVC
from sklearn.preprocessing import MinMaxScaler, StandardScaler, Normalizer,␣
 ↪Binarizer
```

[2]:

```
# Set options
set_option('display.max_columns', 32)

# plt.style.use('seaborn-talk')
plt.style.use('seaborn-white')
```

b) Load the dataset.

[3]:

```
# Load dataset
filename = 'http://archive.ics.uci.edu/ml/machine-learning-databases/
 ↪breast-cancer-wisconsin/wdbc.data'
colnames = ['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']
dataset = read_csv(filename, names=colnames, header=None)
```

[4]:

```
# drop `id` identifier
dataset = dataset.drop(['id'], 1)

# recode target labels to 0 and 1
dataset['diagnosis'] = dataset['diagnosis'].map({'B':0, 'M':1})
dataset.head(3)
```

[4]:

```
   diagnosis  radius_mean  texture_mean  perimeter_mean  area_mean  \
0          1        17.99         10.38           122.8     1001.0
1          1        20.57         17.77           132.9     1326.0
2          1        19.69         21.25           130.0     1203.0
```

```
   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   

   symmetry_mean  fractal_dimension_mean  radius_se  texture_se  perimeter_se  \
0         0.2419                 0.07871     1.0950      0.9053         8.589   
1         0.1812                 0.05667     0.5435      0.7339         3.398   
2         0.2069                 0.05999     0.7456      0.7869         4.585   

   area_se  smoothness_se  compactness_se  concavity_se  concave_points_se  \
0   153.40       0.006399         0.04904       0.05373            0.01587   
1    74.08       0.005225         0.01308       0.01860            0.01340   
2    94.03       0.006150         0.04006       0.03832            0.02058   

   symmetry_se  fractal_dimension_se  radius_worst  texture_worst  \
0      0.03003              0.006193         25.38          17.33   
1      0.01389              0.003532         24.99          23.41   
2      0.02250              0.004571         23.57          25.53   

   perimeter_worst  area_worst  smoothness_worst  compactness_worst  \
0            184.6      2019.0            0.1622             0.6656   
1            158.8      1956.0            0.1238             0.1866   
2            152.5      1709.0            0.1444             0.4245   

   concavity_worst  concave_points_worst  symmetry_worst  \
0           0.7119                0.2654          0.4601   
1           0.2416                0.1860          0.2750   
2           0.4504                0.2430          0.3613   

   fractal_dimension_worst  
0                  0.11890  
1                  0.08902  
2                  0.08758  
```

c) Data visualization.

Pairwise Pearson Correlation

[5]:

```
features_pearson = list(dataset.columns[1:32])
dataset[features_pearson].corr(method='pearson')
```

[5]:

