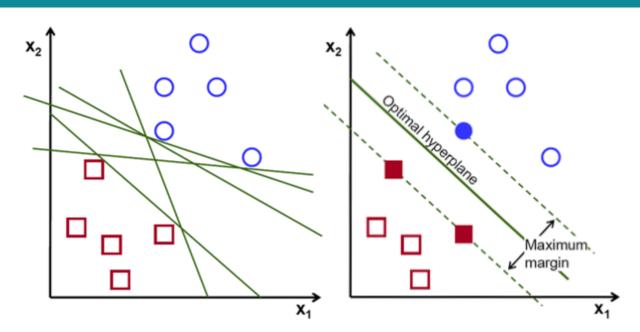
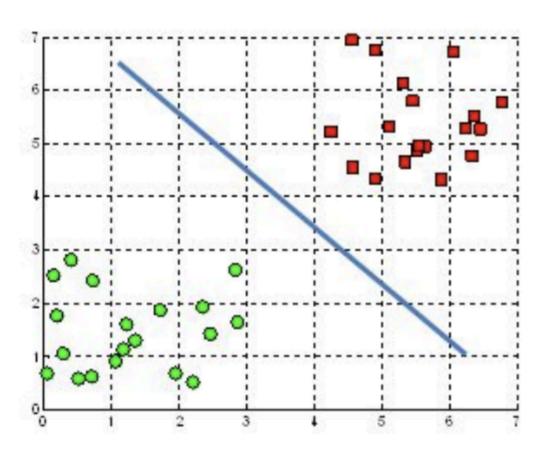


Support Vector Machine(SVM)

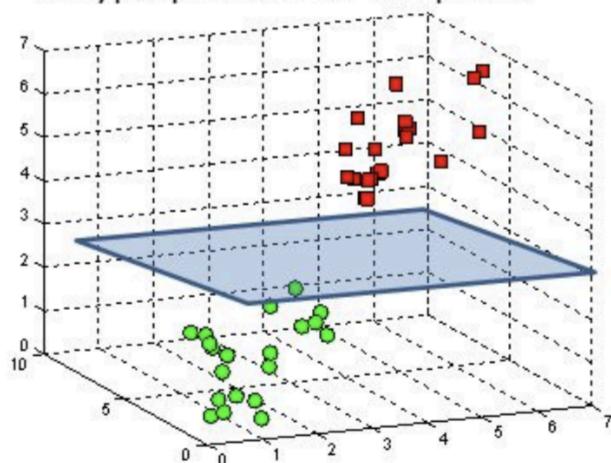


- A Support Vector Machine (SVM) is a very powerful and versatile Machine Learning model, capable of performing linear or nonliner classification, regression, and even outlier detection.
- Support vector machine is highly preferred by many as it produces significant accuracy with less computation power.
- Support Vector Machine, abbreviated as SVM can be used for both regression and classification tasks. But, it is widely used in classification objectives.
- The objective of the support vector machine algorithm is to find a hyperplane in an N-dimensional space(N the number of features) that distinctly classifies the data points.
- To separate the two classes of data points, there are many possible hyperplanes that could be chosen. Our objective is to find a plane that has the maximum margin, i.e the maximum distance between data points of both classes. Maximizing the margin distance provides some reinforcement so that future data points can be classified with more confidence.
- Hyperplanes and Support Vectors

A hyperplane in \mathbb{R}^2 is a line



A hyperplane in \mathbb{R}^3 is a plane



- Hyperplanes are decision boundaries that help classify the data points. Data points falling on either side of the hyperplane can be attributed to different classes.
- Also, the dimension of the hyperplane depends upon the number of features. If the number of input features is 2, then the hyperplane is just a line. If the number of input features is 3, then the hyperplane becomes a two-dimensional plane. It becomes difficult to imagine when the number of features exceeds 3.
- Support vectors are data points that are closer to the hyperplane and influence the position and orientation of the hyperplane.
- Using these support vectors, we maximize the margin of the classifier.
- Deleting the support vectors will change the position of the hyperplane.
- These are the points that help us build our SVM.

SVM: Strengths and Applications:

