Final Project Submission

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2. Student pace: self paced
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Automation Integration Via Machine Learning Dermason Bean Classification

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Business problem:

A food manufacturer who buys bulk quantities of beans wants to see if classification via machine learning can be utilized to help automate some of their production systems and improve their manufacturing efficiency.

Test case area of concern:

The manufacturer imports (7) different types of beans that all go through the same clean and wash cycle together. During this cycle, the beans are all mixed together and need to be separated into their respective 7 categories as effectively as possible. The current method of separation is to have the mixture of beans go down a single conveyor where teams of workers pick out the respective different kinds of beans by hand, and deliver the separated categories over to their associated next process locations. Doing this separation by hand is extremely tedious, time-consuming, and prone to error.

The hope is that automating part of this process would increase efficiency.

For an automation trial run, focused on filtering the Dermanson bean out of the other 6 kinds of mixed beans, we will see if a supervised machine-learning model can be used to correctly classify what is and is not a Dermason bean. Once separated, the Demason bean will be packaged up, and shipped out to retail stores across the county.

Metric of Success:

In this case, the manufacturer has stated that it is most important to try to minimize the false positive rate of classification, shown by the Specificity score, or minimize the number of beans incorrectly categorized as a Dermason bean.

Here, the false negative rate, shown by the Recal score or beans incorrectly categorized as not a Dermason bean, is the more acceptable error metric because all beans not clearly identified as one of the 7 categories will go to the batch processing area where the mixture will be sold to an animal food manufacturer.

Method of Extracting Data From Beans and Filtering Beans into Categories:

After the mixed wash, the beans will go down a conveyor belt that is equipped with a series of high-resolution cameras programmed to take pictures of all the individual beans from different angles. Once these pictures are taken, a computer will analyze the photos with a computer vision program to extract 12 different dimensional metrics such as the bean's area, perimeter, and roundness. This extracted multivariate data will then be put into a Supervised Machine Learning Algorithm in an attempt to classify each bean into its correct category.

Utilized Machine Learning Technologies:

We will be utilizing Decision Trees and Logistic Regression models paired with Stratified-K-Fold cross-validation techniques and grid searches to optimize and tailor these machine-learning models to the manufacturer's requested metric of success. Specifically One Verus All classification will be used to maximize Specificity and Precision, while not letting Recal drop too low.

The Data:

Data Source and Data Use:

Source: "Dry Bean." UCI Machine Learning Repository, 2020, https://doi.org/10.24432/C50S4B.

To simulate this multivariate data extraction I used the "Dry Bean" dataset from the UCI Machine Learning Repository (cited above).

This Dataset contains over 13,000 data instances of beans that have had multivariate data extracted from pictures taken of them via a computer vision system. These data instances are made up of 7 different types of registered dry beans, with each instance having 16 features that describe different dimensional and shape-form metrics the bean exhibits.

Here the "Class" variable, which dictates which of the 7 types of beans each instance is, will be manipulated to create a new variable called "Dermason" that states if the data instance is or is not a Dermason bean. This new "Dermason" variable will be the target-dependent variable and will enable us to use One Versus All classification.

The other 16 variables, listed below, make up the independent variables we will use to train the machine-learning models to classify each data instance as either "Yes" a Dermason bean, or "No" not a Dermason bean. Each of these 16 variables aligns perfectly with potential dimensional metrics that could be extracted should the beans be going down a conveyor belt with cameras and a computer vision program programmed to extract dimensional information from the individual bean pictures they process.

tor4 (SF4)

Independent Variables: 1.) Area (A): The area of a bean zone and the number of pixels within its boundaries. 2.) Perimeter (P): Bean circumference is defined as the length of its border. 3.) Major axis length (L): The distance between the ends of the longest line that can be drawn from a bean. 4.) Minor axis length (l): The longest line that can be drawn from the bean while standing perpendicular to the main axis. 5.) Aspect ratio (K): Defines the relationship between L and l. 6.) Eccentricity (Ec): Eccentricity of the ellipse having the same moments as the region. 7.) Convex area (C): Number of pixels in the smallest convex polygon that can contain the area of a bean seed. 8.) Equivalent diameter (Ed): The diameter of a circle having the same area as a bean seed area. 9.) Extent (Ex): The ratio of the pixels in the bounding box to the bean area. 10.) Solidity (S): Also known as convexity. The ratio of the pixels in the convex shell to those found in beans. 11.) Roundness (R): Calculated with the following formula: (4piA)/(P^2) 12.) Compactness (CO): Measures the roundness of an object: Ed/L 13.) ShapeFactor1 (SF1) 14.) ShapeFactor2 (SF2) 15.) ShapeFactor3 (SF3) 16.) ShapeFactor4 (SF4)

Data limitations

There are some limitations to this dataset that I would like to note:

1. Without seeing the actual pictures that this dataset used to extract each bean's dimensionality and shape factor we have no way of knowing for sure

if each stated bean classification is actually true. Instead, we are only operating under the unverified assumption that these classifications are true.
2. The same can be said for calculations of the bean dimensionality and shape factor variables. Without being able to see the code behind how the computer vision and calculations work, we are only operating under the unverified assumption that these dimensional measurements and shape factors are true.
3. Many factors and attributes can be used to describe the properties of a dried bean. Off the bat, size, weight, and color are three common metrics that I can think of. This dataset only takes into account metrics that I would put under the size umbrella, leaving other potentially very useful information on the table.

Given that information, we can only state that this model will be classifying the type of bean based on unverified dimensional metrics that we assume to be true.

Bring in the data and preview it

In [1]:
```
#hide warning messages that may pop up obscuring notebook view
import warnings
warnings.filterwarnings("ignore")
```

In [2]:
```
#import relevant libraries to help us view and manipulate the data
import pandas as pd
import numpy as np
from scipy import stats

import matplotlib.pyplot as plt
import seaborn as sns
%matplotlib inline

from sklearn.preprocessing import StandardScaler, MinMaxScaler, RobustScaler

from sklearn.linear_model import LogisticRegression
from sklearn.tree import DecisionTreeClassifier

from sklearn.model_selection import train_test_split
from sklearn.model_selection import StratifiedKFold

from sklearn.metrics import accuracy_score, ConfusionMatrixDisplay
from sklearn.metrics import confusion_matrix
from sklearn.metrics import precision_score, recall_score

from imblearn.over_sampling import SMOTE
from imblearn.under_sampling import RandomUnderSampler
from imblearn.pipeline import Pipeline
```

In [3]:
```
#load in the data from an Excel file and save in a pandas dataset
bean_df= pd.read_excel('my_data/Dry_Bean_Dataset.xlsx')
```

```python
#preview the data
bean_df.head()
```

Out[3]:

	Area	Perimeter	MajorAxisLength	MinorAxisLength	AspectRation	Eccent
0	28395	610.291	208.178117	173.888747	1.197191	0.5
1	28734	638.018	200.524796	182.734419	1.097356	0.4
2	29380	624.110	212.826130	175.931143	1.209713	0.5
3	30008	645.884	210.557999	182.516516	1.153638	0.4
4	30140	620.134	201.847882	190.279279	1.060798	0.3

In [4]:

```python
#check for data types and see if any information is missing
bean_df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 13611 entries, 0 to 13610
Data columns (total 17 columns):
 #   Column           Non-Null Count  Dtype  
---  ------           --------------  -----  
 0   Area             13611 non-null  int64  
 1   Perimeter        13611 non-null  float64
 2   MajorAxisLength  13611 non-null  float64
 3   MinorAxisLength  13611 non-null  float64
 4   AspectRation     13611 non-null  float64
 5   Eccentricity     13611 non-null  float64
 6   ConvexArea       13611 non-null  int64  
 7   EquivDiameter    13611 non-null  float64
 8   Extent           13611 non-null  float64
 9   Solidity         13611 non-null  float64
 10  roundness        13611 non-null  float64
 11  Compactness      13611 non-null  float64
 12  ShapeFactor1     13611 non-null  float64
 13  ShapeFactor2     13611 non-null  float64
 14  ShapeFactor3     13611 non-null  float64
 15  ShapeFactor4     13611 non-null  float64
 16  Class            13611 non-null  object 
dtypes: float64(14), int64(2), object(1)
memory usage: 1.8+ MB
```

In [5]:

```python
#check out a decription of the dataset and look for patterns
bean_df.describe()
```

Out[5]:

	Area	Perimeter	MajorAxisLength	MinorAxisLength	Aspec
count	13611.000000	13611.000000	13611.000000	13611.000000	1361
mean	53048.284549	855.283459	320.141867	202.270714	1
std	29324.095717	214.289696	85.694186	44.970091	(
min	20420.000000	524.736000	183.601165	122.512653	1
25%	36328.000000	703.523500	253.303633	175.848170	1
50%	44652.000000	794.941000	296.883367	192.431733	1
75%	61332.000000	977.213000	376.495012	217.031741	1
max	254616.000000	1985.370000	738.860153	460.198497	2

Feature Engineering

Check to see what proportion of the data each of the 7 types of beans takes up. From this take the most frequent bean type and manipulate the data so that it can be used for One Versus All classification of that highest proportion bean type.

In [6]:

```
#check to see the proportion of the data that each bean takes up
bean_df['Class'].value_counts(normalize=True)
```

Out[6]:

```
Class
DERMASON    0.260525
SIRA        0.193667
SEKER       0.148924
HOROZ       0.141650
CALI        0.119756
BARBUNYA    0.097127
BOMBAY      0.038351
Name: proportion, dtype: float64
```

Dermason is the most frequent bean type. Manipulate the data to make that the new target column.

In [7]:

```
#use a lambda function to create a new column showing if each data instance
bean_df['Dermason']= bean_df['Class'].apply(lambda x: 1 if x == 'DERMASON' e
bean_df.head()
```

Out[7]:

	Area	Perimeter	MajorAxisLength	MinorAxisLength	AspectRation	Eccent
0	28395	610.291	208.178117	173.888747	1.197191	0.5
1	28734	638.018	200.524796	182.734419	1.097356	0.4
2	29380	624.110	212.826130	175.931143	1.209713	0.5
3	30008	645.884	210.557999	182.516516	1.153638	0.4
4	30140	620.134	201.847882	190.279279	1.060798	0.3

In [8]:

```
#check to make sure this new Dermason column proportion matches the above pr
bean_df['Dermason'].value_counts(normalize=True)
```

Out[8]:

```
Dermason
0    0.739475
1    0.260525
Name: proportion, dtype: float64
```

Split the data into train and test subsets for model evaluation and training

In [9]:

```
#assign the independent variable columns
X= bean_df.drop(['Dermason','Class'], axis = 1)
#assign the dependant variable columns
y= bean_df['Dermason']

#split up the data into train and test subsets
X_train, X_test, y_train, y_test= train_test_split(X, y, random_state= 24, t
```

Data Preprocessing

Data Distribution Normalization

Check out the distribution of the existing training dataset. Its distribution, if skewed, may result in problematic generalization of under-represented classes (like Dermason Bean), model overfitting, or skewed performance metrics of the binary classifier model.

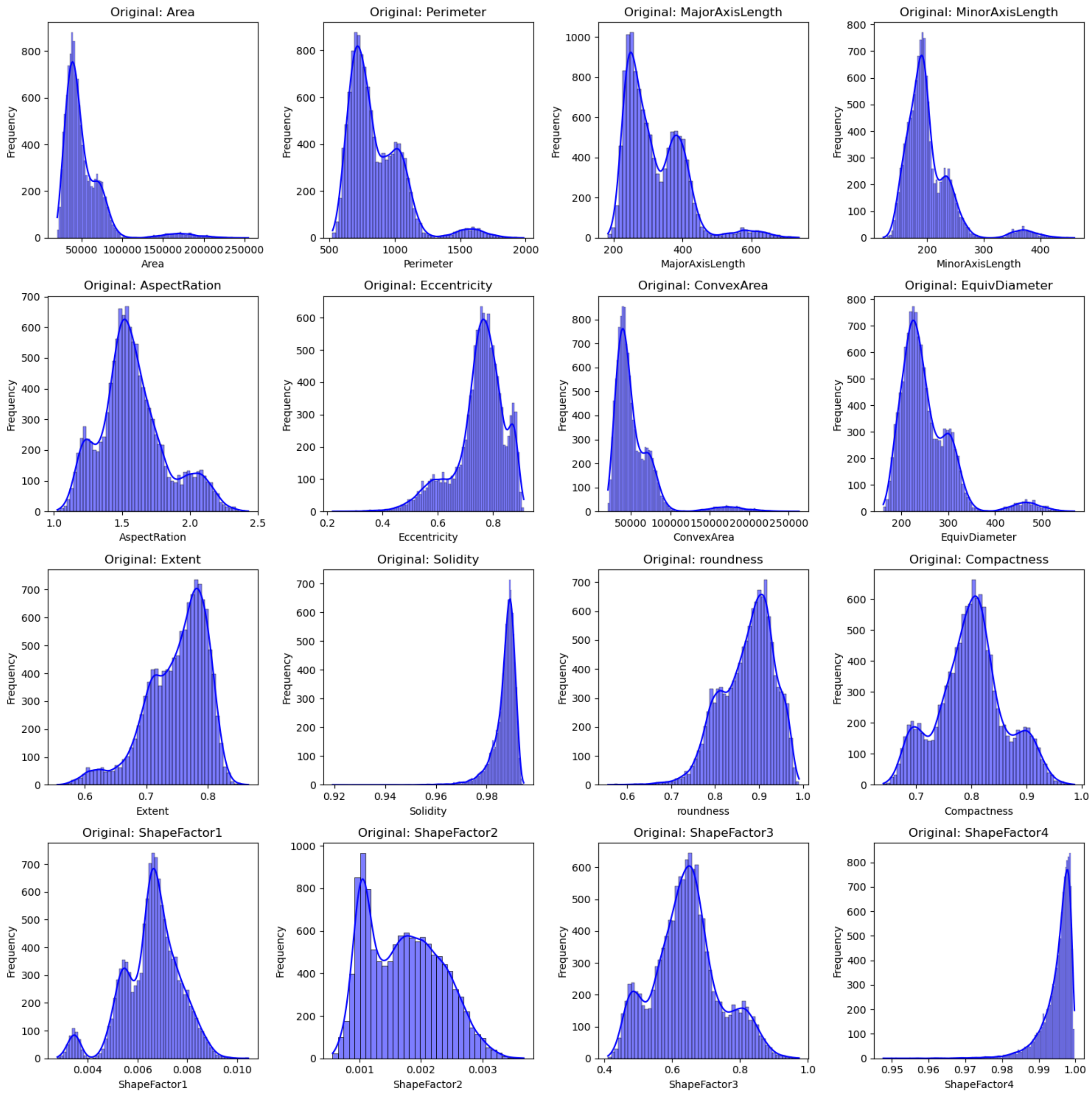
In [10]:

```
#check out the data distrobutions
fig, ax = plt.subplots(4, 4, figsize=(15, 15))

ax = ax.flatten()

#Plot the data
for i, col in enumerate(X_train.columns):
    sns.histplot(X_train[col], kde=True, color='blue', ax=ax[i])
    ax[i].set_title(f'Original: {col}')
    ax[i].set_xlabel(col)
    ax[i].set_ylabel('Frequency')
```

```
plt.tight_layout()
plt.show()
```



Nearly all of the columns in the training dataset are skewed. See if running the right skewed data through Log Transformations, and running the left skewed data through a Box-Cox Transformation can normalize their distributions.