```
                         radius_mean  texture_mean  perimeter_mean  area_mean  \
radius_mean                 1.000000      0.323782        0.997855   0.987357   
texture_mean                0.323782      1.000000        0.329533   0.321086   
perimeter_mean              0.997855      0.329533        1.000000   0.986507   
area_mean                   0.987357      0.321086        0.986507   1.000000   
smoothness_mean             0.170581     -0.023389        0.207278   0.177028   
```

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

                         smoothness_mean  compactness_mean  concavity_mean  \
radius_mean                     0.170581          0.506124        0.676764
texture_mean                   -0.023389          0.236702        0.302418
perimeter_mean                  0.207278          0.556936        0.716136
area_mean                       0.177028          0.498502        0.685983
smoothness_mean                 1.000000          0.659123        0.521984
compactness_mean                0.659123          1.000000        0.883121
concavity_mean                  0.521984          0.883121        1.000000
concave_points_mean             0.553695          0.831135        0.921391
symmetry_mean                   0.557775          0.602641        0.500667
fractal_dimension_mean          0.584792          0.565369        0.336783
radius_se                       0.301467          0.497473        0.631925
texture_se                      0.068406          0.046205        0.076218
perimeter_se                    0.296092          0.548905        0.660391
area_se                         0.246552          0.455653        0.617427
smoothness_se                   0.332375          0.135299        0.098564
compactness_se                  0.318943          0.738722        0.670279
concavity_se                    0.248396          0.570517        0.691270
concave_points_se               0.380676          0.642262        0.683260
symmetry_se                     0.200774          0.229977        0.178009
fractal_dimension_se            0.283607          0.507318        0.449301
```

```
radius_worst                    0.213120          0.535315        0.688236
texture_worst                   0.036072          0.248133        0.299879
perimeter_worst                 0.238853          0.590210        0.729565
area_worst                      0.206718          0.509604        0.675987
smoothness_worst                0.805324          0.565541        0.448822
compactness_worst               0.472468          0.865809        0.754968
concavity_worst                 0.434926          0.816275        0.884103
concave_points_worst            0.503053          0.815573        0.861323
symmetry_worst                  0.394309          0.510223        0.409464
fractal_dimension_worst         0.499316          0.687382        0.514930

                         concave_points_mean  symmetry_mean  \
radius_mean                         0.822529       0.147741
texture_mean                        0.293464       0.071401
perimeter_mean                      0.850977       0.183027
area_mean                           0.823269       0.151293
smoothness_mean                     0.553695       0.557775
compactness_mean                    0.831135       0.602641
concavity_mean                      0.921391       0.500667
concave_points_mean                 1.000000       0.462497
symmetry_mean                       0.462497       1.000000
fractal_dimension_mean              0.166917       0.479921
radius_se                           0.698050       0.303379
texture_se                          0.021480       0.128053
perimeter_se                        0.710650       0.313893
area_se                             0.690299       0.223970
smoothness_se                       0.027653       0.187321
compactness_se                      0.490424       0.421659
concavity_se                        0.439167       0.342627
concave_points_se                   0.615634       0.393298
symmetry_se                         0.095351       0.449137
fractal_dimension_se                0.257584       0.331786
radius_worst                        0.830318       0.185728
texture_worst                       0.292752       0.090651
perimeter_worst                     0.855923       0.219169
area_worst                          0.809630       0.177193
smoothness_worst                    0.452753       0.426675
compactness_worst                   0.667454       0.473200
concavity_worst                     0.752399       0.433721
concave_points_worst                0.910155       0.430297
symmetry_worst                      0.375744       0.699826
fractal_dimension_worst             0.368661       0.438413

                         fractal_dimension_mean  radius_se  texture_se  \
radius_mean                           -0.311631   0.679090   -0.097317
texture_mean                          -0.076437   0.275869    0.386358
perimeter_mean                        -0.261477   0.691765   -0.086761
```

```
area_mean                             -0.283110   0.732562   -0.066280
smoothness_mean                        0.584792   0.301467    0.068406
compactness_mean                       0.565369   0.497473    0.046205
concavity_mean                         0.336783   0.631925    0.076218
concave_points_mean                    0.166917   0.698050    0.021480
symmetry_mean                          0.479921   0.303379    0.128053
fractal_dimension_mean                 1.000000   0.000111    0.164174
radius_se                              0.000111   1.000000    0.213247
texture_se                             0.164174   0.213247    1.000000
perimeter_se                           0.039830   0.972794    0.223171
area_se                               -0.090170   0.951830    0.111567
smoothness_se                          0.401964   0.164514    0.397243
compactness_se                         0.559837   0.356065    0.231700
concavity_se                           0.446630   0.332358    0.194998
concave_points_se                      0.341198   0.513346    0.230283
symmetry_se                            0.345007   0.240567    0.411621
fractal_dimension_se                   0.688132   0.227754    0.279723
radius_worst                          -0.253691   0.715065   -0.111690
texture_worst                         -0.051269   0.194799    0.409003
perimeter_worst                       -0.205151   0.719684   -0.102242
area_worst                            -0.231854   0.751548   -0.083195
smoothness_worst                       0.504942   0.141919   -0.073658
compactness_worst                      0.458798   0.287103   -0.092439
concavity_worst                        0.346234   0.380585   -0.068956
concave_points_worst                   0.175325   0.531062   -0.119638
symmetry_worst                         0.334019   0.094543   -0.128215
fractal_dimension_worst                0.767297   0.049559   -0.045655

                         perimeter_se   area_se  smoothness_se  \
radius_mean                  0.674172  0.735864      -0.222600
texture_mean                 0.281673  0.259845       0.006614