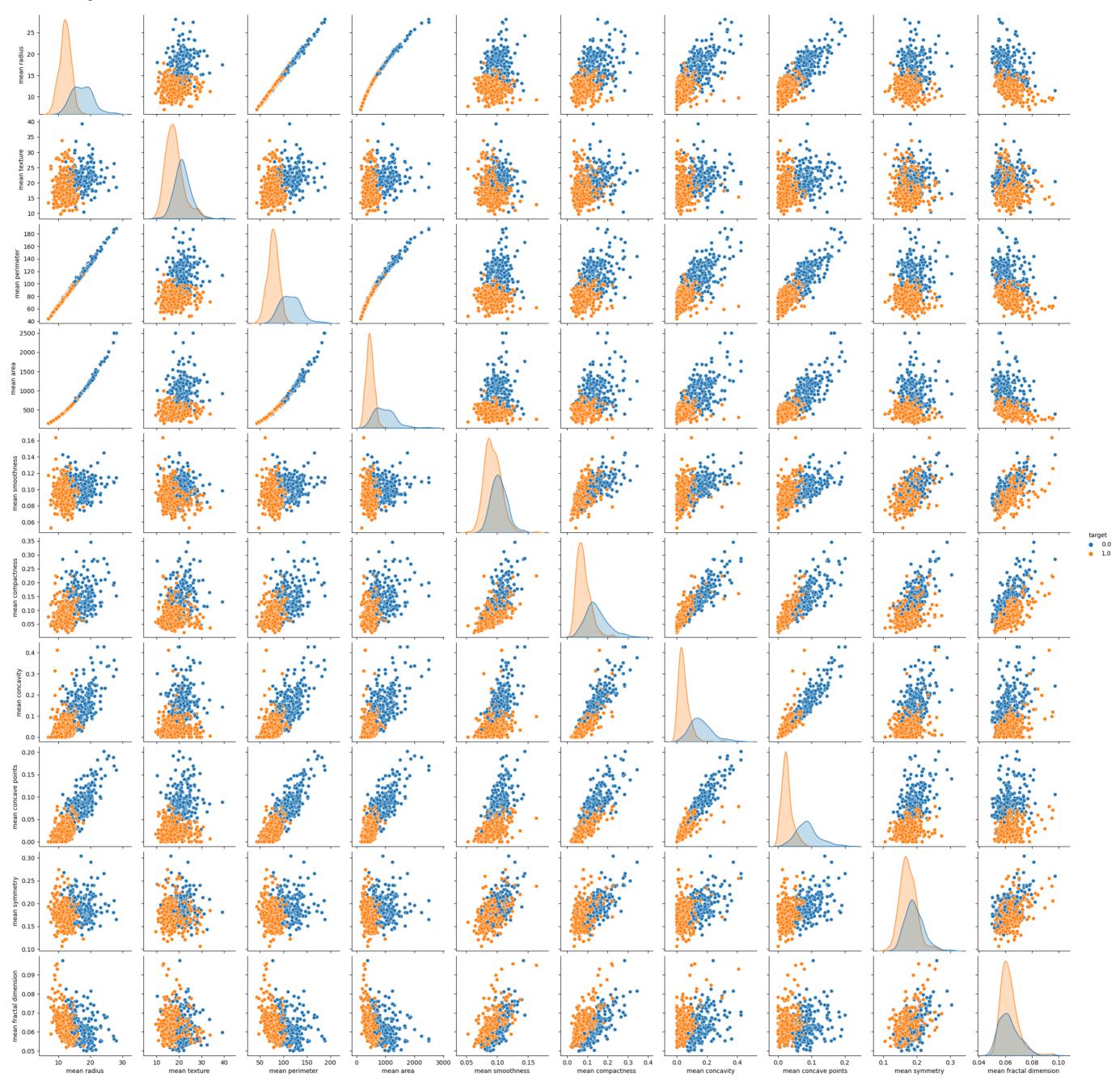
- **High-Dimensional Data Hero:** SVM performs well even with high-dimensional data, making it suitable for complex datasets with many features.
- Clear Margin Champion: SVM excels at classification tasks where there's a clear separation between classes. It identifies the optimal decision boundary that maximizes the margin between classes.
- Kernel Powerhouse: SVMs can handle non-linear data by leveraging kernel functions. These functions essentially map the data into a higher-dimensional space where a linear separation becomes possible.
- Considerations for SVM:
 - Finding the Sweet Spot: Choosing the right kernel function can be crucial for optimal SVM performance. It can significantly impact the model's ability to separate the data effectively.
 - Interpretability Challenges: While the core concept is understandable, interpreting the inner workings of complex SVM models with specific kernels can be challenging.
 - Training Time Considerations: Training SVMs can be computationally expensive, especially for large datasets.

```
import numpy as np
         import pandas as pd
         import matplotlib.pyplot as plt
         import seaborn as sns
         import plotly.express as px
         import plotly.figure_factory as ff
         from sklearn.metrics import confusion_matrix, accuracy_score, classification_report
         from sklearn.metrics import mean_squared_error, r2_score
         import warnings
         warnings.filterwarnings('ignore')
In [2]: | ### Import the Dataset
         from sklearn.datasets import load_breast_cancer
         cancer = load_breast_cancer()
         col_names = list(cancer.feature_names)
         col_names.append('target')
         df = pd.DataFrame(np.c_[cancer.data, cancer.target], columns=col_names)
         df.head()
Out[2]:
                                                                                 mean
                                                                                                     mean
                                                                                                                                                                            worst
                                                                                                                                                                                                 worst
             mean
                     mean
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                                                                               concave
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                                      area smoothness compactness concavity
                                                                                                                                 area smoothness compactness concavity
            radius texture perimeter
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                                                                                                                      perimeter
                                                                                       symmetry
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                                                                                                 dimension
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             17.99
                     10.38
                              122.80
                                    1001.0
                                                0.11840
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             20.29
         5 rows × 31 columns
In [3]: | df.shape ### Checking Shape
Out[3]: (569, 31)
In [4]: | df.describe() ### Get information of the Dataset
Out[4]:
                                                                                                    mean
                                                                                                                          mean
                     mean
                               mean
                                                                  mean
                                                                               mean
                                                                                         mean
                                                                                                               mean
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                                                                                                                                                                                                 worst
                                          mean
                                                  mean area
                                                                                                 concave
                                                                                                                         fractal
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                                       perimeter
                                                            smoothness compactness
                                                                                                                                                                    smoothness
                    radius
                              texture
                                                                                      concavity
                                                                                                           symmetry
                                                                                                                                      texture
                                                                                                                                               perimeter
                                                                                                                                                                               compactness
                                                                                                                                                                                             concavity
                                                                                                   points
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          count
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                 14.127292
                            19.289649
                                       91.969033
                                                 654.889104
                                                               0.096360
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                                                                                                            0.181162
                                                                                                                                   25.677223 107.261213
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          mean
                  3.524049
                             4.301036
                                       24.298981
                                                 351.914129
                                                               0.014064
                                                                            0.052813
                                                                                      0.079720
                                                                                                 0.038803
                                                                                                            0.027414
                                                                                                                       0.007060 ...
                                                                                                                                     6.146258
                                                                                                                                              33.602542
                                                                                                                                                         569.356993
                                                                                                                                                                       0.022832
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                                                                                                                                                                                              0.208624
                                                                                                                                                                                                         0.065
            std
                  6.981000
                             9.710000
                                       43.790000
                                                 143.500000
                                                               0.052630