In [11]:
```
#create a function to normalize the distribution of the data
def TransShift(df):
    #columns with right skewed data
    LogT = ['Area', 'Perimeter', 'MajorAxisLength', 'MinorAxisLength', 'Conv
            'EquivDiameter', 'ShapeFactor2']
    #columns with left skewed data
    BoxCoxT = ['Eccentricity', 'Solidity', 'roundness', 'ShapeFactor4']

    #initialize empty dataframe
    Redist = pd.DataFrame()
```

```
    #loop over the columns of the passed in dataframe and normalize them acc
    for col in df.columns:
        if col in LogT:
            Redist[col] = np.log1p(df[col]) #log1p is value += 1
        #shift the values of the inputted columns in order to avoid overflow
        elif col in BoxCoxT:
            min_val = df[col].min()
            if min_val <= 0:
                shifted_col = df[col] - min_val + 1
            else:
                shifted_col = df[col]
            Redist[col], _ = stats.boxcox(shifted_col)
        else:
            Redist[col] = df[col]

    #returns transformed dataframe
    return Redist
```

In [12]:

```
#call the normalization function on the data to transform it
X_train_Norm= TransShift(X_train)

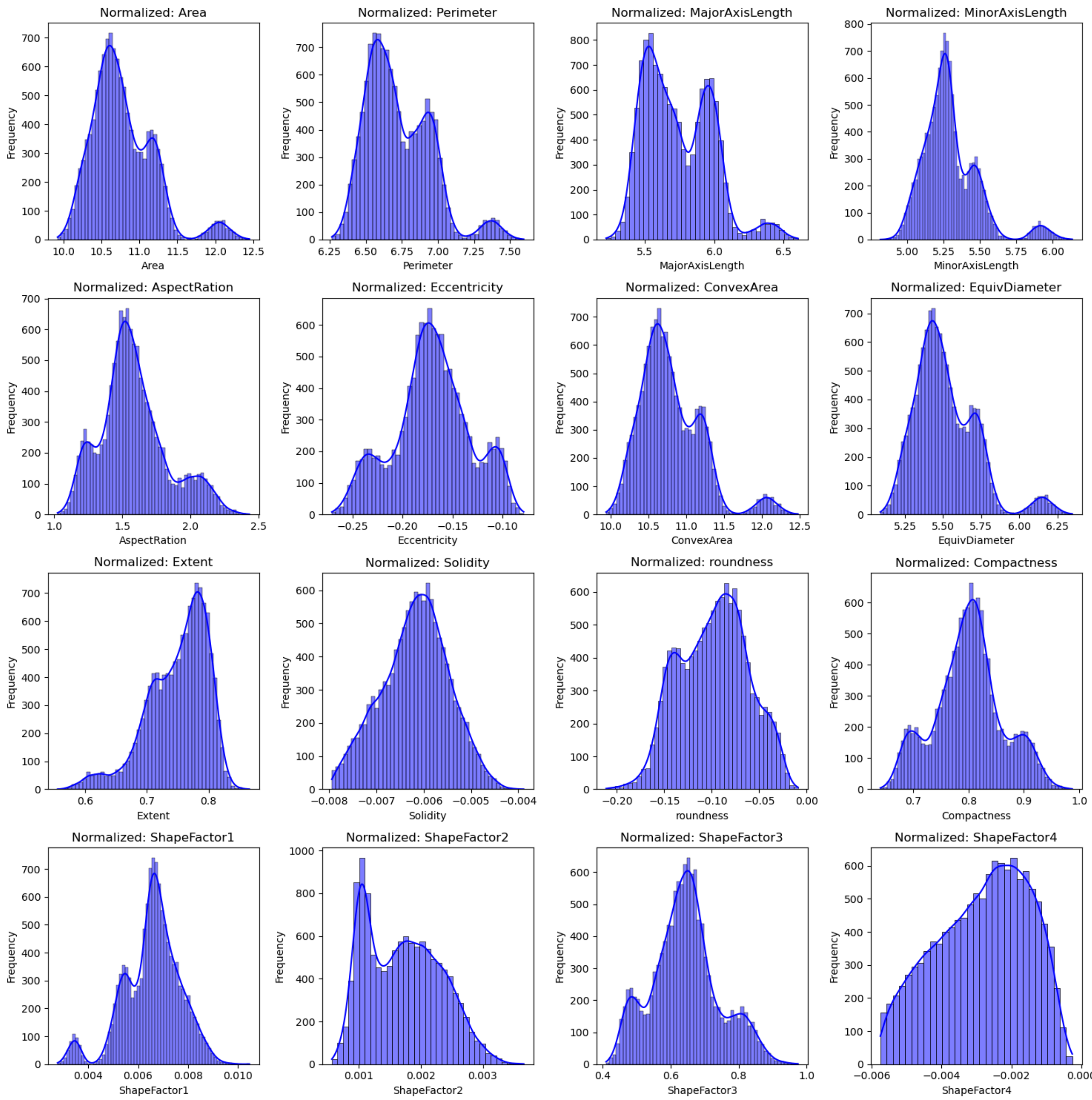
#examine the normalized data
fig, ax = plt.subplots(4, 4, figsize=(15, 15))

ax = ax.flatten()



for i, col in enumerate(X_train_Norm.columns):
    sns.histplot(X_train_Norm[col], kde=True, color='blue', ax=ax[i])
    ax[i].set_title(f'Normalized: {col}')
    ax[i].set_xlabel(col)
    ax[i].set_ylabel('Frequency')

plt.tight_layout()
plt.show()
```



Although not perfect, this technique has greatly improved the distrobutions of the data.

Data value scaling

Using a scaler to scale the values of the independent variables can help some models like Logistic Regression treat all values will equal importance. For example Area is currently counted in the 10,000's range, whereas Shape Factor 1 is counted in the .001's range. Due to Area's number being inherently larger, it may receive a higher weight when taking different factors into account. Scaling the data would help place all the variables on equal footing, potentially allowing the model to make more valuable predictions.

Data SMOTEing and Random Undersampling

Using SMOTEing and Random Undersampling can both help and hurt datasets with unbalanced dependant target variables (like Dermason with ~25% of the datapoints and Not-Dermason with 75% of the datapoints). On the positive side doing these two things can create more synthetic instances of the minority class (Dermason) can cut back the inputted proportion of the majority class (Not-Dermason), bringing the proportion closer to 50%-50%. On the downside, doing both of these things could also create instances of minority class data combinations that are not natural, and potentially eliminate previous training data that was crucial to the model learning.

Model instantiation, tuning, and evaluation

Creation of a class that allows us to pass in different classification models, preprocess the data passed into the models, tune the hyperparameters of the models, and view how effective these models are at achieving the manufacturer's requested success metrics.

This class will use cross-validation to help us understand how the models will react to "unseen" data, and not just overfit on the training data during the tuning stage of the model selection process. In addition to this, since our target class (Dermason) is imbalanced in our dataset (only takes up roughly 25% of the instances), this class will specifically use Stratified K-fold Cross Validation to make sure that each fold the dataset is broken into maintains this similar proportion (~25%), making the folds more representative of the original dataset and easier to compare to each other.

Data preprocessing option selection will be available through choosing the dataset you pass in (normalized distribution or non), whether you want the data scaled/ what kind of scaler, and whether you would like the data to be SMOTE'd / Randomly Undersampled to help the training data's class imbalance move closer to 50%-50% from the existing 25%-75%.

Model hyperparameter tuning options will be available by passing any hyperparameter values the classification model may have into the keyword argument (model_kwargs).

As a representation of how these models are performing in regards to the manufacturer's requested metric of success, the passed in models will output the following:

1. The average Specificity score across the folds for the training and validation datasets.
2. The average Precision score across the folds for the training and validation datasets.

3. The average Recall score across the folds for the training and validation datasets.
4. A confusion matrix for the training and validation sets containing the average TN, FP, FN, TP rates

In [13]:
```
class ModelWithCV():
    #initialize the instance of the class
    def __init__(self, model_instantiator, model_name, X, y, model_kwargs =
                 scaler=False, smote_and_rand_und= False, cv_now=True):
        self.model_instatiator = model_instantiator
        self.model = None
        self.model_kwargs = model_kwargs
        self.name = model_name
        self.scaler= scaler
        self.smote_and_rand_und= smote_and_rand_und
        self.X = X
        self.y = y
        self.cv_specificity_mean = None
        self.cv_precision_mean = None
        self.cv_recall_mean = None
        self.avg_conf_matrix = None
        self.cv_specificity_mean_train = None
        self.cv_precision_mean_train = None
        self.cv_recall_mean_train = None
        self.avg_conf_matrix_train = None
        if cv_now:
            self.cross_validate()

    #perform k-fold cross validation to evaluate model's performance
    def cross_validate(self, X=None, y=None, kfolds=10):

        #check if data is dataframe or series
        cv_X = X if X else self.X
        cv_y = y if y else self.y
        cv_X = cv_X.values if isinstance(cv_X, pd.DataFrame) else cv_X
        cv_y = cv_y.values if isinstance(cv_y, pd.Series) else cv_y

        #set up the stratified splits
        cv_splits = StratifiedKFold(n_splits=kfolds)

        #store splits performance metrics
        specificity_scores_train = []
        precision_scores_train = []
        recall_scores_train = []
        specificity_scores = []
        precision_scores = []
        recall_scores = []
        total_conf_matrix = np.zeros((2, 2))
        total_conf_matrix_train = np.zeros((2, 2))

        if self.scaler:
            print('Scaling')

        if self.smote_and_rand_und:
```

```
            print('SMOTEing and Randomly Undersampling')

        #train and evaluate model in each fold
        #split up the data in the fold into train and evaluate
        for train_idx, test_idx in cv_splits.split(cv_X, cv_y):
            X_train, X_test = cv_X[train_idx], cv_X[test_idx]
            y_train, y_test = cv_y[train_idx], cv_y[test_idx]

            #instantiate the model, make sure random_state is set to 24 for
            self.model = self.model_instatiator(random_state= 24, **self.moc

            #scale the data
            if self.scaler:
                cv_scaler= self.scaler
                X_train = cv_scaler.fit_transform(X_train)
                X_test = cv_scaler.transform(X_test)

            #SMOTE and Randomly undersample the data
            if self.smote_and_rand_und:
                smote = SMOTE(sampling_strategy='auto', random_state=24)
                undersample = RandomUnderSampler(sampling_strategy='auto', r
                pipeline = Pipeline(steps=[('smote', smote), ('undersample',

                X_train, y_train = pipeline.fit_resample(X_train, y_train)

            self.model.fit(X_train, y_train)

            #make train and validation predictions
            y_train_pred = self.model.predict(X_train)
            y_pred = self.model.predict(X_test)

            #make training set confusion matrix
            TN_train, FP_train, FN_train, TP_train = confusion_matrix(y_trai
            total_conf_matrix_train += confusion_matrix(y_train, y_train_pre

            #make training set performance scores
            specificity_train = TN_train / (TN_train + FP_train)
            specificity_scores_train.append(specificity_train)
            precision_train = precision_score(y_train, y_train_pred)
            recall_train = recall_score(y_train, y_train_pred)
            precision_scores_train.append(precision_train)
            recall_scores_train.append(recall_train)

            #make validation set confusion matrix
            TN, FP, FN, TP = confusion_matrix(y_test, y_pred).ravel()
            total_conf_matrix += confusion_matrix(y_test, y_pred)

            #make validation set performance scores
            specificity = TN / (TN + FP)
            specificity_scores.append(specificity)
            precision = precision_score(y_test, y_pred)
            recall = recall_score(y_test, y_pred)
            precision_scores.append(precision)
            recall_scores.append(recall)

        #calculate the average train and val performance scores from the abc
```

```
        self.cv_specificity_mean_train = np.mean(specificity_scores_train)
        self.cv_precision_mean_train = np.mean(precision_scores_train)
        self.cv_recall_mean_train = np.mean(recall_scores_train)
        self.avg_conf_matrix_train = total_conf_matrix_train / kfolds
        self.cv_specificity_mean = np.mean(specificity_scores)
        self.cv_precision_mean = np.mean(precision_scores)
        self.cv_recall_mean = np.mean(recall_scores)
        self.avg_conf_matrix = total_conf_matrix / kfolds

    #print the average performance summaries of the train and val set
    def print_cv_summary(self):
        cv_summary_train = (
            f"CV results for {self.name} model:"
            f"Average specificity: {self.cv_specificity_mean_train:.5f}\n"
            f"Average precision: {self.cv_precision_mean_train:.5f}\n"
            f"Average recall: {self.cv_recall_mean_train:.5f}")
        print('###TRAIN###')
        print(cv_summary_train)

        cv_summary_val = (
            f"CV results for {self.name} model:"
            f"Average specificity: {self.cv_specificity_mean:.5f}\n"
            f"Average precision: {self.cv_precision_mean:.5f}\n"
            f"Average recall: {self.cv_recall_mean:.5f}")
        print('###VAL###')
        print(cv_summary_val)

        return self.cv_specificity_mean, self.cv_precision_mean, self.cv_rec
        self.model_kwargs, self.scaler, self.smote_and_rand_und

    #print the average confusion matrixes of the train and val set
    def plot_avg_conf_matrix(self):
        if self.avg_conf_matrix is not None:
            disp = ConfusionMatrixDisplay(confusion_matrix=self.avg_conf_mat
            disp.plot(cmap=plt.cm.Blues, values_format='.2f')
            plt.title(f"Average Train Confusion Matrix for {self.name}")
            plt.show()

            disp = ConfusionMatrixDisplay(confusion_matrix=self.avg_conf_mat
            disp.plot(cmap=plt.cm.Blues, values_format='.2f')
            plt.title(f"Average Confusion Matrix for {self.name}")
            plt.show()
```