perimeter_mean               0.693135  0.744983      -0.202694
area_mean                    0.726628  0.800086      -0.166777
smoothness_mean              0.296092  0.246552       0.332375
compactness_mean             0.548905  0.455653       0.135299
concavity_mean               0.660391  0.617427       0.098564
concave_points_mean          0.710650  0.690299       0.027653
symmetry_mean                0.313893  0.223970       0.187321
fractal_dimension_mean       0.039830 -0.090170       0.401964
radius_se                    0.972794  0.951830       0.164514
texture_se                   0.223171  0.111567       0.397243
perimeter_se                 1.000000  0.937655       0.151075
area_se                      0.937655  1.000000       0.075150
smoothness_se                0.151075  0.075150       1.000000
compactness_se               0.416322  0.284840       0.336696
concavity_se                 0.362482  0.270895       0.268685
concave_points_se            0.556264  0.415730       0.328429
```

```
symmetry_se                  0.266487  0.134109       0.413506
fractal_dimension_se         0.244143  0.127071       0.427374
radius_worst                 0.697201  0.757373      -0.230691
texture_worst                0.200371  0.196497      -0.074743
perimeter_worst              0.721031  0.761213      -0.217304
area_worst                   0.730713  0.811408      -0.182195
smoothness_worst             0.130054  0.125389       0.314457
compactness_worst            0.341919  0.283257      -0.055558
concavity_worst              0.418899  0.385100      -0.058298
concave_points_worst         0.554897  0.538166      -0.102007
symmetry_worst               0.109930  0.074126      -0.107342
fractal_dimension_worst      0.085433  0.017539       0.101480

                         compactness_se  concavity_se  concave_points_se  \
radius_mean                    0.206000      0.194204           0.376169
texture_mean                   0.191975      0.143293           0.163851
perimeter_mean                 0.250744      0.228082           0.407217
area_mean                      0.212583      0.207660           0.372320
smoothness_mean                0.318943      0.248396           0.380676
compactness_mean               0.738722      0.570517           0.642262
concavity_mean                 0.670279      0.691270           0.683260
concave_points_mean            0.490424      0.439167           0.615634
symmetry_mean                  0.421659      0.342627           0.393298
fractal_dimension_mean         0.559837      0.446630           0.341198
radius_se                      0.356065      0.332358           0.513346
texture_se                     0.231700      0.194998           0.230283
perimeter_se                   0.416322      0.362482           0.556264
area_se                        0.284840      0.270895           0.415730
smoothness_se                  0.336696      0.268685           0.328429
compactness_se                 1.000000      0.801268           0.744083
concavity_se                   0.801268      1.000000           0.771804
concave_points_se              0.744083      0.771804           1.000000
symmetry_se                    0.394713      0.309429           0.312780
fractal_dimension_se           0.803269      0.727372           0.611044
radius_worst                   0.204607      0.186904           0.358127
texture_worst                  0.143003      0.100241           0.086741
perimeter_worst                0.260516      0.226680           0.394999
area_worst                     0.199371      0.188353           0.342271
smoothness_worst               0.227394      0.168481           0.215351
compactness_worst              0.678780      0.484858           0.452888
concavity_worst                0.639147      0.662564           0.549592
concave_points_worst           0.483208      0.440472           0.602450
symmetry_worst                 0.277878      0.197788           0.143116
fractal_dimension_worst        0.590973      0.439329           0.310655

                         symmetry_se  fractal_dimension_se  radius_worst  \
radius_mean                -0.104321             -0.042641      0.969539
```

```
texture_mean                0.009127              0.054458      0.352573
perimeter_mean             -0.081629             -0.005523      0.969476
area_mean                  -0.072497             -0.019887      0.962746
smoothness_mean             0.200774              0.283607      0.213120
compactness_mean            0.229977              0.507318      0.535315
concavity_mean              0.178009              0.449301      0.688236
concave_points_mean         0.095351              0.257584      0.830318
symmetry_mean               0.449137              0.331786      0.185728
fractal_dimension_mean      0.345007              0.688132     -0.253691
radius_se                   0.240567              0.227754      0.715065
texture_se                  0.411621              0.279723     -0.111690
perimeter_se                0.266487              0.244143      0.697201
area_se                     0.134109              0.127071      0.757373
smoothness_se               0.413506              0.427374     -0.230691
compactness_se              0.394713              0.803269      0.204607
concavity_se                0.309429              0.727372      0.186904
concave_points_se           0.312780              0.611044      0.358127
symmetry_se                 1.000000              0.369078     -0.128121
fractal_dimension_se        0.369078              1.000000     -0.037488
radius_worst               -0.128121             -0.037488      1.000000
texture_worst              -0.077473             -0.003195      0.359921
perimeter_worst            -0.103753             -0.001000      0.993708
area_worst                 -0.110343             -0.022736      0.984015
smoothness_worst           -0.012662              0.170568      0.216574
compactness_worst           0.060255              0.390159      0.475820
concavity_worst             0.037119              0.379975      0.573975
concave_points_worst       -0.030413              0.215204      0.787424
symmetry_worst              0.389402              0.111094      0.243529
fractal_dimension_worst     0.078079              0.591328      0.093492

                         texture_worst  perimeter_worst  area_worst  \
radius_mean                   0.297008         0.965137    0.941082
texture_mean                  0.912045         0.358040    0.343546
perimeter_mean                0.303038         0.970387    0.941550
area_mean                     0.287489         0.959120    0.959213
smoothness_mean               0.036072         0.238853    0.206718
compactness_mean              0.248133         0.590210    0.509604
concavity_mean                0.299879         0.729565    0.675987
concave_points_mean           0.292752         0.855923    0.809630
symmetry_mean                 0.090651         0.219169    0.177193
fractal_dimension_mean       -0.051269        -0.205151   -0.231854
radius_se                     0.194799         0.719684    0.751548