                                                                            0.019380
                                                                                      0.000000
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                                                                                                                       0.049960 ...
                                                                                                                                    12.020000
                                                                                                                                              50.410000
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            min
           25%
                 11.700000
                            16.170000
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                                                               0.086370
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                 13.370000
                            18.840000
                                       86.240000
                                                 551.100000
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                                                                                                                       0.061540 ...
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           75%
                 15.780000
                           21.800000
                                      104.100000
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                                                                                                                                                        1084.000000
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                 28.110000
                           39.280000 188.500000 2501.000000
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                                                                                                 0.201200
                                                                                                            0.304000
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                                                                                                                                   49.540000 251.200000
                                                                                                                                                        4254.000000
                                                                                                                                                                       0.222600
                                                                                                                                                                                    1.058000
                                                                                                                                                                                              1.252000
                                                                                                                                                                                                         0.291
           max
         8 rows × 31 columns
In [5]: df.columns ### Checking Columns
Out[5]: Index(['mean radius', 'mean texture', 'mean perimeter', 'mean area',
                 'mean smoothness', 'mean compactness', 'mean concavity',
                  'mean concave points', 'mean symmetry', 'mean fractal dimension',
                 'radius error', 'texture error', 'perimeter error', 'area error',
                 'smoothness error', 'compactness error', 'concavity error',
                 'concave points error', 'symmetry error', 'fractal dimension error',
                 'worst radius', 'worst texture', 'worst perimeter', 'worst area',
                 'worst smoothness', 'worst compactness', 'worst concavity',
                 'worst concave points', 'worst symmetry', 'worst fractal dimension',
                 'target'],
                dtype='object')
In [6]: df.info() ### Checking Information About a DataFrame
         <class 'pandas.core.frame.DataFrame'>
         RangeIndex: 569 entries, 0 to 568
         Data columns (total 31 columns):
              Column
                                          Non-Null Count Dtype
          #
                                          -----
         ---
          0
               mean radius
                                          569 non-null
                                                           float64
          1
              mean texture
                                          569 non-null
                                                           float64
              mean perimeter
                                          569 non-null
                                                           float64
          2
                                          569 non-null
          3
              mean area
                                                           float64
              mean smoothness
                                          569 non-null
                                                           float64
          5
                                          569 non-null
                                                           float64
              mean compactness
              mean concavity
                                          569 non-null
                                                           float64
                                          569 non-null
          7
              mean concave points
                                                           float64
              mean symmetry
                                          569 non-null
                                                           float64
              mean fractal dimension
                                          569 non-null
                                                           float64
          9
          10
              radius error
                                          569 non-null
                                                           float64
          11
              texture error
                                          569 non-null
                                                           float64
          12
              perimeter error
                                          569 non-null
                                                           float64
                                          569 non-null
                                                           float64
          13
              area error
          14 smoothness error
                                          569 non-null
                                                           float64
              compactness error
                                          569 non-null
                                                           float64
          15
              concavity error
                                          569 non-null
                                                           float64
              concave points error
                                          569 non-null
                                                           float64
          17
          18 symmetry error
                                          569 non-null
                                                           float64
                                         569 non-null
          19 fractal dimension error
                                                           float64
          20 worst radius
                                          569 non-null
                                                           float64
          21 worst texture
                                          569 non-null
                                                           float64
          22 worst perimeter
                                          569 non-null
                                                           float64
          23 worst area
                                          569 non-null
                                                           float64
          24 worst smoothness
                                          569 non-null
                                                           float64
          25 worst compactness
                                          569 non-null
                                                           float64
          26 worst concavity
                                          569 non-null
                                                           float64
                                          569 non-null
          27 worst concave points
                                                           float64
          28 worst symmetry
                                          569 non-null
                                                           float64
          29 worst fractal dimension 569 non-null
                                                           float64
                                          569 non-null
                                                           float64
          30 target
         dtypes: float64(31)
         memory usage: 137.9 KB
```