Baseline classification models

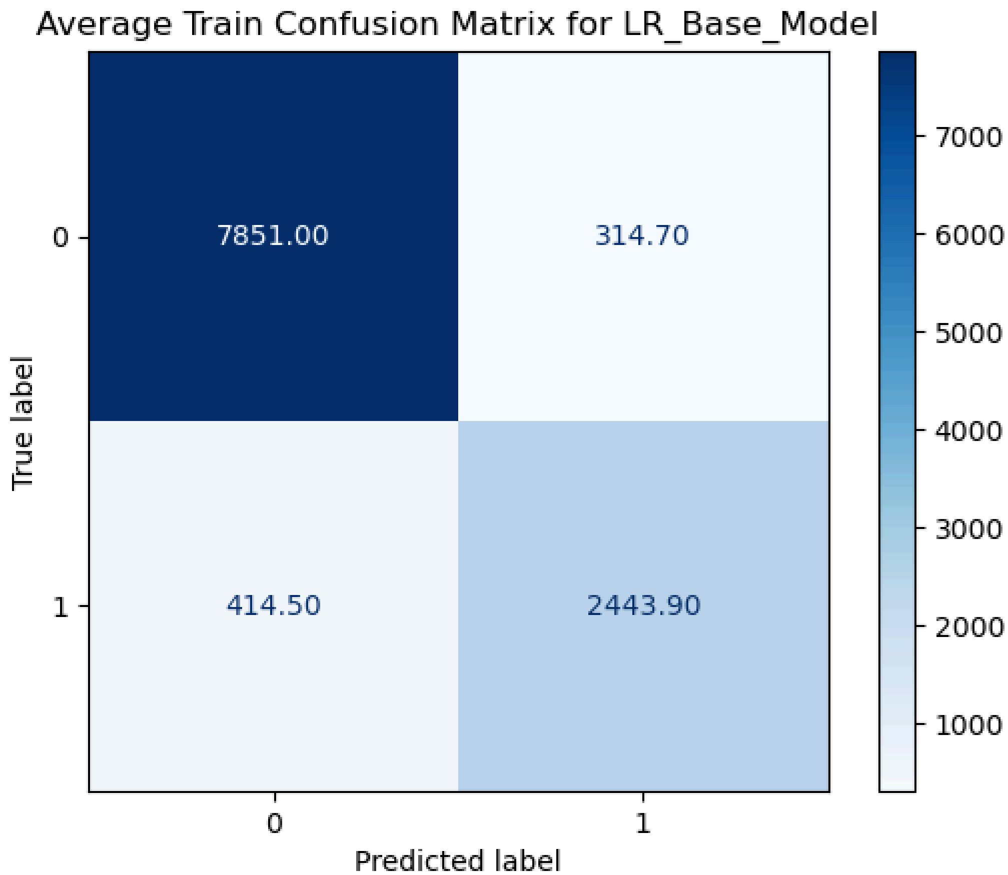
Run a baseline Logistic Regression model to get the unpreprocessed and untuned performance results

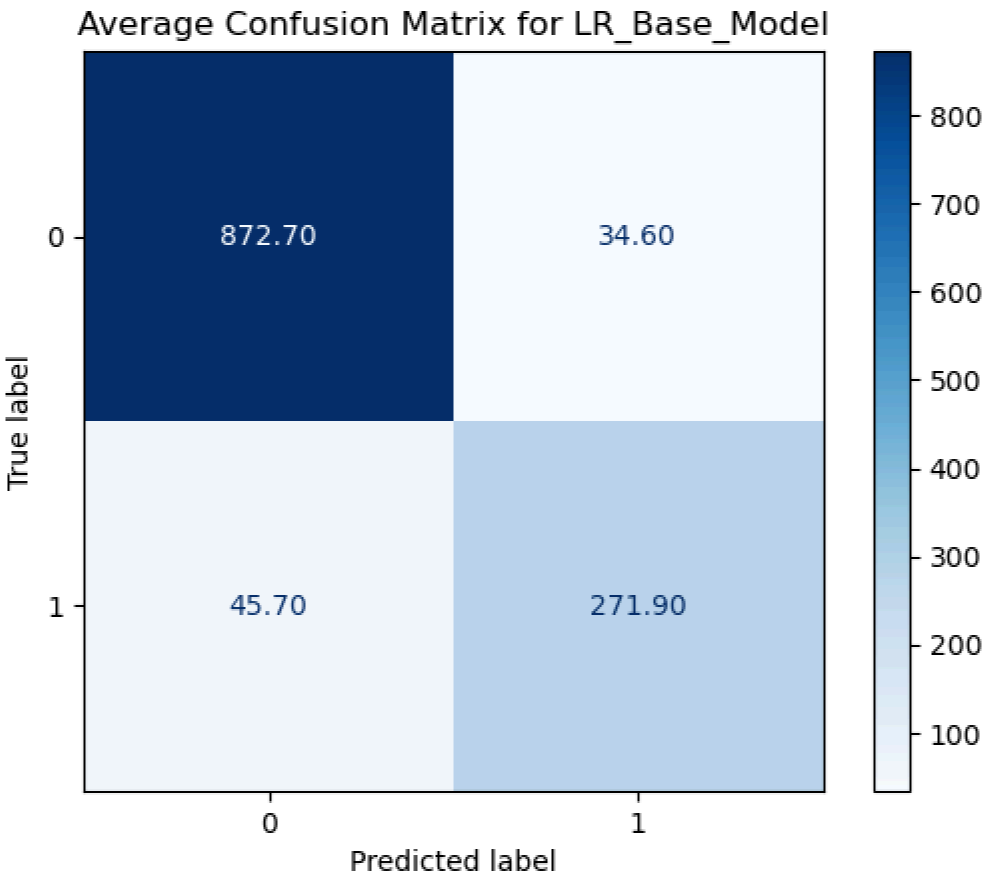
In [14]:
```
LR_Baseline_Results= ModelWithCV(model_instantiator= LogisticRegression,
                                    model_name= 'LR_Base_Model',
                                    X= X_train,
                                    y= y_train,
                                    scaler= False,
                                    smote_and_rand_und= False
```

```
                                    )

LR_Baseline_Results.plot_avg_conf_matrix()

LR_Baseline_Results.print_cv_summary()
```






```
###TRAIN###
CV results for LR_Base_Model model:Average specificity: 0.96146
Average precision: 0.88582
Average recall: 0.85499
###VAL###
CV results for LR_Base_Model model:Average specificity: 0.96187
Average precision: 0.88769
Average recall: 0.85613
```

```
Out[14]: (0.9618657383347337, 0.887693568491631, 0.8561286034561435, {}, False, Fals
e)
```

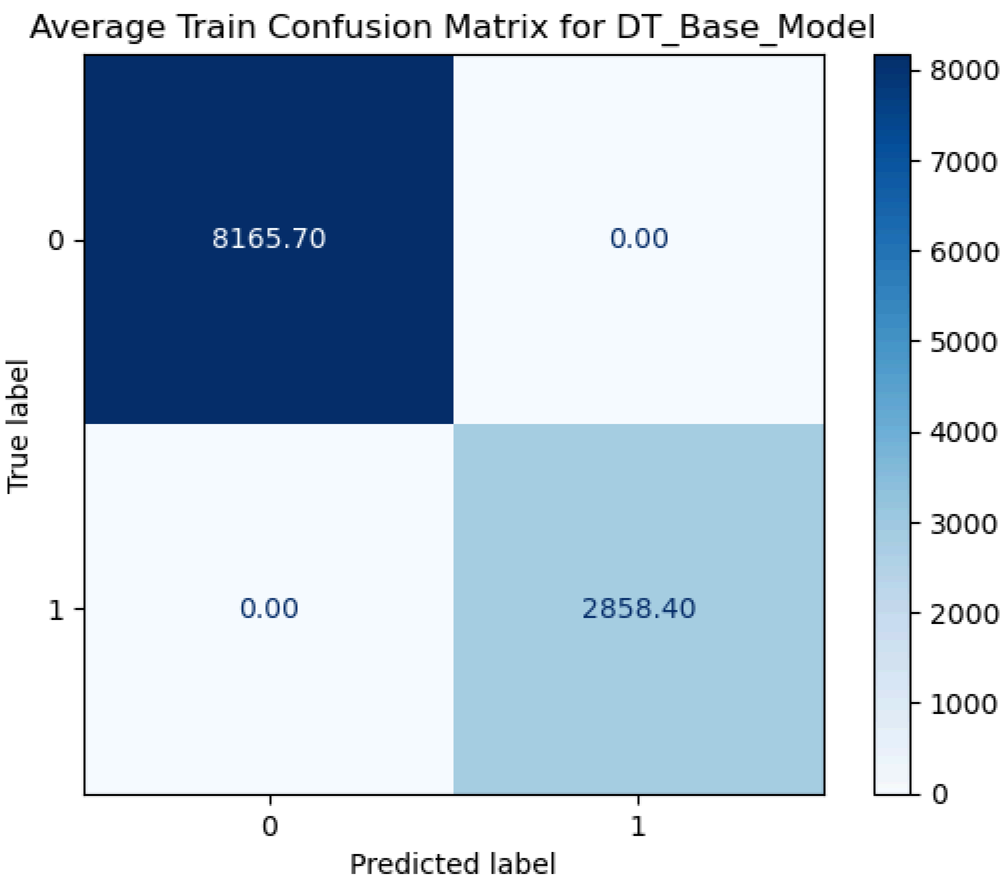
Based off of the baseline model's performance results we can say that the training model does not seem to be overfitting on the data and generalizes well to unseen data. With a 96.187% validation specificity score we can say that the model is already very good at identifying what is not a Dermason bean. The validation precision score of 88.769% tells us that out off all the beans the model predicted to be a Dermason bean roughly 88% of them actually are. These are not a bad scores, although a second filter may be needed on the production line to eliminate the small percentage of non-Dermason beans that were predicted to be Dermason beans. The recal is the lowest of the three metrics, but is still fairly high at 85.613%, and due to this being the manufacturer's least important metric of the three, correctly identifying 85% of the actual Dermason beans is not that bad given all the Dermason beans we failed to identify can still be sold as animal food.

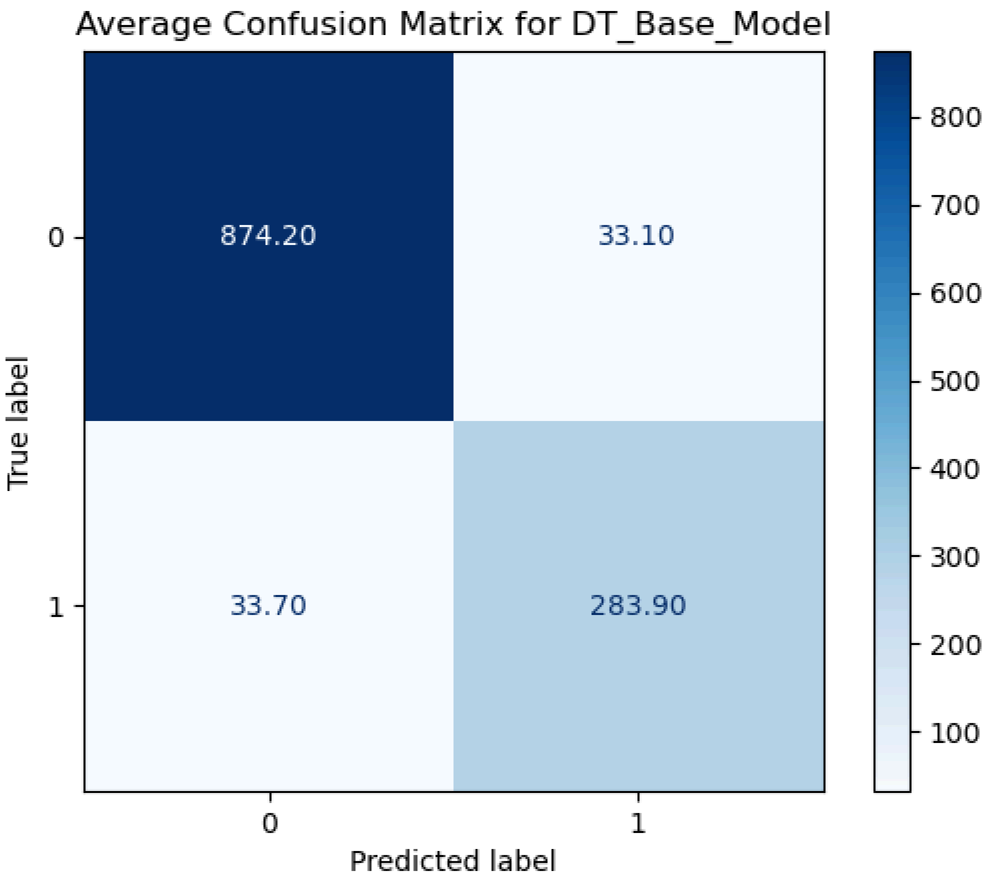
Run a baseline Decision Tree model to get the unpreprocessed and untuned performance results

In [29]:
```
DT_Baseline_Results= ModelWithCV(model_instantiator= DecisionTreeClassifier,
                                    model_name= 'DT_Base_Model',
                                    X= X_train,
                                    y= y_train,
                                    scaler= False,
                                    smote_and_rand_und= False
                                   )

DT_Baseline_Results.plot_avg_conf_matrix()

#compare the summary to the previous Logistic Regression to see which is bet
print('results for dt baseline:')
DT_Baseline_Results.print_cv_summary()
print()
print('results for lr baseline:')
LR_Baseline_Results.print_cv_summary()
```






```
results for dt baseline:
###TRAIN###
CV results for DT_Base_Model model:Average specificity: 1.00000
Average precision: 1.00000
Average recall: 1.00000
###VAL###
CV results for DT_Base_Model model:Average specificity: 0.96352
Average precision: 0.89575
Average recall: 0.89389

results for lr baseline:
###TRAIN###
CV results for LR_Base_Model model:Average specificity: 0.96146
Average precision: 0.88582
Average recall: 0.85499
###VAL###
CV results for LR_Base_Model model:Average specificity: 0.96187
Average precision: 0.88769
Average recall: 0.85613
```

```
Out[29]: (0.9618657383347337, 0.887693568491631, 0.8561286034561435, {}, False, Fals
e)
```

Based off of the Decision Tree (DT) baseline model's performance results we can say that the training model is overfitting on the training data and does not perform as well with unseen data as it does with the training dats. However, with a 96.352% validation specificity score we can say that this model performs better than the baseline Logistic Regression (LR) model at identifying what is not a Dermason bean. The validation precision score of 89.575% tells us that out off all the beans the model predicted to be a Dermason bean roughly 89% of them actually are, which is higher than the LR's score as well. These are not a bad scores, although a second filter may still be needed on the production line to eliminate the small percentage of non-Dermason beans that were predicted to be Dermason beans. The recal score is the still lowest of the three metrics, but is still fairly high at 89.389% and is roughly 4% higher than the LR's score. Due to recal still being the manufacturer's least important metric of the three, correctly identifying 89% of the actual Dermason beans is not that bad given all the Dermason beans we failed to identify can still be sold as animal food.