texture_se                    0.409003        -0.102242   -0.083195
perimeter_se                  0.200371         0.721031    0.730713
area_se                       0.196497         0.761213    0.811408
smoothness_se                -0.074743        -0.217304   -0.182195
compactness_se                0.143003         0.260516    0.199371
```

```
concavity_se                0.100241         0.226680    0.188353
concave_points_se           0.086741         0.394999    0.342271
symmetry_se                -0.077473        -0.103753   -0.110343
fractal_dimension_se       -0.003195        -0.001000   -0.022736
radius_worst                0.359921         0.993708    0.984015
texture_worst               1.000000         0.365098    0.345842
perimeter_worst             0.365098         1.000000    0.977578
area_worst                  0.345842         0.977578    1.000000
smoothness_worst            0.225429         0.236775    0.209145
compactness_worst           0.360832         0.529408    0.438296
concavity_worst             0.368366         0.618344    0.543331
concave_points_worst        0.359755         0.816322    0.747419
symmetry_worst              0.233027         0.269493    0.209146
fractal_dimension_worst     0.219122         0.138957    0.079647

                         smoothness_worst  compactness_worst  concavity_worst  \
radius_mean                      0.119616           0.413463         0.526911
texture_mean                     0.077503           0.277830         0.301025
perimeter_mean                   0.150549           0.455774         0.563879
area_mean                        0.123523           0.390410         0.512606
smoothness_mean                  0.805324           0.472468         0.434926
compactness_mean                 0.565541           0.865809         0.816275
concavity_mean                   0.448822           0.754968         0.884103
concave_points_mean              0.452753           0.667454         0.752399
symmetry_mean                    0.426675           0.473200         0.433721
fractal_dimension_mean           0.504942           0.458798         0.346234
radius_se                        0.141919           0.287103         0.380585
texture_se                      -0.073658          -0.092439        -0.068956
perimeter_se                     0.130054           0.341919         0.418899
area_se                          0.125389           0.283257         0.385100
smoothness_se                    0.314457          -0.055558        -0.058298
compactness_se                   0.227394           0.678780         0.639147
concavity_se                     0.168481           0.484858         0.662564
concave_points_se                0.215351           0.452888         0.549592
symmetry_se                     -0.012662           0.060255         0.037119
fractal_dimension_se             0.170568           0.390159         0.379975
radius_worst                     0.216574           0.475820         0.573975
texture_worst                    0.225429           0.360832         0.368366
perimeter_worst                  0.236775           0.529408         0.618344
area_worst                       0.209145           0.438296         0.543331
smoothness_worst                 1.000000           0.568187         0.518523
compactness_worst                0.568187           1.000000         0.892261
concavity_worst                  0.518523           0.892261         1.000000
concave_points_worst             0.547691           0.801080         0.855434
symmetry_worst                   0.493838           0.614441         0.532520
fractal_dimension_worst          0.617624           0.810455         0.686511
```

```
                         concave_points_worst  symmetry_worst  \
radius_mean                          0.744214        0.163953
texture_mean                         0.295316        0.105008
perimeter_mean                       0.771241        0.189115
area_mean                            0.722017        0.143570
smoothness_mean                      0.503053        0.394309
compactness_mean                     0.815573        0.510223
concavity_mean                       0.861323        0.409464
concave_points_mean                  0.910155        0.375744
symmetry_mean                        0.430297        0.699826
fractal_dimension_mean               0.175325        0.334019
radius_se                            0.531062        0.094543
texture_se                          -0.119638       -0.128215
perimeter_se                         0.554897        0.109930
area_se                              0.538166        0.074126
smoothness_se                       -0.102007       -0.107342
compactness_se                       0.483208        0.277878
concavity_se                         0.440472        0.197788
concave_points_se                    0.602450        0.143116
symmetry_se                         -0.030413        0.389402
fractal_dimension_se                 0.215204        0.111094
radius_worst                         0.787424        0.243529
texture_worst                        0.359755        0.233027
perimeter_worst                      0.816322        0.269493
area_worst                           0.747419        0.209146
smoothness_worst                     0.547691        0.493838
compactness_worst                    0.801080        0.614441
concavity_worst                      0.855434        0.532520
concave_points_worst                 1.000000        0.502528
symmetry_worst                       0.502528        1.000000
fractal_dimension_worst              0.511114        0.537848

                         fractal_dimension_worst
radius_mean                             0.007066
texture_mean                            0.119205
perimeter_mean                          0.051019
area_mean                               0.003738
smoothness_mean                         0.499316
compactness_mean                        0.687382
concavity_mean                          0.514930
concave_points_mean                     0.368661
symmetry_mean                           0.438413
fractal_dimension_mean                  0.767297
radius_se                               0.049559
texture_se                             -0.045655
perimeter_se                            0.085433
area_se                                 0.017539
```

```
smoothness_se                            0.101480
compactness_se                           0.590973
concavity_se                             0.439329
concave_points_se                        0.310655
symmetry_se                              0.078079
fractal_dimension_se                     0.591328
radius_worst                             0.093492
texture_worst                            0.219122
perimeter_worst                          0.138957
area_worst                               0.079647
smoothness_worst                         0.617624
compactness_worst                        0.810455
concavity_worst                          0.686511
concave_points_worst                     0.511114
symmetry_worst                           0.537848
fractal_dimension_worst                  1.000000
```