In [1]: | ### Importing Libraries

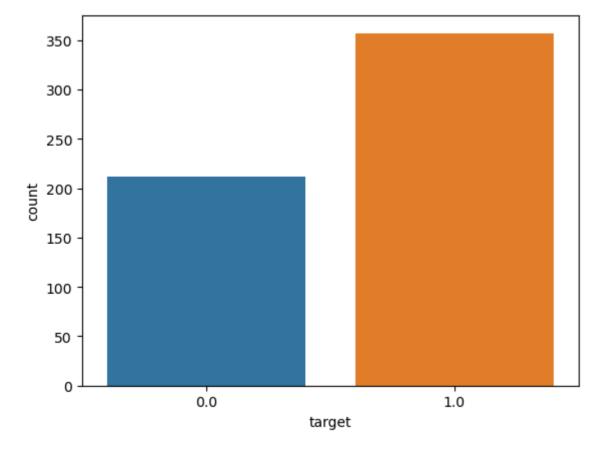
```
In [7]: df.isnull().sum() ### Checking Null Values in the Data
Out[7]: mean radius
                                  0
        mean texture
                                  0
                                  0
        mean perimeter
                                  0
        mean area
                                  0
        mean smoothness
                                  0
        mean compactness
        mean concavity
                                  0
                                  0
        mean concave points
                                  0
        mean symmetry
        mean fractal dimension
                                  0
        radius error
        texture error
        perimeter error
                                  0
                                  0
        area error
                                  0
        smoothness error
                                  0
        compactness error
        concavity error
                                  0
                                  0
        concave points error
                                  0
        symmetry error
                                  0
        fractal dimension error
        worst radius
        worst texture
                                  0
                                  0
        worst perimeter
                                  0
        worst area
                                  0
        worst smoothness
                                  0
        worst compactness
                                  0
        worst concavity
        worst concave points
        worst symmetry
        worst fractal dimension
                                 0
        target
        dtype: int64
In [8]: print(cancer.target_names)
        ['malignant' 'benign']
In [9]: df1 = pd.DataFrame.copy(df)
        df1.shape
Out[9]: (569, 31)
```

Out[10]: <seaborn.axisgrid.PairGrid at 0x25e4f84ea10>



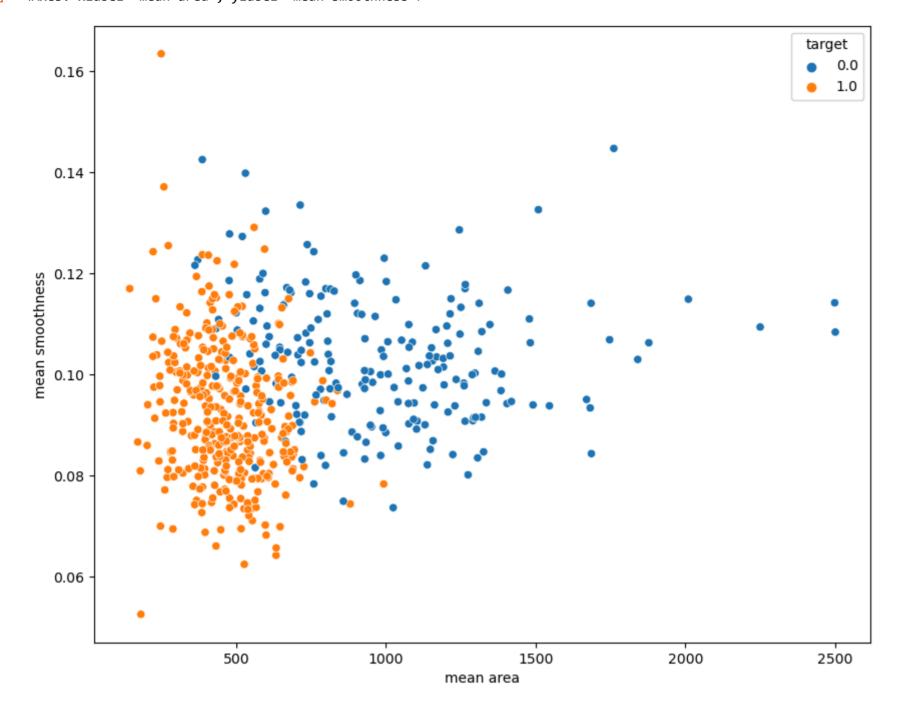
In [11]: ### Checking count
sns.countplot(x = df1['target'], label = "Count")

Out[11]: <Axes: xlabel='target', ylabel='count'>



```
In [12]: plt.figure(figsize=(10, 8))
sns.scatterplot(x = 'mean area', y = 'mean smoothness', hue = 'target', data = df1)
```

Out[12]: <Axes: xlabel='mean area', ylabel='mean smoothness'>



In [13]: # Let's check the correlation between the variables
 plt.figure(figsize=(20,10))
 sns.heatmap(df1.corr(), annot=True)