Tuned classification models

Now that we have a general idea how well each model will perform when presented with unseen data, let's run grid searches on the models to find out which preprocessing and hyperparameter tuning will result in the most effective versions of these models in reference to the manufacturers requested success metrics.

Run a grid search for preprocessing and hyperparameter tuning the Logistic Regression model

I would like to note that this search scale has been narrowed down to parameters previously discovered to be effective, while still demonstrating the effectiveness and utility of the code. This has been done because previous wider searches have proven to be too computationally expensive for my current computer to handle, and cause the notebook to significantly slow down and-or crash. The original grid search parameters are noted above the current ones for reference. One potential way to mitigate this problem could be to split up the grid search and tune for one parameter at a time.

In [16]:

```
#store iteration results
lr_metric_tracker= []
lr_data_and_scaler= []

#iterable options

#trained either using as is distributed data "X_train" or data transformed w
#box-cox and Log "X_Train_Norm"
data_sets= [X_train, X_train_Norm]

#[0.01, 0.1, 1, 10, 100, 1000, 10000, 100000, 1000000, 10000000, 100000000,
C= [1, 10, 10000, 100000]
```

```
#as shown below
int_fit= [True, False]

#['liblinear', 'saga', 'lbfgs']
solvers = ['liblinear', 'saga']

#as shown below
smote= [True, False]

#[False (no scaler), StandardScaler(), MinMaxScaler()]
scaler= [False, MinMaxScaler()]


#nested for loops to iterate through all the above options
for data, data_name in zip(data_sets, ["X_train", "X_train_Norm"]):
    for fit in int_fit:
        for sm in smote:
            for sc in scaler:
                for c in C:
                    for solvera in solvers:
                        model_kwargs= {'C': c, 'solver': solvera, 'fit_inter
                        print(model_kwargs)
                        temp= ModelWithCV(model_instantiator= LogisticRegres
                                                            model_name= 'Tur
                                                            X= data,
                                                            y= y_train,
                                                            scaler= sc,
                                                            smote_and_rand_u
                                                            model_kwargs= mo
                                                           )

                        lr_metric_tracker.append(temp.print_cv_summary())
                        lr_data_and_scaler.append(data_name)

                        print()
                        print('#### NEXT ITERATION###')
```

```
{'C': 1, 'solver': 'liblinear', 'fit_intercept': True, 'penalty': 'l2'}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 0.90486
Average precision: 0.90594
Average recall: 0.91635
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 0.90466
Average precision: 0.77059
Average recall: 0.91309

#### NEXT ITERATION###
{'C': 1, 'solver': 'saga', 'fit_intercept': True, 'penalty': 'l2'}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 1.00000
Average precision: 1.00000
Average recall: 0.00451
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 1.00000
Average precision: 0.90000
Average recall: 0.00441

#### NEXT ITERATION###
{'C': 10, 'solver': 'liblinear', 'fit_intercept': True, 'penalty': 'l2'}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 0.90458
Average precision: 0.90569
Average recall: 0.91638
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 0.90323
Average precision: 0.76799
Average recall: 0.91309

#### NEXT ITERATION###
{'C': 10, 'solver': 'saga', 'fit_intercept': True, 'penalty': 'l2'}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 1.00000
Average precision: 1.00000
Average recall: 0.00451
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 1.00000
Average precision: 0.90000
Average recall: 0.00441

#### NEXT ITERATION###
{'C': 10000, 'solver': 'liblinear', 'fit_intercept': True, 'penalty': 'l2'}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 0.90501
Average precision: 0.90607
Average recall: 0.91633
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 0.90488
```

```
Average precision: 0.77102
Average recall: 0.91309

#### NEXT ITERATION###
{'C': 10000, 'solver': 'saga', 'fit_intercept': True, 'penalty': 'l2'}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 1.00000
Average precision: 1.00000
Average recall: 0.00451
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 1.00000
Average precision: 0.90000
Average recall: 0.00441

#### NEXT ITERATION###
{'C': 100000, 'solver': 'liblinear', 'fit_intercept': True, 'penalty': 'l2'}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 0.90487
Average precision: 0.90595
Average recall: 0.91633
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 0.90466
Average precision: 0.77061
Average recall: 0.91309

#### NEXT ITERATION###
{'C': 100000, 'solver': 'saga', 'fit_intercept': True, 'penalty': 'l2'}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 1.00000
Average precision: 1.00000
Average recall: 0.00451
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 1.00000
Average precision: 0.90000
Average recall: 0.00441

#### NEXT ITERATION###
{'C': 1, 'solver': 'liblinear', 'fit_intercept': True, 'penalty': 'l2'}
Scaling
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 0.94299
Average precision: 0.94373
Average recall: 0.95610
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 0.94258
Average precision: 0.85277
Average recall: 0.94679

#### NEXT ITERATION###
{'C': 1, 'solver': 'saga', 'fit_intercept': True, 'penalty': 'l2'}
Scaling
SMOTEing and Randomly Undersampling
```

```
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 0.94315
Average precision: 0.94387
Average recall: 0.95601
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 0.94324
Average precision: 0.85447
Average recall: 0.94804

#### NEXT ITERATION###
{'C': 10, 'solver': 'liblinear', 'fit_intercept': True, 'penalty': 'l2'}
Scaling
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 0.94913
Average precision: 0.94982
Average recall: 0.96286
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 0.94897
Average precision: 0.86794
Average recall: 0.95403

#### NEXT ITERATION###
{'C': 10, 'solver': 'saga', 'fit_intercept': True, 'penalty': 'l2'}
Scaling
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 0.94921
Average precision: 0.94989
Average recall: 0.96280
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 0.94875
Average precision: 0.86740
Average recall: 0.95340

#### NEXT ITERATION###
{'C': 10000, 'solver': 'liblinear', 'fit_intercept': True, 'penalty': 'l2'}
Scaling
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 0.95115
Average precision: 0.95183
Average recall: 0.96529
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 0.95063
Average precision: 0.87204
Average recall: 0.95718

#### NEXT ITERATION###
{'C': 10000, 'solver': 'saga', 'fit_intercept': True, 'penalty': 'l2'}
Scaling
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 0.95165
Average precision: 0.95227
Average recall: 0.96453
```

```
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 0.95173
Average precision: 0.87451
Average recall: 0.95718

#### NEXT ITERATION###
{'C': 100000, 'solver': 'liblinear', 'fit_intercept': True, 'penalty': 'l2'}
Scaling
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 0.95115
Average precision: 0.95185
Average recall: 0.96572
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 0.95074
Average precision: 0.87221
Average recall: 0.95655

#### NEXT ITERATION###
{'C': 100000, 'solver': 'saga', 'fit_intercept': True, 'penalty': 'l2'}
Scaling
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 0.95164
Average precision: 0.95225
Average recall: 0.96453
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 0.95173
Average precision: 0.87451
Average recall: 0.95718

#### NEXT ITERATION###
{'C': 1, 'solver': 'liblinear', 'fit_intercept': True, 'penalty': 'l2'}
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 0.95629
Average precision: 0.86861
Average recall: 0.82515
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 0.95448
Average precision: 0.86433
Average recall: 0.82494

#### NEXT ITERATION###
{'C': 1, 'solver': 'saga', 'fit_intercept': True, 'penalty': 'l2'}
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 1.00000
Average precision: 0.00000
Average recall: 0.00000
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 1.00000
Average precision: 0.00000
Average recall: 0.00000

#### NEXT ITERATION###
{'C': 10, 'solver': 'liblinear', 'fit_intercept': True, 'penalty': 'l2'}
###TRAIN###
```

```
CV results for Tuned_LR_Model model:Average specificity: 0.95648
Average precision: 0.86909
Average recall: 0.82515
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 0.95470
Average precision: 0.86495
Average recall: 0.82462

#### NEXT ITERATION###
{'C': 10, 'solver': 'saga', 'fit_intercept': True, 'penalty': 'l2'}
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 1.00000
Average precision: 0.00000
Average recall: 0.00000
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 1.00000
Average precision: 0.00000
Average recall: 0.00000

#### NEXT ITERATION###
{'C': 10000, 'solver': 'liblinear', 'fit_intercept': True, 'penalty': 'l2'}
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 0.95618
Average precision: 0.86831
Average recall: 0.82504
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 0.95602
Average precision: 0.86851
Average recall: 0.82494

#### NEXT ITERATION###
{'C': 10000, 'solver': 'saga', 'fit_intercept': True, 'penalty': 'l2'}
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 1.00000
Average precision: 0.00000
Average recall: 0.00000
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 1.00000
Average precision: 0.00000
Average recall: 0.00000

#### NEXT ITERATION###
{'C': 100000, 'solver': 'liblinear', 'fit_intercept': True, 'penalty': 'l2'}
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 0.95768
Average precision: 0.87221
Average recall: 0.82522
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 0.95724
Average precision: 0.87162
Average recall: 0.82494

#### NEXT ITERATION###
{'C': 100000, 'solver': 'saga', 'fit_intercept': True, 'penalty': 'l2'}
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 1.00000
```

```
Average precision: 0.00000
Average recall: 0.00000
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 1.00000
Average precision: 0.00000
Average recall: 0.00000

#### NEXT ITERATION###
{'C': 1, 'solver': 'liblinear', 'fit_intercept': True, 'penalty': 'l2'}
Scaling
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 0.97728
Average precision: 0.92986
Average recall: 0.86031
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 0.97686
Average precision: 0.92898
Average recall: 0.86052

#### NEXT ITERATION###
{'C': 1, 'solver': 'saga', 'fit_intercept': True, 'penalty': 'l2'}
Scaling
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 0.97700
Average precision: 0.92907
Average recall: 0.86062
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 0.97675
Average precision: 0.92856
Average recall: 0.85989

#### NEXT ITERATION###
{'C': 10, 'solver': 'liblinear', 'fit_intercept': True, 'penalty': 'l2'}
Scaling
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 0.97512
Average precision: 0.92626
Average recall: 0.89295
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 0.97487
Average precision: 0.92579
Average recall: 0.89168

#### NEXT ITERATION###
{'C': 10, 'solver': 'saga', 'fit_intercept': True, 'penalty': 'l2'}
Scaling
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 0.97520
Average precision: 0.92648
Average recall: 0.89277
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 0.97487
Average precision: 0.92576
Average recall: 0.89105

#### NEXT ITERATION###
```

```
{'C': 10000, 'solver': 'liblinear', 'fit_intercept': True, 'penalty': 'l2'}
Scaling
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 0.97407
Average precision: 0.92472
Average recall: 0.90970
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 0.97399
Average precision: 0.92459
Average recall: 0.90712

#### NEXT ITERATION###
{'C': 10000, 'solver': 'saga', 'fit_intercept': True, 'penalty': 'l2'}
Scaling
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 0.97422
Average precision: 0.92476
Average recall: 0.90512
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 0.97388
Average precision: 0.92416
Average recall: 0.90428

#### NEXT ITERATION###
{'C': 100000, 'solver': 'liblinear', 'fit_intercept': True, 'penalty': 'l2'}
Scaling
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 0.97407
Average precision: 0.92472
Average recall: 0.90974
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 0.97399
Average precision: 0.92455
Average recall: 0.90649

#### NEXT ITERATION###
{'C': 100000, 'solver': 'saga', 'fit_intercept': True, 'penalty': 'l2'}
Scaling
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 0.97423
Average precision: 0.92479
Average recall: 0.90512
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 0.97388
Average precision: 0.92416
Average recall: 0.90428

#### NEXT ITERATION###
{'C': 1, 'solver': 'liblinear', 'fit_intercept': False, 'penalty': 'l2'}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 0.90483
Average precision: 0.90592
Average recall: 0.91636
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 0.90455
```

```
Average precision: 0.77038
Average recall: 0.91309

#### NEXT ITERATION###
{'C': 1, 'solver': 'saga', 'fit_intercept': False, 'penalty': 'l2'}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 1.00000
Average precision: 1.00000
Average recall: 0.00451
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 1.00000
Average precision: 0.90000
Average recall: 0.00441

#### NEXT ITERATION###
{'C': 10, 'solver': 'liblinear', 'fit_intercept': False, 'penalty': 'l2'}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 0.90485
Average precision: 0.90593
Average recall: 0.91636
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 0.90477
Average precision: 0.77081
Average recall: 0.91309

#### NEXT ITERATION###
{'C': 10, 'solver': 'saga', 'fit_intercept': False, 'penalty': 'l2'}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 1.00000
Average precision: 1.00000
Average recall: 0.00451
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 1.00000
Average precision: 0.90000
Average recall: 0.00441

#### NEXT ITERATION###
{'C': 10000, 'solver': 'liblinear', 'fit_intercept': False, 'penalty': 'l2'}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 0.90482
Average precision: 0.90590
Average recall: 0.91633
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 0.90477
Average precision: 0.77081
Average recall: 0.91309

#### NEXT ITERATION###
{'C': 10000, 'solver': 'saga', 'fit_intercept': False, 'penalty': 'l2'}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 1.00000
```

```
Average precision: 1.00000
Average recall: 0.00451
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 1.00000
Average precision: 0.90000
Average recall: 0.00441

#### NEXT ITERATION###
{'C': 100000, 'solver': 'liblinear', 'fit_intercept': False, 'penalty': 'l
2'}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 0.90491
Average precision: 0.90598
Average recall: 0.91632
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 0.90477
Average precision: 0.77081
Average recall: 0.91309

#### NEXT ITERATION###
{'C': 100000, 'solver': 'saga', 'fit_intercept': False, 'penalty': 'l2'}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 1.00000
Average precision: 1.00000
Average recall: 0.00451
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 1.00000
Average precision: 0.90000
Average recall: 0.00441

#### NEXT ITERATION###
{'C': 1, 'solver': 'liblinear', 'fit_intercept': False, 'penalty': 'l2'}
Scaling
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 0.94269
Average precision: 0.94346
Average recall: 0.95627
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 0.94214
Average precision: 0.85185
Average recall: 0.94710

#### NEXT ITERATION###
{'C': 1, 'solver': 'saga', 'fit_intercept': False, 'penalty': 'l2'}
Scaling
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 0.94267
Average precision: 0.94344
Average recall: 0.95627
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 0.94214
Average precision: 0.85185
```

```
Average recall: 0.94710

#### NEXT ITERATION###
{'C': 10, 'solver': 'liblinear', 'fit_intercept': False, 'penalty': 'l2'}
Scaling
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 0.94918
Average precision: 0.94987
Average recall: 0.96292
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 0.94853
Average precision: 0.86697
Average recall: 0.95403

#### NEXT ITERATION###
{'C': 10, 'solver': 'saga', 'fit_intercept': False, 'penalty': 'l2'}
Scaling
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 0.94919
Average precision: 0.94988
Average recall: 0.96288
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 0.94864
Average precision: 0.86719
Average recall: 0.95371

#### NEXT ITERATION###
{'C': 10000, 'solver': 'liblinear', 'fit_intercept': False, 'penalty': 'l2'}
Scaling
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 0.95104
Average precision: 0.95171
Average recall: 0.96495
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 0.95040
Average precision: 0.87151
Average recall: 0.95655

#### NEXT ITERATION###
{'C': 10000, 'solver': 'saga', 'fit_intercept': False, 'penalty': 'l2'}
Scaling
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 0.95163
Average precision: 0.95224
Average recall: 0.96452
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 0.95151
Average precision: 0.87402
Average recall: 0.95718

#### NEXT ITERATION###
{'C': 100000, 'solver': 'liblinear', 'fit_intercept': False, 'penalty': 'l
```

```
2'}
Scaling
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 0.95089
Average precision: 0.95158
Average recall: 0.96509
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 0.95051
Average precision: 0.87174
Average recall: 0.95655

#### NEXT ITERATION###
{'C': 100000, 'solver': 'saga', 'fit_intercept': False, 'penalty': 'l2'}
Scaling
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 0.95163
Average precision: 0.95224
Average recall: 0.96452
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 0.95151
Average precision: 0.87402
Average recall: 0.95718

#### NEXT ITERATION###
{'C': 1, 'solver': 'liblinear', 'fit_intercept': False, 'penalty': 'l2'}
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 0.95622
Average precision: 0.86839
Average recall: 0.82497
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 0.95658
Average precision: 0.86991
Average recall: 0.82431

#### NEXT ITERATION###
{'C': 1, 'solver': 'saga', 'fit_intercept': False, 'penalty': 'l2'}
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 1.00000
Average precision: 0.00000
Average recall: 0.00000
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 1.00000
Average precision: 0.00000
Average recall: 0.00000

#### NEXT ITERATION###
{'C': 10, 'solver': 'liblinear', 'fit_intercept': False, 'penalty': 'l2'}
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 0.95728
Average precision: 0.87120
Average recall: 0.82525
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 0.95691
Average precision: 0.87082
```

```
Average recall: 0.82494

#### NEXT ITERATION###
{'C': 10, 'solver': 'saga', 'fit_intercept': False, 'penalty': 'l2'}
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 1.00000
Average precision: 0.00000
Average recall: 0.00000
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 1.00000
Average precision: 0.00000
Average recall: 0.00000

#### NEXT ITERATION###
{'C': 10000, 'solver': 'liblinear', 'fit_intercept': False, 'penalty': 'l2'}
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 0.95488
Average precision: 0.86495
Average recall: 0.82508
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 0.95492
Average precision: 0.86574
Average recall: 0.82494

#### NEXT ITERATION###
{'C': 10000, 'solver': 'saga', 'fit_intercept': False, 'penalty': 'l2'}
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 1.00000
Average precision: 0.00000
Average recall: 0.00000
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 1.00000
Average precision: 0.00000
Average recall: 0.00000

#### NEXT ITERATION###
{'C': 100000, 'solver': 'liblinear', 'fit_intercept': False, 'penalty': 'l
2'}
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 0.95572
Average precision: 0.86707
Average recall: 0.82494
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 0.95503
Average precision: 0.86577
Average recall: 0.82462

#### NEXT ITERATION###
{'C': 100000, 'solver': 'saga', 'fit_intercept': False, 'penalty': 'l2'}
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 1.00000
Average precision: 0.00000
Average recall: 0.00000
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 1.00000
Average precision: 0.00000
```

```
Average recall: 0.00000

#### NEXT ITERATION###
{'C': 1, 'solver': 'liblinear', 'fit_intercept': False, 'penalty': 'l2'}
Scaling
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 0.97723
Average precision: 0.92973
Average recall: 0.86048
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 0.97697
Average precision: 0.92939
Average recall: 0.86146

#### NEXT ITERATION###
{'C': 1, 'solver': 'saga', 'fit_intercept': False, 'penalty': 'l2'}
Scaling
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 0.97720
Average precision: 0.92962
Average recall: 0.86045
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 0.97697
Average precision: 0.92939
Average recall: 0.86146

#### NEXT ITERATION###
{'C': 10, 'solver': 'liblinear', 'fit_intercept': False, 'penalty': 'l2'}
Scaling
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 0.97516
Average precision: 0.92640
Average recall: 0.89305
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 0.97498
Average precision: 0.92617
Average recall: 0.89200

#### NEXT ITERATION###
{'C': 10, 'solver': 'saga', 'fit_intercept': False, 'penalty': 'l2'}
Scaling
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 0.97515
Average precision: 0.92637
Average recall: 0.89309
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 0.97498