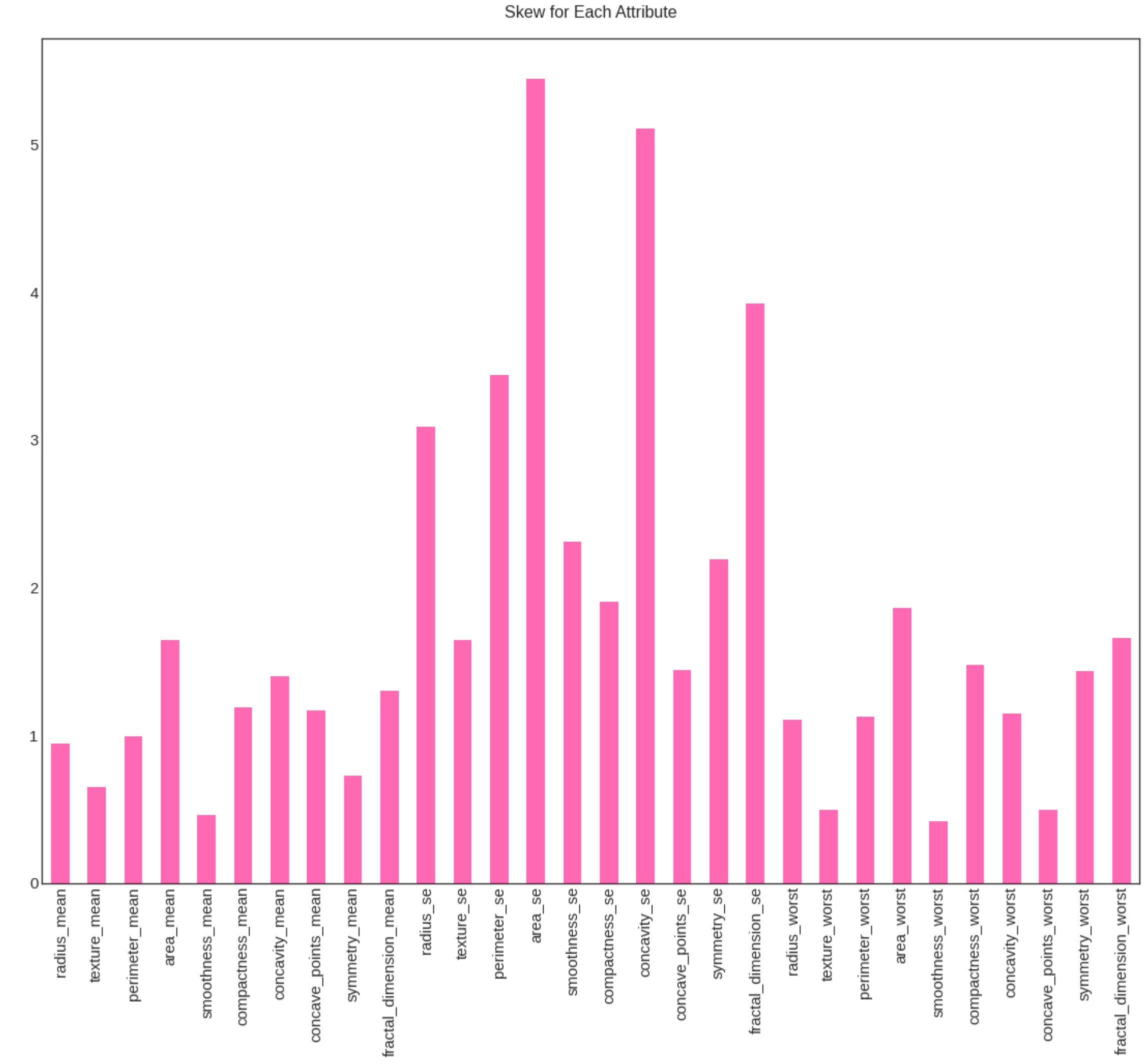
[6]:
```
pd.set_option('display.max_rows', 1000)

sorted_mat = dataset[features_pearson].corr(method='pearson').unstack().
 ↪sort_values(ascending=False)

# Print the 10 strongest positive pairwise correlations after self-correlations.
print('* Strongest Positive Correlations *\n', sorted_mat[31:].head(10))

# Print the 10 weakest pairwise correlations.
print('\n* Closest to Zero Correlations *\n', sorted_mat[:807].tail(10))

# Print the 10 strongest negative pairwise correlations.
print('\n* Strongest Negative Correlations *\n', sorted_mat.tail(10))
```

```
* Strongest Positive Correlations *
 perimeter_mean   radius_mean        0.997855
radius_worst     perimeter_worst    0.993708
perimeter_worst  radius_worst       0.993708
radius_mean      area_mean          0.987357
area_mean        radius_mean        0.987357
                 perimeter_mean     0.986507
perimeter_mean   area_mean          0.986507
area_worst       radius_worst       0.984015
radius_worst     area_worst         0.984015
perimeter_worst  area_worst         0.977578
dtype: float64

* Closest to Zero Correlations *
 smoothness_se            texture_mean                0.006614
area_mean                fractal_dimension_worst    0.003738
```

```
fractal_dimension_worst  area_mean                 0.003738
radius_se                fractal_dimension_mean    0.000111
fractal_dimension_mean   radius_se                 0.000111
perimeter_worst          fractal_dimension_se     -0.001000
fractal_dimension_se     perimeter_worst          -0.001000
texture_worst            fractal_dimension_se     -0.003195
fractal_dimension_se     texture_worst            -0.003195
                         perimeter_mean           -0.005523
dtype: float64

* Strongest Negative Correlations *
 fractal_dimension_mean  area_worst               -0.231854
area_worst              fractal_dimension_mean   -0.231854
radius_worst            fractal_dimension_mean   -0.253691
fractal_dimension_mean  radius_worst             -0.253691
                        perimeter_mean           -0.261477
perimeter_mean          fractal_dimension_mean   -0.261477
area_mean               fractal_dimension_mean   -0.283110
fractal_dimension_mean  area_mean                -0.283110
radius_mean             fractal_dimension_mean   -0.311631
fractal_dimension_mean  radius_mean              -0.311631
dtype: float64
```