Out[13]: <Axes: >

```
- 1.0
          mean radius - 1 0.32 1 0.99 0.17 0.51 0.68 0.82 0.15 -0.31 0.68 0.097 0.67 0.74 -0.22 0.21 0.19 0.38 -0.1 -0.043 0.97 0.3 0.97 0.94 0.12 0.41 0.53 0.74 0.160.0071-0.73
                                 0.33 0.32 -0.023 0.24 0.3 0.29 0.071-0.076 0.28 0.39 0.28 0.260.00660.19 0.14 0.160.00910.054 0.35 0.91 0.36 0.34 0.078 0.28 0.3 0.3 0.1 0.12 -0.42
                           0.33 1 0.99 0.21 0.56 0.72 0.85 0.18 -0.26 0.69 -0.087 0.69 0.74 -0.2 0.25 0.23 0.41 -0.0820.0051 0.97 0.3 0.97 0.94 0.15 0.46 0.56 0.77 0.19 0.051 -0.74
           mean area - 0.99 0.32 0.99 1 0.18 0.5 0.69 0.82 0.15 -0.28 0.73 -0.066 0.73 0.8 -0.17 0.21 0.21 0.37 -0.072-0.02 0.96 0.29 0.96 0.96 0.96 0.12 0.39 0.51 0.72 0.140.0037-0.71
                                                                                                                                                                                                      - 0.8
    mean smoothness - 0.17 -0.023 0.21 0.18 1 0.66 0.52 0.55 0.56 0.58 0.3 0.068 0.3 0.25 0.33 0.32 0.25 0.38 0.2 0.28 0.21 0.036 0.24 0.21 0.81 0.47 0.43 0.5 0.39 0.5 -0.36
   mean compactness - 0.51 0.24 0.56 0.5 0.66 1 0.88 0.83 0.6 0.57 0.5 0.046 0.55 0.46 0.14 0.74 0.57 0.64 0.23 0.51 0.54 0.25 0.59 0.51 0.57 0.87 0.82 0.82 0.51 0.69 -0.6
       mean concavity - 0.68 0.3 0.72 0.69 0.52 0.88 1 0.92 0.5 0.34 0.63 0.076 0.66 0.62 0.099 0.67 0.69 0.68 0.18 0.45 0.69 0.3 0.73 0.68 0.45 0.75 0.88 0.86 0.41 0.51 -0.7
                                                                                                                                                                                                       0.6
                                                                0.46 0.17 0.7 0.021 0.71 0.69 0.028 0.49 0.44 0.62 0.095 0.26 0.83 0.29 0.86 0.81 0.45 0.67 0.75 0.91 0.38 0.37 -0.78
                                            0.55 0.83 0.92 1
      mean symmetry - 0.15 0.071 0.18 0.15 0.56 0.6
                                                     0.5 0.46 1 0.48 0.3 0.13 0.31 0.22 0.19 0.42 0.34 0.39 0.45 0.33 0.19 0.091 0.22 0.18 0.43 0.47 0.43 0.43 0.47 0.43 0.47 0.43
mean fractal dimension -0.31-0.076-0.26 -0.28 0.58 0.57 0.34 0.17 0.48 1 0.000110.16 0.04 -0.09 0.4 0.56 0.45 0.34 0.35 0.69 -0.25-0.051-0.21 -0.23 0.5 0.46 0.35 0.18 0.33 0.77 0.013
          radius error - 0.68 0.28 0.69 0.73 0.3 0.5 0.63 0.7 0.30.0001 1 0.21 0.97 0.95 0.16 0.36 0.33 0.51 0.24 0.23 0.72 0.19 0.72 0.75 0.14 0.29 0.38 0.53 0.095 0.05 -0.57
                                                                                                                                                                                                       0.4
          texture error -0.097 0.39 -0.0870.0660.0680.0460.0760.021 0.13 0.16 0.21 1 0.22 0.11 0.4 0.23 0.19 0.23 0.41 0.28 -0.11 0.41 -0.1 -0.0830.0740.0920.069-0.12 -0.13-0.0460.008
       area error - 0.74 0.26 0.74 0.8 0.25 0.46 0.62 0.69 0.22 -0.09 0.95 0.11 0.94 1 0.075 0.28 0.27 0.42 0.13 0.13 0.76 0.2 0.76 0.81 0.13 0.28 0.39 0.54 0.0740.018 -0.55
                                                                                                                                                                                                       - 0.2
     smoothness error -0.220.0066 -0.2 -0.17 0.33 0.14 0.0990.028 0.19 0.4 0.16 0.4 0.15 0.075 1 0.34 0.27 0.33 0.41 0.43 -0.23-0.075-0.22 -0.18 0.31 -0.0560.058 -0.1 -0.11 0.1 0.067
    compactness error - 0.21 0.19 0.25 0.21 0.32 0.74 0.67 0.49 0.42 0.56 0.36 0.23 0.42 0.28 0.34 1 0.8 0.74 0.39 0.8 0.2 0.14 0.26 0.2 0.23 0.68 0.64 0.48 0.28 0.59 -0.29
       concavity error - 0.19 0.14 0.23 0.21 0.25 0.57 0.69 0.44 0.34 0.45 0.33 0.19 0.36 0.27 0.27 0.8 1 0.77 0.31 0.73 0.19 0.1 0.23 0.19 0.17 0.48 0.66 0.44 0.2 0.44 -0.25
   concave points error - 0.38 0.16 0.41 0.37 0.38 0.64 0.68 0.62 0.39 0.34 0.51 0.23 0.56 0.42 0.33 0.74 0.77 1 0.31 0.61 0.36 0.087 0.39 0.34 0.22 0.45 0.55 0.6 0.14 0.31 -0.41
                                                                                                                                                                                                       - 0.0
       symmetry error - -0.1 0.009 to 0.082 0.072 0.2 0.23 0.18 0.095 0.45 0.35 0.24 0.41 0.27 0.13 0.41 0.39 0.31 0.31 1 0.37 -0.13 -0.077 -0.1 -0.11 -0.013 0.06 0.037 -0.03 0.39 0.0780.0069
fractal dimension error -0.0430.0540.00550.02 0.28 0.51 0.45 0.26 0.33 0.69 0.23 0.28 0.24 0.13 0.43 0.8 0.73 0.61 0.37 1 +0.0370.00320.0010.023 0.17 0.39 0.38 0.22 0.11 0.59 +0.078