Average precision: 0.92617
Average recall: 0.89200

#### NEXT ITERATION###
{'C': 10000, 'solver': 'liblinear', 'fit_intercept': False, 'penalty': 'l2'}
Scaling
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 0.97398
Average precision: 0.92446
```

```
Average recall: 0.90977
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 0.97388
Average precision: 0.92430
Average recall: 0.90743

#### NEXT ITERATION###
{'C': 10000, 'solver': 'saga', 'fit_intercept': False, 'penalty': 'l2'}
Scaling
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 0.97428
Average precision: 0.92498
Average recall: 0.90582
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 0.97399
Average precision: 0.92441
Average recall: 0.90397

#### NEXT ITERATION###
{'C': 100000, 'solver': 'liblinear', 'fit_intercept': False, 'penalty': 'l
2'}
Scaling
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 0.97399
Average precision: 0.92450
Average recall: 0.90984
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 0.97399
Average precision: 0.92460
Average recall: 0.90743

#### NEXT ITERATION###
{'C': 100000, 'solver': 'saga', 'fit_intercept': False, 'penalty': 'l2'}
Scaling
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 0.97428
Average precision: 0.92498
Average recall: 0.90582
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 0.97399
Average precision: 0.92441
Average recall: 0.90397

#### NEXT ITERATION###
{'C': 1, 'solver': 'liblinear', 'fit_intercept': True, 'penalty': 'l2'}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 0.86081
Average precision: 0.86707
Average recall: 0.90790
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 0.86036
Average precision: 0.69536
Average recall: 0.90901

#### NEXT ITERATION###
```

```
{'C': 1, 'solver': 'saga', 'fit_intercept': True, 'penalty': 'l2'}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 0.82910
Average precision: 0.83865
Average recall: 0.88830
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 0.82939
Average precision: 0.64635
Average recall: 0.88917

#### NEXT ITERATION###
{'C': 10, 'solver': 'liblinear', 'fit_intercept': True, 'penalty': 'l2'}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 0.93244
Average precision: 0.93337
Average recall: 0.94643
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 0.93244
Average precision: 0.83061
Average recall: 0.94206

#### NEXT ITERATION###
{'C': 10, 'solver': 'saga', 'fit_intercept': True, 'penalty': 'l2'}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 0.83172
Average precision: 0.83980
Average recall: 0.88212
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 0.83203
Average precision: 0.64836
Average recall: 0.88351

#### NEXT ITERATION###
{'C': 10000, 'solver': 'liblinear', 'fit_intercept': True, 'penalty': 'l2'}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 0.95203
Average precision: 0.95254
Average recall: 0.96275
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 0.95151
Average precision: 0.87386
Average recall: 0.95560

#### NEXT ITERATION###
{'C': 10000, 'solver': 'saga', 'fit_intercept': True, 'penalty': 'l2'}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 0.83198
Average precision: 0.83989
Average recall: 0.88138
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 0.83269
```

```
Average precision: 0.64919
Average recall: 0.88319

#### NEXT ITERATION###
{'C': 100000, 'solver': 'liblinear', 'fit_intercept': True, 'penalty': 'l2'}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 0.95219
Average precision: 0.95271
Average recall: 0.96329
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 0.95140
Average precision: 0.87375
Average recall: 0.95686

#### NEXT ITERATION###
{'C': 100000, 'solver': 'saga', 'fit_intercept': True, 'penalty': 'l2'}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 0.83198
Average precision: 0.83989
Average recall: 0.88138
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 0.83269
Average precision: 0.64919
Average recall: 0.88319

#### NEXT ITERATION###
{'C': 1, 'solver': 'liblinear', 'fit_intercept': True, 'penalty': 'l2'}
Scaling
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 0.93819
Average precision: 0.93838
Average recall: 0.94119
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 0.93850
Average precision: 0.84180
Average recall: 0.93042

#### NEXT ITERATION###
{'C': 1, 'solver': 'saga', 'fit_intercept': True, 'penalty': 'l2'}
Scaling
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 0.93884
Average precision: 0.93916
Average recall: 0.94400
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 0.93850
Average precision: 0.84206
Average recall: 0.93325

#### NEXT ITERATION###
{'C': 10, 'solver': 'liblinear', 'fit_intercept': True, 'penalty': 'l2'}
Scaling
```

```
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 0.94959
Average precision: 0.94989
Average recall: 0.95558
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 0.95007
Average precision: 0.86918
Average recall: 0.94332

#### NEXT ITERATION###
{'C': 10, 'solver': 'saga', 'fit_intercept': True, 'penalty': 'l2'}
Scaling
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 0.95003
Average precision: 0.95039
Average recall: 0.95716
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 0.95030
Average precision: 0.86977
Average recall: 0.94458

#### NEXT ITERATION###
{'C': 10000, 'solver': 'liblinear', 'fit_intercept': True, 'penalty': 'l2'}
Scaling
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 0.95255
Average precision: 0.95324
Average recall: 0.96744
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 0.95217
Average precision: 0.87553
Average recall: 0.95655

#### NEXT ITERATION###
{'C': 10000, 'solver': 'saga', 'fit_intercept': True, 'penalty': 'l2'}
Scaling
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 0.95263
Average precision: 0.95312
Average recall: 0.96311
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 0.95217
Average precision: 0.87504
Average recall: 0.95308

#### NEXT ITERATION###
{'C': 100000, 'solver': 'liblinear', 'fit_intercept': True, 'penalty': 'l2'}
Scaling
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 0.95349
Average precision: 0.95417
```

```
Average recall: 0.96843
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 0.95338
Average precision: 0.87830
Average recall: 0.95686

#### NEXT ITERATION###
{'C': 100000, 'solver': 'saga', 'fit_intercept': True, 'penalty': 'l2'}
Scaling
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 0.95264
Average precision: 0.95314
Average recall: 0.96314
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 0.95217
Average precision: 0.87504
Average recall: 0.95308

#### NEXT ITERATION###
{'C': 1, 'solver': 'liblinear', 'fit_intercept': True, 'penalty': 'l2'}
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 0.97489
Average precision: 0.89858
Average recall: 0.63543
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 0.97454
Average precision: 0.89698
Average recall: 0.63475

#### NEXT ITERATION###
{'C': 1, 'solver': 'saga', 'fit_intercept': True, 'penalty': 'l2'}
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 0.96730
Average precision: 0.85921
Average recall: 0.57007
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 0.96727
Average precision: 0.85911
Average recall: 0.57052

#### NEXT ITERATION###
{'C': 10, 'solver': 'liblinear', 'fit_intercept': True, 'penalty': 'l2'}
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 0.98004
Average precision: 0.93440
Average recall: 0.81224
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 0.97983
Average precision: 0.93396
Average recall: 0.81172

#### NEXT ITERATION###
{'C': 10, 'solver': 'saga', 'fit_intercept': True, 'penalty': 'l2'}
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 0.96031
```

```
Average precision: 0.83939
Average recall: 0.59257
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 0.95944
Average precision: 0.83669
Average recall: 0.59287

#### NEXT ITERATION###
{'C': 10000, 'solver': 'liblinear', 'fit_intercept': True, 'penalty': 'l2'}
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 0.97465
Average precision: 0.92563
Average recall: 0.90131
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 0.97465
Average precision: 0.92584
Average recall: 0.90050

#### NEXT ITERATION###
{'C': 10000, 'solver': 'saga', 'fit_intercept': True, 'penalty': 'l2'}
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 0.95948
Average precision: 0.83721
Average recall: 0.59533
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 0.95900
Average precision: 0.83589
Average recall: 0.59602

#### NEXT ITERATION###
{'C': 100000, 'solver': 'liblinear', 'fit_intercept': True, 'penalty': 'l2'}
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 0.97465
Average precision: 0.92565
Average recall: 0.90166
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 0.97465
Average precision: 0.92596
Average recall: 0.90113

#### NEXT ITERATION###
{'C': 100000, 'solver': 'saga', 'fit_intercept': True, 'penalty': 'l2'}
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 0.95948
Average precision: 0.83721
Average recall: 0.59533
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 0.95900
Average precision: 0.83589
Average recall: 0.59602

#### NEXT ITERATION###
{'C': 1, 'solver': 'liblinear', 'fit_intercept': True, 'penalty': 'l2'}
Scaling
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 0.97268
```

```
Average precision: 0.91584
Average recall: 0.84939
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 0.97245
Average precision: 0.91559
Average recall: 0.84792

#### NEXT ITERATION###
{'C': 1, 'solver': 'saga', 'fit_intercept': True, 'penalty': 'l2'}
Scaling
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 0.97390
Average precision: 0.91955
Average recall: 0.85212
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 0.97355
Average precision: 0.91892
Average recall: 0.85107

#### NEXT ITERATION###
{'C': 10, 'solver': 'liblinear', 'fit_intercept': True, 'penalty': 'l2'}
Scaling
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 0.97567
Average precision: 0.92686
Average recall: 0.88095
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 0.97542
Average precision: 0.92639
Average recall: 0.88004

#### NEXT ITERATION###
{'C': 10, 'solver': 'saga', 'fit_intercept': True, 'penalty': 'l2'}
Scaling
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 0.97595
Average precision: 0.92778
Average recall: 0.88273
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 0.97553
Average precision: 0.92691
Average recall: 0.88256

#### NEXT ITERATION###
{'C': 10000, 'solver': 'liblinear', 'fit_intercept': True, 'penalty': 'l2'}
Scaling
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 0.97401
Average precision: 0.92442
Average recall: 0.90789
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 0.97355
Average precision: 0.92326
Average recall: 0.90396

#### NEXT ITERATION###
```

```
{'C': 10000, 'solver': 'saga', 'fit_intercept': True, 'penalty': 'l2'}
Scaling
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 0.97505
Average precision: 0.92624
Average recall: 0.89487
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 0.97465
Average precision: 0.92530
Average recall: 0.89358

#### NEXT ITERATION###
{'C': 100000, 'solver': 'liblinear', 'fit_intercept': True, 'penalty': 'l2'}
Scaling
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 0.97372
Average precision: 0.92380
Average recall: 0.91019
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 0.97322
Average precision: 0.92262
Average recall: 0.90806

#### NEXT ITERATION###
{'C': 100000, 'solver': 'saga', 'fit_intercept': True, 'penalty': 'l2'}
Scaling
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 0.97505
Average precision: 0.92624
Average recall: 0.89487
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 0.97465
Average precision: 0.92530
Average recall: 0.89358

#### NEXT ITERATION###
{'C': 1, 'solver': 'liblinear', 'fit_intercept': False, 'penalty': 'l2'}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 0.82532
Average precision: 0.83573
Average recall: 0.88871
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 0.82410
Average precision: 0.63951
Average recall: 0.88980

#### NEXT ITERATION###
{'C': 1, 'solver': 'saga', 'fit_intercept': False, 'penalty': 'l2'}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 0.78986
Average precision: 0.80622
Average recall: 0.87429
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 0.78927
```

```
Average precision: 0.59296
Average recall: 0.87563

#### NEXT ITERATION###
{'C': 10, 'solver': 'liblinear', 'fit_intercept': False, 'penalty': 'l2'}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 0.91812
Average precision: 0.91964
Average recall: 0.93700
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 0.91811
Average precision: 0.80024
Average recall: 0.93450

#### NEXT ITERATION###
{'C': 10, 'solver': 'saga', 'fit_intercept': False, 'penalty': 'l2'}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 0.79811
Average precision: 0.81120
Average recall: 0.86743
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 0.79753
Average precision: 0.60060
Average recall: 0.86871

#### NEXT ITERATION###
{'C': 10000, 'solver': 'liblinear', 'fit_intercept': False, 'penalty': 'l2'}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 0.95198
Average precision: 0.95256
Average recall: 0.96423
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 0.95173
Average precision: 0.87461
Average recall: 0.95812

#### NEXT ITERATION###
{'C': 10000, 'solver': 'saga', 'fit_intercept': False, 'penalty': 'l2'}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 0.79889
Average precision: 0.81165
Average recall: 0.86666
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 0.79830
Average precision: 0.60123
Average recall: 0.86776

#### NEXT ITERATION###
{'C': 100000, 'solver': 'liblinear', 'fit_intercept': False, 'penalty': 'l
2'}
SMOTEing and Randomly Undersampling
###TRAIN###
```

```
CV results for Tuned_LR_Model model:Average specificity: 0.95266
Average precision: 0.95323
Average recall: 0.96488
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 0.95239
Average precision: 0.87613
Average recall: 0.95812

#### NEXT ITERATION###
{'C': 100000, 'solver': 'saga', 'fit_intercept': False, 'penalty': 'l2'}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 0.79889
Average precision: 0.81165
Average recall: 0.86666
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 0.79830
Average precision: 0.60123
Average recall: 0.86776

#### NEXT ITERATION###
{'C': 1, 'solver': 'liblinear', 'fit_intercept': False, 'penalty': 'l2'}
Scaling
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 0.93743
Average precision: 0.93756
Average recall: 0.93943
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 0.93729
Average precision: 0.83910
Average recall: 0.92947

#### NEXT ITERATION###
{'C': 1, 'solver': 'saga', 'fit_intercept': False, 'penalty': 'l2'}
Scaling
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 0.93745
Average precision: 0.93757
Average recall: 0.93943
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 0.93729
Average precision: 0.83910
Average recall: 0.92947

#### NEXT ITERATION###
{'C': 10, 'solver': 'liblinear', 'fit_intercept': False, 'penalty': 'l2'}
Scaling
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 0.94925
Average precision: 0.94951
Average recall: 0.95431
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 0.94952
```

```
Average precision: 0.86801
Average recall: 0.94395

#### NEXT ITERATION###
{'C': 10, 'solver': 'saga', 'fit_intercept': False, 'penalty': 'l2'}
Scaling
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 0.94929
Average precision: 0.94954
Average recall: 0.95425
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 0.94952
Average precision: 0.86801
Average recall: 0.94395

#### NEXT ITERATION###
{'C': 10000, 'solver': 'liblinear', 'fit_intercept': False, 'penalty': 'l2'}
Scaling
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 0.95383
Average precision: 0.95441
Average recall: 0.96649
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 0.95349
Average precision: 0.87831
Average recall: 0.95497

#### NEXT ITERATION###
{'C': 10000, 'solver': 'saga', 'fit_intercept': False, 'penalty': 'l2'}
Scaling
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 0.95288
Average precision: 0.95331
Average recall: 0.96212
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 0.95239
Average precision: 0.87526
Average recall: 0.95056

#### NEXT ITERATION###
{'C': 100000, 'solver': 'liblinear', 'fit_intercept': False, 'penalty': 'l
2'}
Scaling
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 0.95386
Average precision: 0.95449
Average recall: 0.96777
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 0.95371
Average precision: 0.87907
Average recall: 0.95718
```

```
#### NEXT ITERATION###
{'C': 100000, 'solver': 'saga', 'fit_intercept': False, 'penalty': 'l2'}
Scaling
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 0.95288
Average precision: 0.95331
Average recall: 0.96213
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 0.95250
Average precision: 0.87550
Average recall: 0.95056

#### NEXT ITERATION###
{'C': 1, 'solver': 'liblinear', 'fit_intercept': False, 'penalty': 'l2'}
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 0.96346
Average precision: 0.84250
Average recall: 0.55842
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 0.96308
Average precision: 0.84128
Average recall: 0.55824

#### NEXT ITERATION###
{'C': 1, 'solver': 'saga', 'fit_intercept': False, 'penalty': 'l2'}
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 0.95605
Average precision: 0.78546
Average recall: 0.45970
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 0.95536
Average precision: 0.78296
Average recall: 0.45906

#### NEXT ITERATION###
{'C': 10, 'solver': 'liblinear', 'fit_intercept': False, 'penalty': 'l2'}
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 0.97889
Average precision: 0.92761
Average recall: 0.77288
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 0.97895
Average precision: 0.92795
Average recall: 0.77268

#### NEXT ITERATION###
{'C': 10, 'solver': 'saga', 'fit_intercept': False, 'penalty': 'l2'}
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 0.94999
Average precision: 0.78240
Average recall: 0.51371
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 0.95040
Average precision: 0.78387
Average recall: 0.51322
```

```
#### NEXT ITERATION###
{'C': 10000, 'solver': 'liblinear', 'fit_intercept': False, 'penalty': 'l2'}
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 0.97487
Average precision: 0.92607
Average recall: 0.89921
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 0.97454
Average precision: 0.92536
Average recall: 0.89767

#### NEXT ITERATION###
{'C': 10000, 'solver': 'saga', 'fit_intercept': False, 'penalty': 'l2'}
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 0.94913
Average precision: 0.78115
Average recall: 0.51872
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 0.94930
Average precision: 0.78177
Average recall: 0.51825

#### NEXT ITERATION###
{'C': 100000, 'solver': 'liblinear', 'fit_intercept': False, 'penalty': 'l
2'}
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 0.97481
Average precision: 0.92596
Average recall: 0.90001
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 0.97465
Average precision: 0.92559
Average recall: 0.89704

#### NEXT ITERATION###
{'C': 100000, 'solver': 'saga', 'fit_intercept': False, 'penalty': 'l2'}
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 0.94913
Average precision: 0.78115
Average recall: 0.51872
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 0.94930
Average precision: 0.78177
Average recall: 0.51825

#### NEXT ITERATION###
{'C': 1, 'solver': 'liblinear', 'fit_intercept': False, 'penalty': 'l2'}
Scaling
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 0.97236
Average precision: 0.91468
Average recall: 0.84642
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 0.97201
Average precision: 0.91433
```

```
Average recall: 0.84635

#### NEXT ITERATION###
{'C': 1, 'solver': 'saga', 'fit_intercept': False, 'penalty': 'l2'}
Scaling
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 0.97236
Average precision: 0.91468
Average recall: 0.84642
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 0.97201
Average precision: 0.91433
Average recall: 0.84635

#### NEXT ITERATION###
{'C': 10, 'solver': 'liblinear', 'fit_intercept': False, 'penalty': 'l2'}
Scaling
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 0.97535
Average precision: 0.92584
Average recall: 0.87923
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 0.97509
Average precision: 0.92536
Average recall: 0.87846

#### NEXT ITERATION###
{'C': 10, 'solver': 'saga', 'fit_intercept': False, 'penalty': 'l2'}
Scaling
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 0.97535
Average precision: 0.92584
Average recall: 0.87916
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 0.97509
Average precision: 0.92533
Average recall: 0.87815

#### NEXT ITERATION###
{'C': 10000, 'solver': 'liblinear', 'fit_intercept': False, 'penalty': 'l2'}
Scaling
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 0.97513
Average precision: 0.92711
Average recall: 0.90379
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 0.97509
Average precision: 0.92716
Average recall: 0.90239

#### NEXT ITERATION###
{'C': 10000, 'solver': 'saga', 'fit_intercept': False, 'penalty': 'l2'}
Scaling
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 0.97558
Average precision: 0.92762
```

```
Average recall: 0.89403
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 0.97553
Average precision: 0.92769
Average recall: 0.89263

#### NEXT ITERATION###
{'C': 100000, 'solver': 'liblinear', 'fit_intercept': False, 'penalty': 'l
2'}
Scaling
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 0.97432
Average precision: 0.92534
Average recall: 0.90921
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 0.97443
Average precision: 0.92576
Average recall: 0.90742

#### NEXT ITERATION###
{'C': 100000, 'solver': 'saga', 'fit_intercept': False, 'penalty': 'l2'}
Scaling
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 0.97558
Average precision: 0.92762
Average recall: 0.89403
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 0.97553
Average precision: 0.92767
Average recall: 0.89232

#### NEXT ITERATION###
```