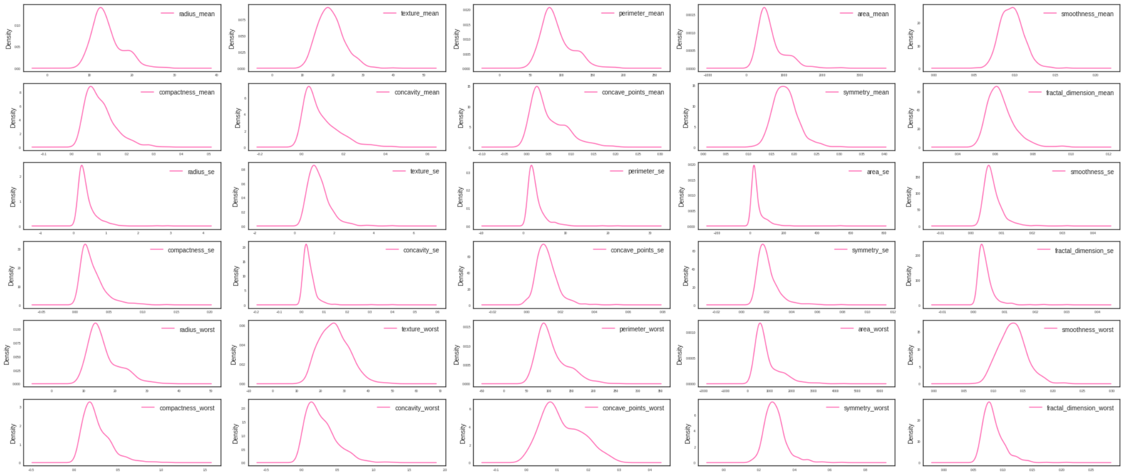
Skew for Each Attribute

[7]:
```
features = list(dataset.columns[1:32])
s = dataset[features].skew()
plt.figure(figsize=(19, 15))
s.plot(kind = 'bar', fontsize=15, color='hotpink')
plt.title('Skew for Each Attribute', fontsize=16, pad=20);
```