          worst radius - 0.97 0.35 0.97 0.96 0.21 0.54 0.69 0.83 0.19 -0.25 0.72 -0.11 0.7 0.76 -0.23 0.2 0.19 0.36 -0.13-0.037 1 0.36 0.99 0.98 0.22 0.48 0.57 0.79 0.24 0.093-0.78
         worst texture - 0.3 0.91 0.3 0.29 0.036 0.25 0.3 0.29 0.091-0.051 0.19 0.41 0.2 0.2 -0.075 0.14 0.1 0.087-0.0770.00320.36 1 0.37 0.35 0.23 0.36 0.37 0.36 0.23 0.22 -0.46
       worst perimeter - 0.97 0.36 0.97 0.96 0.24 0.59 0.73 0.86 0.22 -0.21 0.72 -0.1 0.72 0.76 -0.22 0.26 0.23 0.39 -0.1 -0.001 0.99 0.37 1 0.98 0.24 0.53 0.62 0.82 0.27 0.14 -0.78
           worst area - 0.94 0.34 0.94 0.96 0.21 0.51 0.68 0.81 0.18 -0.23 0.75 -0.083 0.73 0.81 -0.18 0.2 0.19 0.34 -0.11 -0.023 0.98 0.35 0.98 1 0.21 0.44 0.54 0.75 0.21 0.08 -0.73
     worst smoothness - 0.12 0.078 0.15 0.12 0.81 0.57 0.45 0.45 0.45 0.43 0.5 0.14 0.074 0.13 0.13 0.13 0.23 0.17 0.22 0.013 0.17 0.22 0.23 0.24 0.21 1 0.57 0.52 0.55 0.49 0.62 0.42
   worst compactness - 0.41 0.28 0.46 0.39 0.47 0.87 0.75 0.67 0.47 0.46 0.29 -0.092 0.34 0.28 -0.056 0.68 0.48 0.45 0.06 0.39 0.48 0.36 0.53 0.44 0.57 1 0.89 0.8 0.61 0.81 -0.59
       worst concavity - 0.53 0.3 0.56 0.51 0.43 0.82 0.88 0.75 0.43 0.35 0.38 0.069 0.42 0.39 0.058 0.64 0.66 0.55 0.037 0.38 0.57 0.37 0.62 0.54 0.52 0.89 1 0.86 0.53 0.69 0.66
  worst concave points - 0.74 0.3 0.77 0.72 0.5 0.82 0.86 0.91 0.43 0.18 0.53 -0.12 0.55 0.54 -0.1 0.48 0.44 0.6 -0.03 0.22 0.79 0.36 0.82 0.75 0.55 0.8 0.86 1 0.5 0.51 -0.79
       worst symmetry - 0.16 0.11 0.19 0.14 0.39 0.51 0.41 0.38 0.7 0.33 0.095-0.13 0.11 0.074-0.11 0.28 0.2 0.14 0.39 0.11 0.24 0.23 0.27 0.21 0.49 0.61 0.53 0.5 1 0.54
worst fractal dimension -0.00710.12 0.0510.0037 0.5 0.69 0.51 0.37 0.44 0.77 0.05-0.0460.0850.018 0.1 0.59 0.44 0.31 0.078 0.59 0.093 0.22 0.14 0.08 0.62 0.81 0.69 0.51 0.54 1 -0.32
               target -0.73 -0.42 -0.74 -0.71 -0.36 -0.6 -0.7 -0.78 -0.33 0.013 -0.570.0083-0.56 -0.55 0.067 -0.29 -0.25 -0.410.00650.078-0.78 -0.46 -0.78 -0.73 -0.42 -0.59 -0.66 -0.79 -0.42 -0.32
                                                            mean concave points
                                                                                                                                     worst texture
                                                  mean compactness
                                                       mean concavity
                                                                 mean symmetry
                                                                      mean fractal dimension
                                                                                                                          fractal dimension error
                                                                                                                                                    worst smoothness
                                                                                                                                                                    worst concave points
                                                                                                                                                                              worst fractal dimension
                                  mean perimeter
                                                                                 texture error
                                                                                                                concave points error
                                                                                                                                          worst perimeter
                                                                                                                                                         worst compactness
                                                                                           area
                                                                                                      compactness
                                                                                                           concavity
```

```
In [14]: ### Finding numerical variables
colname_num = [var for var in df1.columns if df1[var].dtype!='0']
print('There are {} numerical variables\n'.format(len(colname_num)))
print('The numerical variables are :', colname_num)
```