Create a new dataframe going over the performance results of each of these iterations and the models' inputs.

In [17]:

```
#change the dataframe display output so that the full list of Kwargs can be
pd.set_option('display.max_colwidth', None)
```

In [18]:

```
#merge the outputted data from the two lists into one data frame
lr_metrics_df= pd.DataFrame(lr_metric_tracker)
lr_data_scaler_df= pd.DataFrame(lr_data_and_scaler)
lr_tuned_results_df = pd.merge(lr_metrics_df, lr_data_scaler_df, left_index=

#print the length of the new data frame so we know how many model variations
print(len(lr_tuned_results_df))

#update the column names of the dataset so they make sense
lr_new_col_names= ['v_avg_spec', 'v_avg_prec', 'v_avg_rec', 'v_Kwargs_hyp_pa
lr_tuned_results_df.columns= lr_new_col_names

#preview the new dataset
lr_tuned_results_df.head()
```

```
128
```

Out[18]:

	v_avg_spec	v_avg_prec	v_avg_rec	v_Kwargs_hyp_para	scaler	v_SM_RU	n
0	0.904663	0.770589	0.913092	{'C': 1, 'solver': 'liblinear', 'fit_intercept': True, 'penalty': 'l2'}	False	True	
1	1.000000	0.900000	0.004410	{'C': 1, 'solver': 'saga', 'fit_intercept': True, 'penalty': 'l2'}	False	True	
2	0.903230	0.767993	0.913092	{'C': 10, 'solver': 'liblinear', 'fit_intercept': True, 'penalty': 'l2'}	False	True	
3	1.000000	0.900000	0.004410	{'C': 10, 'solver': 'saga', 'fit_intercept': True, 'penalty': 'l2'}	False	True	
4	0.904884	0.771019	0.913092	{'C': 10000, 'solver': 'liblinear', 'fit_intercept': True, 'penalty': 'l2'}	False	True	

Sort the new dataframe to show which models had the highest specificity rating.

In [19]:

```
#sort by highest specificity rate
lr_tuned_grid_search_spec_sorted = lr_tuned_results_df.sort_values(\
    by=['v_avg_spec', 'v_avg_prec', 'v_avg_rec'], ascending=[False, False, F

pd.set_option('display.max_rows', None)

lr_tuned_grid_search_spec_sorted
```

Out[19]:

	v_avg_spec	v_avg_prec	v_avg_rec	v_Kwargs_hyp_para	scaler	v_
1	1.000000	0.900000	0.004410	{'C': 1, 'solver': 'saga', 'fit_intercept': True, 'penalty': 'l2'}	False	
3	1.000000	0.900000	0.004410	{'C': 10, 'solver': 'saga', 'fit_intercept': True, 'penalty': 'l2'}	False	
5	1.000000	0.900000	0.004410	{'C': 10000, 'solver': 'saga', 'fit_intercept': True, 'penalty': 'l2'}	False	
7	1.000000	0.900000	0.004410	{'C': 100000, 'solver': 'saga', 'fit_intercept': True, 'penalty': 'l2'}	False	
33	1.000000	0.900000	0.004410	{'C': 1, 'solver': 'saga', 'fit_intercept': False, 'penalty': 'l2'}	False	
35	1.000000	0.900000	0.004410	{'C': 10, 'solver': 'saga', 'fit_intercept': False, 'penalty': 'l2'}	False	
37	1.000000	0.900000	0.004410	{'C': 10000, 'solver': 'saga', 'fit_intercept': False, 'penalty': 'l2'}	False	
39	1.000000	0.900000	0.004410	{'C': 100000, 'solver': 'saga', 'fit_intercept': False, 'penalty': 'l2'}	False	
17	1.000000	0.000000	0.000000	{'C': 1, 'solver': 'saga', 'fit_intercept': True, 'penalty': 'l2'}	False	
19	1.000000	0.000000	0.000000	{'C': 10, 'solver': 'saga', 'fit_intercept': True, 'penalty': 'l2'}	False	
21	1.000000	0.000000	0.000000	{'C': 10000, 'solver': 'saga', 'fit_intercept': True, 'penalty': 'l2'}	False	
23	1.000000	0.000000	0.000000	{'C': 100000, 'solver': 'saga', 'fit_intercept': True, 'penalty': 'l2'}	False	
49	1.000000	0.000000	0.000000	{'C': 1, 'solver': 'saga', 'fit_intercept': False, 'penalty': 'l2'}	False	
51	1.000000	0.000000	0.000000	{'C': 10, 'solver': 'saga', 'fit_intercept': False, 'penalty': 'l2'}	False	
53	1.000000	0.000000	0.000000	{'C': 10000, 'solver': 'saga', 'fit_intercept': False, 'penalty': 'l2'}	False	
55	1.000000	0.000000	0.000000	{'C': 100000, 'solver': 'saga', 'fit_intercept': False, 'penalty': 'l2'}	False	