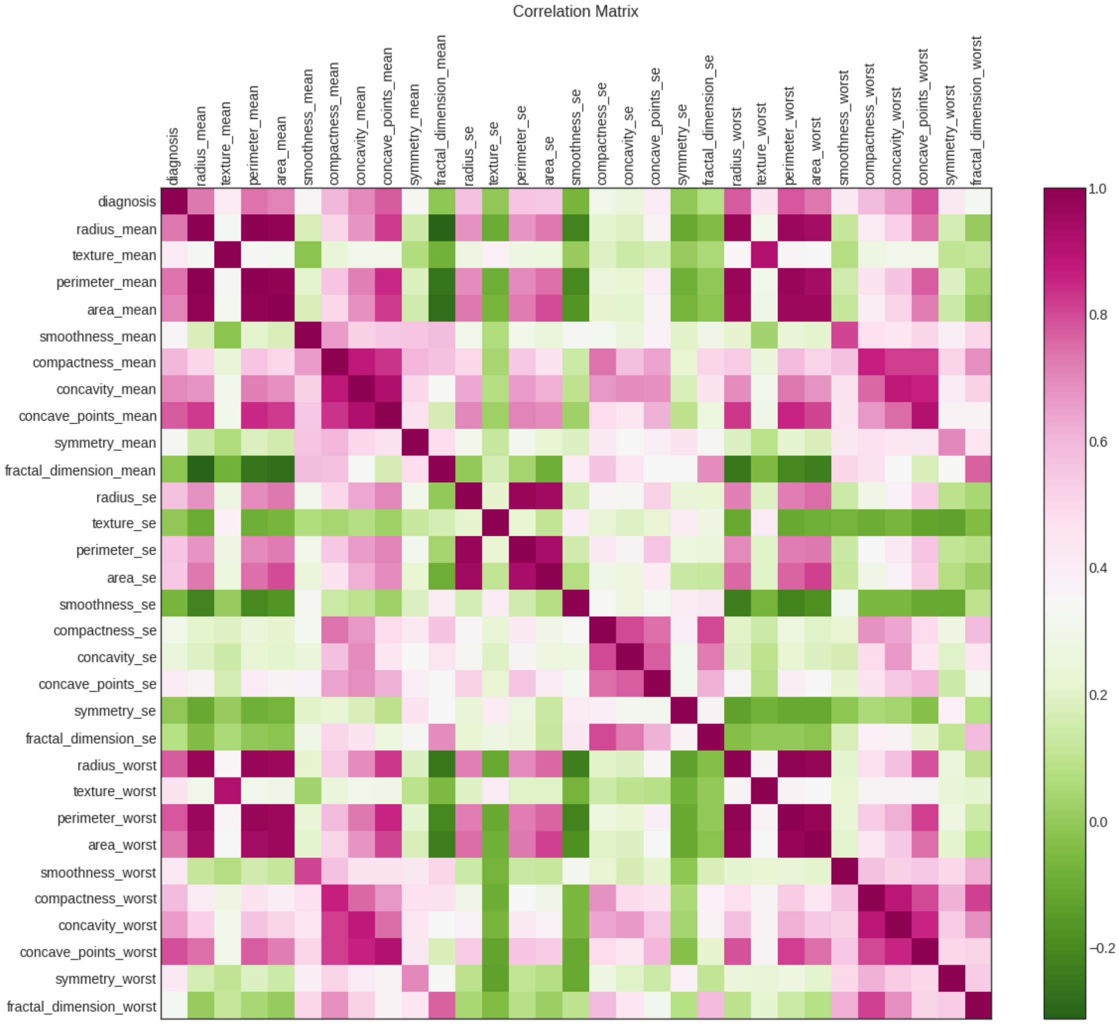
Univariate Density Plot

[8]:
```
dataset.select_dtypes('float').plot(kind='kde', subplots=True, layout=(20,5),␣
↪figsize=(25,35),
                sharex=False, sharey=False, fontsize=5, color='hotpink')
plt.tight_layout()
plt.show()
```



Correlation Matrix Plot

[9]:
```
f = plt.figure(figsize=(19, 15))
features = list(dataset.columns[0:32])
plt.matshow(dataset[features].corr(), fignum=f.number, cmap='PiYG_r')
plt.xticks(range(dataset[features].select_dtypes(['number']).shape[1]),␣
 ↪dataset[features].select_dtypes(['number']).columns, fontsize=14,␣
 ↪rotation=90)
plt.yticks(range(dataset[features].select_dtypes(['number']).shape[1]),␣
 ↪dataset[features].select_dtypes(['number']).columns, fontsize=14)
cb = plt.colorbar()
cb.ax.tick_params(labelsize=14)
plt.title('Correlation Matrix', fontsize=16, pad=130);
```



4 Listing 7

Rescaling Data, Standardize Data, Normalize Data, Binarize Data. Analysis

The unit of measurement for each feature was not provided in the data dictionary documentation. Features such as radius have a different unit and scale than those such as texture or symmetry. Rescaling allows for all values to fall between the given interval, [0,1]. For a given feature, the new value is proportional to the original value's place inside the spread of [0, max(feature)]. For example, the texture_mean of the first value (10.38) lies closer to the original minimum (9.71) than the 25th percentile (16.17). Rescaling transforms the value from 10.38 to 0.023: (10.38 - 9.71) / (39.28 - 9.71) = 0.023

Standardization (Z-score normalization) of the data assumes Gaussian distributions of real-valued features. By standardizing to a mean of 0 and a standard deviation of 1, better performance should be seen with linear algorithms such as logistic regression and linear discriminant analysis.

The minimum and maximum values are highly influenced by the presence of outliers, which may increase the overall spread. Minimum and maximum values for each feature vary, dependent on the original spread of each feature.

Normalization does not assume Gaussian distribution, and lends itself to algorithms that don't make this assumption, such as k-nearest neighbors and artificial neural networks. By having the bound at a fixed range, 0 to 1, the smaller standard deviations lead to sensitivity to outliers.

Binarization transforms the values to 0 or 1, dependent on whether each value falls below or above a given threshold. The features of this dataset all have a theoretical minimum of 0, but differing maximums. Given the differences in spread, rather than fix the threshold to a constant, we vary it based on the mean of each feature. This can be achieved by providing a list of the 30 feature means as the binarizer threshold, or by fitting and transforming on a standardized dataset and setting the threshold to the standardized mean of 0.

[10]:

```
# Set precision.
np.set_printoptions(precision=3)
```

[11]:

```
# Separate out target variable and print original values for first two rows.
X = dataset.values[:, 1:]
Y = dataset.values[:, 0]
print(X[0:2, :])
```

```
[[1.799e+01 1.038e+01 1.228e+02 1.001e+03 1.184e-01 2.776e-01 3.001e-01
  1.471e-01 2.419e-01 7.871e-02 1.095e+00 9.053e-01 8.589e+00 1.534e+02
  6.399e-03 4.904e-02 5.373e-02 1.587e-02 3.003e-02 6.193e-03 2.538e+01
  1.733e+01 1.846e+02 2.019e+03 1.622e-01 6.656e-01 7.119e-01 2.654e-01
  4.601e-01 1.189e-01]
 [2.057e+01 1.777e+01 1.329e+02 1.326e+03 8.474e-02 7.864e-02 8.690e-02
  7.017e-02 1.812e-01 5.667e-02 5.435e-01 7.339e-01 3.398e+00 7.408e+01
  5.225e-03 1.308e-02 1.860e-02 1.340e-02 1.389e-02 3.532e-03 2.499e+01
  2.341e+01 1.588e+02 1.956e+03 1.238e-01 1.866e-01 2.416e-01 1.860e-01
  2.750e-01 8.902e-02]]
```