There are 31 numerical variables

The numerical variables are : ['mean radius', 'mean texture', 'mean perimeter', 'mean area', 'mean smoothness', 'mean compactness', 'mean concavity', 'mean concavity', 'mean concavity', 'mean fractal dimension', 'radius error', 'texture error', 'area error', 'smoothness error', 'compactness error', 'concavity error', 'concave points error', 'symmetry error', 'fractal dimension error', 'worst radius', 'worst texture', 'worst perimeter', 'worst area', 'worst smoothness', 'worst compactness', 'worst concavity', 'worst concave points', 'worst symmetry', 'worst fractal dimension', 'target']

```
In [15]: df2 = df1.copy()
df2.shape
```

Out[15]: (569, 31)

In [16]: df2.head(15)

Out[16]:

```
worst
                                                                                                       mean
                                                                                                                                                                                     worst
                                                                                                                                                  worst
                                                                                                                                                                           worst
     mean
             mean
                        mean
                                mean
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                                                            mean
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                                                                                           mean
                                                                                                                   worst
                                                                                                                             worst
                                                                                                                                     worst
                                                                              concave
                                                                                                      fractal
                                                                                                                                                                                  concave
                                                                                                                                                                                                           fractal
                                                                                                                                                                                                                  target
                                 area smoothness compactness concavity
            texture perimeter
     radius
                                                                                                                                      area smoothness compactness concavity
                                                                                       symmetry
                                                                                                                 texture
                                                                                                                         perimeter
                                                                                                                                                                                            symmetry
                                                                               points
                                                                                                  dimension
                                                                                                                                                                                    points
                                                                                                                                                                                                       dimension
      17.99
              10.38
                        122.80
                                1001.0
                                           0.11840
                                                          0.27760
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                                                                              0.14710
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      15.85
              23.95
                        103.70
                                782.7
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      13.73
              22.61
                         93.60
                                578.3
                                           0.11310
                                                          0.22930
                                                                    0.21280
                                                                              0.08025
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                                                                                                     0.07682 ...
                                                                                                                   32.01
                                                                                                                             108.80
                                                                                                                                     697.7
                                                                                                                                                  0.1651
                                                                                                                                                                0.7725
                                                                                                                                                                          0.6943
                                                                                                                                                                                   0.22080
                                                                                                                                                                                               0.3596
                                                                                                                                                                                                          0.14310
15 rows × 31 columns
     print(f"{col} has {df2[col].nunique()} categories\n")
mean radius has 456 categories
mean texture has 479 categories
mean perimeter has 522 categories
mean area has 539 categories
```

```
In [17]: for col in df2.columns:
         mean smoothness has 474 categories
         mean compactness has 537 categories
         mean concavity has 537 categories
         mean concave points has 542 categories
         mean symmetry has 432 categories
         mean fractal dimension has 499 categories
         radius error has 540 categories
         texture error has 519 categories
         perimeter error has 533 categories
         area error has 528 categories
         smoothness error has 547 categories
         compactness error has 541 categories
         concavity error has 533 categories
         concave points error has 507 categories
         symmetry error has 498 categories
         fractal dimension error has 545 categories
         worst radius has 457 categories
         worst texture has 511 categories
         worst perimeter has 514 categories
         worst area has 544 categories
         worst smoothness has 411 categories
         worst compactness has 529 categories
         worst concavity has 539 categories
         worst concave points has 492 categories
         worst symmetry has 500 categories
         worst fractal dimension has 535 categories
         target has 2 categories
```

```
In [18]: df3 = df2.copy()
         df3.columns
```

```
Out[18]: Index(['mean radius', 'mean texture', 'mean perimeter', 'mean area',
                 'mean smoothness', 'mean compactness', 'mean concavity',
                'mean concave points', 'mean symmetry', 'mean fractal dimension',
                'radius error', 'texture error', 'perimeter error', 'area error',
                'smoothness error', 'compactness error', 'concavity error',
                'concave points error', 'symmetry error', 'fractal dimension error',
                'worst radius', 'worst texture', 'worst perimeter', 'worst area',
                'worst smoothness', 'worst compactness', 'worst concavity',
                'worst concave points', 'worst symmetry', 'worst fractal dimension',
                'target'],
               dtype='object')
```

```
In [19]: | ### Splitting Data into X and y
         X = df3.values[:,:-1]
         y = df3.values[:,-1]
         print('X:',X.shape)
         print('*' * 13)
         print('y:',y.shape)
```

X: (569, 30) ****** y: (569,)

```
In [20]: ### Feature Scaling
         from sklearn.preprocessing import StandardScaler,MinMaxScaler
         scaler = StandardScaler()
         scaler.fit(X)
         X = scaler.transform(X)
         MinMax = MinMaxScaler()
         MinMax.fit(X)
         X = MinMax.transform(X)
         \#x = scaler.fit transform(x)
         print(X)
         [[0.52103744 0.0226581 0.54598853 ... 0.91202749 0.59846245 0.41886396]
          [0.64314449 0.27257355 0.61578329 ... 0.63917526 0.23358959 0.22287813]
          [0.60149557 0.3902604 0.59574321 ... 0.83505155 0.40370589 0.21343303]
          [0.45525108 0.62123774 0.44578813 ... 0.48728522 0.12872068 0.1519087 ]
          [0.64456434 0.66351031 0.66553797 ... 0.91065292 0.49714173 0.45231536]
          [0.03686876 0.50152181 0.02853984 ... 0.
                                                           0.25744136 0.10068215]]
In [21]: y = y.astype(int) ### convert y in to integer always perform this operation
In [22]: | ### Splitting into Training and Testing Data
         from sklearn.model_selection import train_test_split
         X_train, X_test, y_train, y_test = train_test_split(X,y,test_size=0.2,random_state=42)
         print("X_train: ",X_train.shape)
         print("X_test: ",X_test.shape)
         print("y_train: ",y_train.shape)
         print("y_test: ",y_test.shape)
         X_train: (455, 30)
         X_test: (114, 30)
         y train: (455,)
         y_test: (114,)
```