	v_avg_spec	v_avg_prec	v_avg_rec	v_Kwargs_hyp_para	scaler	v_
82	0.979831	0.933961	0.811720	{'C': 10, 'solver': 'liblinear', 'fit_intercept': True, 'penalty': 'l2'}	False	
114	0.978949	0.927953	0.772675	{'C': 10, 'solver': 'liblinear', 'fit_intercept': False, 'penalty': 'l2'}	False	
56	0.976966	0.929386	0.861462	{'C': 1, 'solver': 'liblinear', 'fit_intercept': False, 'penalty': 'l2'}	MinMaxScaler()	
57	0.976966	0.929386	0.861462	{'C': 1, 'solver': 'saga', 'fit_intercept': False, 'penalty': 'l2'}	MinMaxScaler()	
24	0.976855	0.928979	0.860518	{'C': 1, 'solver': 'liblinear', 'fit_intercept': True, 'penalty': 'l2'}	MinMaxScaler()	
25	0.976745	0.928565	0.859885	{'C': 1, 'solver': 'saga', 'fit_intercept': True, 'penalty': 'l2'}	MinMaxScaler()	
125	0.975533	0.927688	0.892632	{'C': 10000, 'solver': 'saga', 'fit_intercept': False, 'penalty': 'l2'}	MinMaxScaler()	
127	0.975533	0.927672	0.892318	{'C': 100000, 'solver': 'saga', 'fit_intercept': False, 'penalty': 'l2'}	MinMaxScaler()	
91	0.975533	0.926914	0.882556	{'C': 10, 'solver': 'saga', 'fit_intercept': True, 'penalty': 'l2'}	MinMaxScaler()	
90	0.975422	0.926393	0.880040	{'C': 10, 'solver': 'liblinear', 'fit_intercept': True, 'penalty': 'l2'}	MinMaxScaler()	
124	0.975092	0.927163	0.902389	{'C': 10000, 'solver': 'liblinear', 'fit_intercept': False, 'penalty': 'l2'}	MinMaxScaler()	
122	0.975092	0.925356	0.878464	{'C': 10, 'solver': 'liblinear', 'fit_intercept': False, 'penalty': 'l2'}	MinMaxScaler()	
123	0.975092	0.925330	0.878149	{'C': 10, 'solver': 'saga', 'fit_intercept': False, 'penalty': 'l2'}	MinMaxScaler()	

	v_avg_spec	v_avg_prec	v_avg_rec	v_Kwargs_hyp_para	scaler	v_
58	0.974981	0.926172	0.891997	{'C': 10, 'solver': 'liblinear', 'fit_intercept': False, 'penalty': 'l2'}	MinMaxScaler()	
59	0.974981	0.926172	0.891997	{'C': 10, 'solver': 'saga', 'fit_intercept': False, 'penalty': 'l2'}	MinMaxScaler()	
26	0.974871	0.925788	0.891682	{'C': 10, 'solver': 'liblinear', 'fit_intercept': True, 'penalty': 'l2'}	MinMaxScaler()	
27	0.974871	0.925762	0.891053	{'C': 10, 'solver': 'saga', 'fit_intercept': True, 'penalty': 'l2'}	MinMaxScaler()	
86	0.974652	0.925956	0.901131	{'C': 100000, 'solver': 'liblinear', 'fit_intercept': True, 'penalty': 'l2'}	False	
118	0.974652	0.925594	0.897036	{'C': 100000, 'solver': 'liblinear', 'fit_intercept': False, 'penalty': 'l2'}	False	
84	0.974651	0.925839	0.900501	{'C': 10000, 'solver': 'liblinear', 'fit_intercept': True, 'penalty': 'l2'}	False	
93	0.974651	0.925304	0.893578	{'C': 10000, 'solver': 'saga', 'fit_intercept': True, 'penalty': 'l2'}	MinMaxScaler()	
95	0.974651	0.925304	0.893578	{'C': 100000, 'solver': 'saga', 'fit_intercept': True, 'penalty': 'l2'}	MinMaxScaler()	
116	0.974541	0.925355	0.897666	{'C': 10000, 'solver': 'liblinear', 'fit_intercept': False, 'penalty': 'l2'}	False	
80	0.974540	0.896979	0.634752	{'C': 1, 'solver': 'liblinear', 'fit_intercept': True, 'penalty': 'l2'}	False	
126	0.974431	0.925757	0.907424	{'C': 100000, 'solver': 'liblinear', 'fit_intercept': False, 'penalty': 'l2'}	MinMaxScaler()	
62	0.973990	0.924603	0.907430	{'C': 100000, 'solver': 'liblinear', 'fit_intercept': False, 'penalty': 'l2'}	MinMaxScaler()	
61	0.973990	0.924408	0.903969	{'C': 10000, 'solver': 'saga', 'fit_intercept':	MinMaxScaler()	

	v_avg_spec	v_avg_prec	v_avg_rec	v_Kwargs_hyp_para	scaler	v_
				False, 'penalty': 'l2'}		
63	0.973990	0.924408	0.903969	{'C': 100000, 'solver': 'saga', 'fit_intercept': False, 'penalty': 'l2'}	MinMaxScaler()	
28	0.973990	0.924595	0.907116	{'C': 10000, 'solver': 'liblinear', 'fit_intercept': True, 'penalty': 'l2'}	MinMaxScaler()	
30	0.973990	0.924552	0.906486	{'C': 100000, 'solver': 'liblinear', 'fit_intercept': True, 'penalty': 'l2'}	MinMaxScaler()	
60	0.973880	0.924300	0.907430	{'C': 10000, 'solver': 'liblinear', 'fit_intercept': False, 'penalty': 'l2'}	MinMaxScaler()	
29	0.973880	0.924165	0.904283	{'C': 10000, 'solver': 'saga', 'fit_intercept': True, 'penalty': 'l2'}	MinMaxScaler()	
31	0.973880	0.924165	0.904283	{'C': 100000, 'solver': 'saga', 'fit_intercept': True, 'penalty': 'l2'}	MinMaxScaler()	
92	0.973549	0.923256	0.903963	{'C': 10000, 'solver': 'liblinear', 'fit_intercept': True, 'penalty': 'l2'}	MinMaxScaler()	
89	0.973548	0.918917	0.851071	{'C': 1, 'solver': 'saga', 'fit_intercept': True, 'penalty': 'l2'}	MinMaxScaler()	
94	0.973219	0.922625	0.908057	{'C': 100000, 'solver': 'liblinear', 'fit_intercept': True, 'penalty': 'l2'}	MinMaxScaler()	
88	0.972446	0.915585	0.847922	{'C': 1, 'solver': 'liblinear', 'fit_intercept': True, 'penalty': 'l2'}	MinMaxScaler()	
120	0.972006	0.914328	0.846346	{'C': 1, 'solver': 'liblinear', 'fit_intercept': False, 'penalty': 'l2'}	MinMaxScaler()	
121	0.972006	0.914328	0.846346	{'C': 1, 'solver': 'saga', 'fit_intercept': False, 'penalty': 'l2'}	MinMaxScaler()	
81	0.967265	0.859113	0.570519	{'C': 1, 'solver': 'saga', 'fit_intercept': True, 'penalty': 'l2'}	False	
112	0.963076	0.841277	0.558243	{'C': 1, 'solver': 'liblinear',	False	

	v_avg_spec	v_avg_prec	v_avg_rec	v_Kwargs_hyp_para	scaler	v_
				'fit_intercept': False, 'penalty': 'l2'}		
83	0.959440	0.836688	0.592869	{'C': 10, 'solver': 'saga', 'fit_intercept': True, 'penalty': 'l2'}	False	
85	0.958999	0.835893	0.596019	{'C': 10000, 'solver': 'saga', 'fit_intercept': True, 'penalty': 'l2'}	False	
87	0.958999	0.835893	0.596019	{'C': 100000, 'solver': 'saga', 'fit_intercept': True, 'penalty': 'l2'}	False	
22	0.957237	0.871619	0.824937	{'C': 100000, 'solver': 'liblinear', 'fit_intercept': True, 'penalty': 'l2'}	False	
50	0.956907	0.870824	0.824938	{'C': 10, 'solver': 'liblinear', 'fit_intercept': False, 'penalty': 'l2'}	False	
48	0.956576	0.869910	0.824308	{'C': 1, 'solver': 'liblinear', 'fit_intercept': False, 'penalty': 'l2'}	False	
20	0.956024	0.868510	0.824937	{'C': 10000, 'solver': 'liblinear', 'fit_intercept': True, 'penalty': 'l2'}	False	
113	0.955361	0.782958	0.459058	{'C': 1, 'solver': 'saga', 'fit_intercept': False, 'penalty': 'l2'}	False	
54	0.955032	0.865769	0.824623	{'C': 100000, 'solver': 'liblinear', 'fit_intercept': False, 'penalty': 'l2'}	False	
52	0.954923	0.865738	0.824936	{'C': 10000, 'solver': 'liblinear', 'fit_intercept': False, 'penalty': 'l2'}	False	
18	0.954702	0.864949	0.824624	{'C': 10, 'solver': 'liblinear', 'fit_intercept': True, 'penalty': 'l2'}	False	
16	0.954482	0.864325	0.824938	{'C': 1, 'solver': 'liblinear', 'fit_intercept': True, 'penalty': 'l2'}	False	
110	0.953711	0.879067	0.957176	{'C': 100000, 'solver': 'liblinear', 'fit_intercept': False, 'penalty': 'l2'}	MinMaxScaler()	

	v_avg_spec	v_avg_prec	v_avg_rec	v_Kwargs_hyp_para	scaler	v_
108	0.953490	0.878306	0.954971	{'C': 10000, 'solver': 'liblinear', 'fit_intercept': False, 'penalty': 'l2'}	MinMaxScaler()	
78	0.953380	0.878297	0.956861	{'C': 100000, 'solver': 'liblinear', 'fit_intercept': True, 'penalty': 'l2'}	MinMaxScaler()	
111	0.952499	0.875501	0.950561	{'C': 100000, 'solver': 'saga', 'fit_intercept': False, 'penalty': 'l2'}	MinMaxScaler()	
109	0.952389	0.875261	0.950561	{'C': 10000, 'solver': 'saga', 'fit_intercept': False, 'penalty': 'l2'}	MinMaxScaler()	
102	0.952388	0.876128	0.958122	{'C': 100000, 'solver': 'liblinear', 'fit_intercept': False, 'penalty': 'l2'}	False	
77	0.952168	0.875040	0.953082	{'C': 10000, 'solver': 'saga', 'fit_intercept': True, 'penalty': 'l2'}	MinMaxScaler()	
79	0.952168	0.875040	0.953082	{'C': 100000, 'solver': 'saga', 'fit_intercept': True, 'penalty': 'l2'}	MinMaxScaler()	
76	0.952168	0.875528	0.956545	{'C': 10000, 'solver': 'liblinear', 'fit_intercept': True, 'penalty': 'l2'}	MinMaxScaler()	
13	0.951728	0.874510	0.957177	{'C': 10000, 'solver': 'saga', 'fit_intercept': True, 'penalty': 'l2'}	MinMaxScaler()	
15	0.951728	0.874510	0.957177	{'C': 100000, 'solver': 'saga', 'fit_intercept': True, 'penalty': 'l2'}	MinMaxScaler()	
100	0.951727	0.874615	0.958121	{'C': 10000, 'solver': 'liblinear', 'fit_intercept': False, 'penalty': 'l2'}	False	
45	0.951507	0.874023	0.957177	{'C': 10000, 'solver': 'saga', 'fit_intercept': False, 'penalty': 'l2'}	MinMaxScaler()	
47	0.951507	0.874023	0.957177	{'C': 100000, 'solver': 'saga', 'fit_intercept': False, 'penalty': 'l2'}	MinMaxScaler()	
68	0.951507	0.873864	0.955604	{'C': 10000, 'solver': 'liblinear', 'fit_intercept': True, 'penalty': 'l2'}	False	

	v_avg_spec	v_avg_prec	v_avg_rec	v_Kwargs_hyp_para	scaler	v_
70	0.951397	0.873752	0.956862	{'C': 100000, 'solver': 'liblinear', 'fit_intercept': True, 'penalty': 'l2'}	False	
14	0.950735	0.872207	0.956547	{'C': 100000, 'solver': 'liblinear', 'fit_intercept': True, 'penalty': 'l2'}	MinMaxScaler()	
12	0.950625	0.872040	0.957177	{'C': 10000, 'solver': 'liblinear', 'fit_intercept': True, 'penalty': 'l2'}	MinMaxScaler()	
46	0.950515	0.871736	0.956546	{'C': 100000, 'solver': 'liblinear', 'fit_intercept': False, 'penalty': 'l2'}	MinMaxScaler()	
44	0.950405	0.871515	0.956546	{'C': 10000, 'solver': 'liblinear', 'fit_intercept': False, 'penalty': 'l2'}	MinMaxScaler()	
115	0.950401	0.783874	0.513218	{'C': 10, 'solver': 'saga', 'fit_intercept': False, 'penalty': 'l2'}	False	
75	0.950295	0.869766	0.944580	{'C': 10, 'solver': 'saga', 'fit_intercept': True, 'penalty': 'l2'}	MinMaxScaler()	
74	0.950075	0.869184	0.943320	{'C': 10, 'solver': 'liblinear', 'fit_intercept': True, 'penalty': 'l2'}	MinMaxScaler()	
106	0.949524	0.868005	0.943950	{'C': 10, 'solver': 'liblinear', 'fit_intercept': False, 'penalty': 'l2'}	MinMaxScaler()	
107	0.949524	0.868005	0.943950	{'C': 10, 'solver': 'saga', 'fit_intercept': False, 'penalty': 'l2'}	MinMaxScaler()	
117	0.949299	0.781768	0.518253	{'C': 10000, 'solver': 'saga', 'fit_intercept': False, 'penalty': 'l2'}	False	
119	0.949299	0.781768	0.518253	{'C': 100000, 'solver': 'saga', 'fit_intercept': False, 'penalty': 'l2'}	False	
10	0.948973	0.867942	0.954026	{'C': 10, 'solver': 'liblinear', 'fit_intercept': True, 'penalty': 'l2'}	MinMaxScaler()	