a) Rescaling

[12]:

```
scaler_rescaled = MinMaxScaler(feature_range=(0, 1))
X_rescaled = scaler_rescaled.fit_transform(X)
print(X_rescaled[0:2, :])
```

```
[[0.521 0.023 0.546 0.364 0.594 0.792 0.703 0.731 0.686 0.606 0.356 0.12
  0.369 0.274 0.159 0.351 0.136 0.301 0.312 0.183 0.621 0.142 0.668 0.451
  0.601 0.619 0.569 0.912 0.598 0.419]
 [0.643 0.273 0.616 0.502 0.29  0.182 0.204 0.349 0.38  0.141 0.156 0.083
  0.124 0.126 0.119 0.081 0.047 0.254 0.085 0.091 0.607 0.304 0.54  0.435
  0.348 0.155 0.193 0.639 0.234 0.223]]
```

b) Standardization

[13]:

```
scaler_standardized = StandardScaler()
X_standardized = scaler_standardized.fit_transform(X)
print(X_standardized[0:2, :])
```

```
[[ 1.097e+00 -2.073e+00  1.270e+00  9.844e-01  1.568e+00  3.284e+00
   2.653e+00  2.532e+00  2.218e+00  2.256e+00  2.490e+00 -5.653e-01
   2.833e+00  2.488e+00 -2.140e-01  1.317e+00  7.240e-01  6.608e-01
   1.149e+00  9.071e-01  1.887e+00 -1.359e+00  2.304e+00  2.001e+00
   1.308e+00  2.617e+00  2.110e+00  2.296e+00  2.751e+00  1.937e+00]
 [ 1.830e+00 -3.536e-01  1.686e+00  1.909e+00 -8.270e-01 -4.871e-01
  -2.385e-02  5.481e-01  1.392e-03 -8.687e-01  4.993e-01 -8.762e-01
   2.633e-01  7.424e-01 -6.054e-01 -6.929e-01 -4.408e-01  2.602e-01
  -8.055e-01 -9.944e-02  1.806e+00 -3.692e-01  1.535e+00  1.890e+00
  -3.756e-01 -4.304e-01 -1.467e-01  1.087e+00 -2.439e-01  2.812e-01]]
```

c) Normalization

[14]:

```
scaler_normalized = Normalizer()
X_normalized = scaler_normalized.fit_transform(X)
print(X_normalized[0:2, :])
```

```
[[7.925e-03 4.573e-03 5.410e-02 4.410e-01 5.216e-05 1.223e-04 1.322e-04
  6.480e-05 1.066e-04 3.468e-05 4.824e-04 3.988e-04 3.784e-03 6.758e-02
  2.819e-06 2.160e-05 2.367e-05 6.991e-06 1.323e-05 2.728e-06 1.118e-02
  7.635e-03 8.132e-02 8.895e-01 7.146e-05 2.932e-04 3.136e-04 1.169e-04
  2.027e-04 5.238e-05]
 [8.666e-03 7.486e-03 5.599e-02 5.586e-01 3.570e-05 3.313e-05 3.661e-05
  2.956e-05 7.634e-05 2.387e-05 2.290e-04 3.092e-04 1.432e-03 3.121e-02
  2.201e-06 5.510e-06 7.836e-06 5.645e-06 5.852e-06 1.488e-06 1.053e-02
  9.862e-03 6.690e-02 8.240e-01 5.215e-05 7.861e-05 1.018e-04 7.836e-05
  1.159e-04 3.750e-05]]
```

d) Binarization

[15]:

```
# Print the 30 feature means.
print(X.mean(axis=0))

# Binarize X with the means as thresholds.
binarizer = Binarizer(threshold=X.mean(axis=0)).fit(X)
X_binarized = binarizer.transform(X)
print(X_binarized[0:2, :])
```

```
[1.413e+01 1.929e+01 9.197e+01 6.549e+02 9.636e-02 1.043e-01 8.880e-02
 4.892e-02 1.812e-01 6.280e-02 4.052e-01 1.217e+00 2.866e+00 4.034e+01
 7.041e-03 2.548e-02 3.189e-02 1.180e-02 2.054e-02 3.795e-03 1.627e+01
 2.568e+01 1.073e+02 8.806e+02 1.324e-01 2.543e-01 2.722e-01 1.146e-01
 2.901e-01 8.395e-02]
[[1. 0. 1. 1. 1. 1. 1. 1. 1. 1. 1. 0. 1. 1. 0. 1. 1. 1. 1. 1. 1. 0. 1. 1.
  1. 1. 1. 1. 1. 1.]
 [1. 0. 1. 1. 0. 0. 0. 1. 1. 0. 1. 0. 1. 1. 0. 0. 0. 1. 0. 0. 1. 0. 1. 1.
  0. 0. 0. 1. 0. 1.]]
```

[16]:

```
# Alternatively, binarize the standarized X with the threshold at the standard␣
 ↪mean of 0.
binarizer = Binarizer(threshold=0).fit(X_standardized)
X_binarized = binarizer.transform(X_standardized)
print(X_binarized[0:2, :])
```

```
[[1. 0. 1. 1. 1. 1. 1. 1. 1. 1. 1. 0. 1. 1. 0. 1. 1. 1. 1. 1. 1. 0. 1. 1.
  1. 1. 1. 1. 1. 1.]
 [1. 0. 1. 1. 0. 0. 0. 1. 1. 0. 1. 0. 1. 1. 0. 0. 0. 1. 0. 0. 1. 0. 1. 1.
  0. 0. 0. 1. 0. 1.]]
```