Linear Kernel SVM

The simplest and fastest option. It assumes the data is already linearly separable in the original feature space. This makes it efficient for datasets where a clear linear boundary already exists.

```
In [23]: #importing model
        from sklearn.svm import LinearSVC
        #create a model object
        linear_svc = LinearSVC(loss='hinge', dual=True)
        #train the model object
        linear_svc.fit(X_train,y_train)
        #predict score using the model
        y_pred = linear_svc.predict(X_test)
        print(y_pred)
        1011011111111100111110011001110011100110010
        1 1 0]
In [24]: # Checking confusion matrix for the model
        cfm = confusion_matrix(y_test,y_pred)
        dff = pd.DataFrame(cfm)
        dff.style.set_properties(**{"background-color": "#F3FFFF","color":"black","border": "2px solid black"})
Out[24]:
           0 1
In [25]: # Checking classification report score for the model
        cr = classification_report(y_test,y_pred)
        print("Classification report: ")
        print(cr)
        # Checking accuracy score for the model
        acc = accuracy_score(y_test,y_pred)
        print("Accuracy of the model: ",acc)
        Classification report:
                   precision
                              recall f1-score support
                        1.00
                                0.93
                                         0.96
                                                   43
                 0
                 1
                        0.96
                                1.00
                                         0.98
                                                   71
                                         0.97
                                                  114
           accuracy
          macro avg
                        0.98
                                0.97
                                         0.97
                                                  114
        weighted avg
                        0.97
                                0.97
                                         0.97
                                                  114
       Accuracy of the model: 0.9736842105263158
```

Polynomial Kernel SVM

This kernel applies a polynomial transformation to the data, essentially creating new features based on combinations of the existing ones. This can be particularly useful for capturing non-linear relationships between features in the data. However, choosing the right polynomial degree is crucial to avoid overfitting.

```
In [26]: #importing model
       from sklearn.svm import SVC
       #create a model object
       svc = SVC(kernel='poly', degree=2, gamma='auto', coef0=1, C=5)
       #train the model object
       svc.fit(X_train,y_train)
       #predict score using the model
       y_pred = svc.predict(X_test)
       print(y_pred)
       1011011111111001111100110011100110011
       1 1 0]
In [27]: # Checking confusion matrix for the model
       cfm = confusion_matrix(y_test,y_pred)
       dff = pd.DataFrame(cfm)
       dff.style.set_properties(**{"background-color": "#F3FFFF","color":"black","border": "2px solid black"})
Out[27]:
```

```
In [28]: # Checking classification report score for the model
         cr = classification_report(y_test,y_pred)
         print("Classification report: ")
         print(cr)
         # Checking accuracy score for the model
         acc = accuracy_score(y_test,y_pred)
         print("Accuracy of the model: ",acc)
         Classification report:
                      precision
                                   recall f1-score support
                   0
                           1.00
                                     0.95
                                               0.98
                                                          43
                   1
                           0.97
                                     1.00
                                               0.99
                                                          71
             accuracy
                                               0.98
                                                         114
            macro avg
                                     0.98
                           0.99
                                               0.98
                                                         114
         weighted avg
                           0.98
                                     0.98
                                               0.98
                                                         114
        Accuracy of the model: 0.9824561403508771
```

Radial Basis Function (RBF) Kernel SVM

Often referred to as the "Swiss Army Knife" of kernels due to its versatility. The RBF kernel transforms data points based on their distance from a specific point in the higher-dimensional space. This allows it to effectively handle complex non-linear relationships and works well for a wide range of datasets. However, it can be computationally more expensive compared to the linear kernel.

```
In [29]: #importing model
        from sklearn.svm import SVC
        #create a model object
        radial_svc = SVC(kernel='rbf', gamma=0.5, C=0.1)
        #train the model object
        radial_svc.fit(X_train,y_train)
        #predict score using the model
        y_pred = radial_svc.predict(X_test)
        print(y_pred)
        10110111111111001111100110011100110011
        1 1 0]
In [30]: # Checking confusion matrix for the model
        cfm = confusion_matrix(y_test,y_pred)
        dff = pd.DataFrame(cfm)
        dff.style.set_properties(**{"background-color": "#F3FFFF","color":"black","border": "2px solid black"})
Out[30]:
          39
In [31]: | # Checking classification report score for the model
        cr = classification_report(y_test,y_pred)
        print("Classification report: ")
        print(cr)
        # Checking accuracy score for the model
        acc = accuracy_score(y_test,y_pred)
        print("Accuracy of the model: ",acc)
        Classification report:
                   precision
                              recall f1-score support
                        0.97
                                0.91
                                        0.94
                                                   43
                                0.99
                                        0.97
                                                  71
                1
                        0.95
           accuracy
                                        0.96
                                                  114
                       0.96
          macro avg
                                0.95
                                        0.95
                                                  114
        weighted avg
                                0.96
                                        0.96
                                                  114
                       0.96
        Accuracy of the model: 0.956140350877193
                                                                Made with / by Zahid Salim Shaikh
```