	v_avg_spec	v_avg_prec	v_avg_rec	v_Kwargs_hyp_para	scaler	v_
11	0.948752	0.867398	0.953396	{'C': 10, 'solver': 'saga', 'fit_intercept': True, 'penalty': 'l2'}	MinMaxScaler()	
43	0.948642	0.867190	0.953710	{'C': 10, 'solver': 'saga', 'fit_intercept': False, 'penalty': 'l2'}	MinMaxScaler()	
42	0.948531	0.866965	0.954026	{'C': 10, 'solver': 'liblinear', 'fit_intercept': False, 'penalty': 'l2'}	MinMaxScaler()	
9	0.943241	0.854465	0.948044	{'C': 1, 'solver': 'saga', 'fit_intercept': True, 'penalty': 'l2'}	MinMaxScaler()	
8	0.942580	0.852775	0.946786	{'C': 1, 'solver': 'liblinear', 'fit_intercept': True, 'penalty': 'l2'}	MinMaxScaler()	
40	0.942139	0.851846	0.947101	{'C': 1, 'solver': 'liblinear', 'fit_intercept': False, 'penalty': 'l2'}	MinMaxScaler()	
41	0.942139	0.851846	0.947101	{'C': 1, 'solver': 'saga', 'fit_intercept': False, 'penalty': 'l2'}	MinMaxScaler()	
72	0.938501	0.841801	0.930416	{'C': 1, 'solver': 'liblinear', 'fit_intercept': True, 'penalty': 'l2'}	MinMaxScaler()	
73	0.938501	0.842059	0.933246	{'C': 1, 'solver': 'saga', 'fit_intercept': True, 'penalty': 'l2'}	MinMaxScaler()	
104	0.937289	0.839103	0.929469	{'C': 1, 'solver': 'liblinear', 'fit_intercept': False, 'penalty': 'l2'}	MinMaxScaler()	
105	0.937289	0.839103	0.929469	{'C': 1, 'solver': 'saga', 'fit_intercept': False, 'penalty': 'l2'}	MinMaxScaler()	
66	0.932439	0.830608	0.942058	{'C': 10, 'solver': 'liblinear', 'fit_intercept': True, 'penalty': 'l2'}	False	
98	0.918111	0.800238	0.934504	{'C': 10, 'solver': 'liblinear', 'fit_intercept': False, 'penalty': 'l2'}	False	

	v_avg_spec	v_avg_prec	v_avg_rec	v_Kwargs_hyp_para	scaler	v_
4	0.904884	0.771019	0.913092	{'C': 10000, 'solver': 'liblinear', 'fit_intercept': True, 'penalty': 'l2'}	False	
34	0.904774	0.770814	0.913092	{'C': 10, 'solver': 'liblinear', 'fit_intercept': False, 'penalty': 'l2'}	False	
38	0.904774	0.770814	0.913092	{'C': 100000, 'solver': 'liblinear', 'fit_intercept': False, 'penalty': 'l2'}	False	
36	0.904774	0.770812	0.913092	{'C': 10000, 'solver': 'liblinear', 'fit_intercept': False, 'penalty': 'l2'}	False	
6	0.904663	0.770610	0.913092	{'C': 100000, 'solver': 'liblinear', 'fit_intercept': True, 'penalty': 'l2'}	False	
0	0.904663	0.770589	0.913092	{'C': 1, 'solver': 'liblinear', 'fit_intercept': True, 'penalty': 'l2'}	False	
32	0.904553	0.770384	0.913092	{'C': 1, 'solver': 'liblinear', 'fit_intercept': False, 'penalty': 'l2'}	False	
2	0.903230	0.767993	0.913092	{'C': 10, 'solver': 'liblinear', 'fit_intercept': True, 'penalty': 'l2'}	False	
64	0.860357	0.695361	0.909005	{'C': 1, 'solver': 'liblinear', 'fit_intercept': True, 'penalty': 'l2'}	False	
69	0.832693	0.649186	0.883191	{'C': 10000, 'solver': 'saga', 'fit_intercept': True, 'penalty': 'l2'}	False	
71	0.832693	0.649186	0.883191	{'C': 100000, 'solver': 'saga', 'fit_intercept': True, 'penalty': 'l2'}	False	
67	0.832032	0.648361	0.883507	{'C': 10, 'solver': 'saga', 'fit_intercept': True, 'penalty': 'l2'}	False	
65	0.829386	0.646352	0.889174	{'C': 1, 'solver': 'saga', 'fit_intercept': True, 'penalty': 'l2'}	False	
96	0.824096	0.639505	0.889802	{'C': 1, 'solver': 'liblinear',	False	

	v_avg_spec	v_avg_prec	v_avg_rec	v_Kwargs_hyp_para	scaler	v_
				'fit_intercept': False, 'penalty': 'l2'}		
101	0.798304	0.601226	0.867760	{'C': 10000, 'solver': 'saga', 'fit_intercept': False, 'penalty': 'l2'}	False	
103	0.798304	0.601226	0.867760	{'C': 100000, 'solver': 'saga', 'fit_intercept': False, 'penalty': 'l2'}	False	
99	0.797532	0.600600	0.868705	{'C': 10, 'solver': 'saga', 'fit_intercept': False, 'penalty': 'l2'}	False	
97	0.789265	0.592964	0.875631	{'C': 1, 'solver': 'saga', 'fit_intercept': False, 'penalty': 'l2'}	False	

Even though there are some instances where the specificity score is technically perfect we are not interested in those instances due to their major loss of the recal score (correctly identifying less than 1% of the Dermason beans as Dermason beans). Due to this we will scroll down the list to find a more balances instance where there is not so much loss on recal.

Optimizing for Specificity and Precision, without sacrificing too much recall, we have located an instance where the following average validation set scores are achieved:

1. Specificity: 97.9831%
2. Precision: 92.7953%
3. Recal: 81.720%

This was achieved through the following:

Data Preprocessing:

1. Scaler: None
2. Data distribution normalization through Box-Cox and Log transformation: True
3. Class imbalance redistribution through SMOTE and Random Undersampling: False

Model Hyperparameter Tuning:

1. C= 10
2. solver= liblinear
3. fit_intercept= True
4. penalty= l2

Now, sort the new dataframe to show which models had the highest precision rating to see if this gives us a better answer.

In [20]:
```
#sort by highest precision rate
lr_tuned_grid_search_prec_sorted = lr_tuned_results_df.sort_values(\
    by=['v_avg_prec', 'v_avg_spec', 'v_avg_rec'], ascending=[False, False, F

lr_tuned_grid_search_prec_sorted
```

Out[20]:

	v_avg_spec	v_avg_prec	v_avg_rec	v_Kwargs_hyp_para	scaler	v_
82	0.979831	0.933961	0.811720	{'C': 10, 'solver': 'liblinear', 'fit_intercept': True, 'penalty': 'l2'}	False	
56	0.976966	0.929386	0.861462	{'C': 1, 'solver': 'liblinear', 'fit_intercept': False, 'penalty': 'l2'}	MinMaxScaler()	
57	0.976966	0.929386	0.861462	{'C': 1, 'solver': 'saga', 'fit_intercept': False, 'penalty': 'l2'}	MinMaxScaler()	
24	0.976855	0.928979	0.860518	{'C': 1, 'solver': 'liblinear', 'fit_intercept': True, 'penalty': 'l2'}	MinMaxScaler()	
25	0.976745	0.928565	0.859885	{'C': 1, 'solver': 'saga', 'fit_intercept': True, 'penalty': 'l2'}	MinMaxScaler()	
114	0.978949	0.927953	0.772675	{'C': 10, 'solver': 'liblinear', 'fit_intercept': False, 'penalty': 'l2'}	False	
125	0.975533	0.927688	0.892632	{'C': 10000, 'solver': 'saga', 'fit_intercept': False, 'penalty': 'l2'}	MinMaxScaler()	
127	0.975533	0.927672	0.892318	{'C': 100000, 'solver': 'saga', 'fit_intercept': False, 'penalty': 'l2'}	MinMaxScaler()	
124	0.975092	0.927163	0.902389	{'C': 10000, 'solver': 'liblinear', 'fit_intercept': False, 'penalty': 'l2'}	MinMaxScaler()	
91	0.975533	0.926914	0.882556	{'C': 10, 'solver': 'saga', 'fit_intercept': True, 'penalty': 'l2'}	MinMaxScaler()	
90	0.975422	0.926393	0.880040	{'C': 10, 'solver': 'liblinear', 'fit_intercept': True, 'penalty': 'l2'}	MinMaxScaler()	
58	0.974981	0.926172	0.891997	{'C': 10, 'solver': 'liblinear', 'fit_intercept': False, 'penalty': 'l2'}	MinMaxScaler()	
59	0.974981	0.926172	0.891997	{'C': 10, 'solver': 'saga', 'fit_intercept': False, 'penalty': 'l2'}	MinMaxScaler()	

	v_avg_spec	v_avg_prec	v_avg_rec	v_Kwargs_hyp_para	scaler	v_
86	0.974652	0.925956	0.901131	{'C': 100000, 'solver': 'liblinear', 'fit_intercept': True, 'penalty': 'l2'}	False	
84	0.974651	0.925839	0.900501	{'C': 10000, 'solver': 'liblinear', 'fit_intercept': True, 'penalty': 'l2'}	False	
26	0.974871	0.925788	0.891682	{'C': 10, 'solver': 'liblinear', 'fit_intercept': True, 'penalty': 'l2'}	MinMaxScaler()	
27	0.974871	0.925762	0.891053	{'C': 10, 'solver': 'saga', 'fit_intercept': True, 'penalty': 'l2'}	MinMaxScaler()	
126	0.974431	0.925757	0.907424	{'C': 100000, 'solver': 'liblinear', 'fit_intercept': False, 'penalty': 'l2'}	MinMaxScaler()	
118	0.974652	0.925594	0.897036	{'C': 100000, 'solver': 'liblinear', 'fit_intercept': False, 'penalty': 'l2'}	False	
122	0.975092	0.925356	0.878464	{'C': 10, 'solver': 'liblinear', 'fit_intercept': False, 'penalty': 'l2'}	MinMaxScaler()	
116	0.974541	0.925355	0.897666	{'C': 10000, 'solver': 'liblinear', 'fit_intercept': False, 'penalty': 'l2'}	False	
123	0.975092	0.925330	0.878149	{'C': 10, 'solver': 'saga', 'fit_intercept': False, 'penalty': 'l2'}	MinMaxScaler()	
93	0.974651	0.925304	0.893578	{'C': 10000, 'solver': 'saga', 'fit_intercept': True, 'penalty': 'l2'}	MinMaxScaler()	
95	0.974651	0.925304	0.893578	{'C': 100000, 'solver': 'saga', 'fit_intercept': True, 'penalty': 'l2'}	MinMaxScaler()	
62	0.973990	0.924603	0.907430	{'C': 100000, 'solver': 'liblinear', 'fit_intercept': False, 'penalty': 'l2'}	MinMaxScaler()	
28	0.973990	0.924595	0.907116	{'C': 10000, 'solver': 'liblinear', 'fit_intercept': True, 'penalty': 'l2'}	MinMaxScaler()	
30	0.973990	0.924552	0.906486	{'C': 100000, 'solver': 'liblinear',	MinMaxScaler()	

	v_avg_spec	v_avg_prec	v_avg_rec	v_Kwargs_hyp_para	scaler	v_
				'fit_intercept': True, 'penalty': 'l2'}		
61	0.973990	0.924408	0.903969	{'C': 10000, 'solver': 'saga', 'fit_intercept': False, 'penalty': 'l2'}	MinMaxScaler()	
63	0.973990	0.924408	0.903969	{'C': 100000, 'solver': 'saga', 'fit_intercept': False, 'penalty': 'l2'}	MinMaxScaler()	
60	0.973880	0.924300	0.907430	{'C': 10000, 'solver': 'liblinear', 'fit_intercept': False, 'penalty': 'l2'}	MinMaxScaler()	
29	0.973880	0.924165	0.904283	{'C': 10000, 'solver': 'saga', 'fit_intercept': True, 'penalty': 'l2'}	MinMaxScaler()	
31	0.973880	0.924165	0.904283	{'C': 100000, 'solver': 'saga', 'fit_intercept': True, 'penalty': 'l2'}	MinMaxScaler()	
92	0.973549	0.923256	0.903963	{'C': 10000, 'solver': 'liblinear', 'fit_intercept': True, 'penalty': 'l2'}	MinMaxScaler()	
94	0.973219	0.922625	0.908057	{'C': 100000, 'solver': 'liblinear', 'fit_intercept': True, 'penalty': 'l2'}	MinMaxScaler()	
89	0.973548	0.918917	0.851071	{'C': 1, 'solver': 'saga', 'fit_intercept': True, 'penalty': 'l2'}	MinMaxScaler()	
88	0.972446	0.915585	0.847922	{'C': 1, 'solver': 'liblinear', 'fit_intercept': True, 'penalty': 'l2'}	MinMaxScaler()	
120	0.972006	0.914328	0.846346	{'C': 1, 'solver': 'liblinear', 'fit_intercept': False, 'penalty': 'l2'}	MinMaxScaler()	
121	0.972006	0.914328	0.846346	{'C': 1, 'solver': 'saga', 'fit_intercept': False, 'penalty': 'l2'}	MinMaxScaler()	
1	1.000000	0.900000	0.004410	{'C': 1, 'solver': 'saga', 'fit_intercept': True, 'penalty': 'l2'}	False	
3	1.000000	0.900000	0.004410	{'C': 10, 'solver': 'saga', 'fit_intercept': True, 'penalty': 'l2'}	False	
5	1.000000	0.900000	0.004410	{'C': 10000, 'solver': 'saga', 'fit_intercept': True, 'penalty': 'l2'}	False	

	v_avg_spec	v_avg_prec	v_avg_rec	v_Kwargs_hyp_para	scaler	v_
7	1.000000	0.900000	0.004410	{'C': 100000, 'solver': 'saga', 'fit_intercept': True, 'penalty': 'l2'}	False	
33	1.000000	0.900000	0.004410	{'C': 1, 'solver': 'saga', 'fit_intercept': False, 'penalty': 'l2'}	False	
35	1.000000	0.900000	0.004410	{'C': 10, 'solver': 'saga', 'fit_intercept': False, 'penalty': 'l2'}	False	
37	1.000000	0.900000	0.004410	{'C': 10000, 'solver': 'saga', 'fit_intercept': False, 'penalty': 'l2'}	False	
39	1.000000	0.900000	0.004410	{'C': 100000, 'solver': 'saga', 'fit_intercept': False, 'penalty': 'l2'}	False	
80	0.974540	0.896979	0.634752	{'C': 1, 'solver': 'liblinear', 'fit_intercept': True, 'penalty': 'l2'}	False	
110	0.953711	0.879067	0.957176	{'C': 100000, 'solver': 'liblinear', 'fit_intercept': False, 'penalty': 'l2'}	MinMaxScaler()	
108	0.953490	0.878306	0.954971	{'C': 10000, 'solver': 'liblinear', 'fit_intercept': False, 'penalty': 'l2'}	MinMaxScaler()	
78	0.953380	0.878297	0.956861	{'C': 100000, 'solver': 'liblinear', 'fit_intercept': True, 'penalty': 'l2'}	MinMaxScaler()	
102	0.952388	0.876128	0.958122	{'C': 100000, 'solver': 'liblinear', 'fit_intercept': False, 'penalty': 'l2'}	False	
76	0.952168	0.875528	0.956545	{'C': 10000, 'solver': 'liblinear', 'fit_intercept': True, 'penalty': 'l2'}	MinMaxScaler()	
111	0.952499	0.875501	0.950561	{'C': 100000, 'solver': 'saga', 'fit_intercept': False, 'penalty': 'l2'}	MinMaxScaler()	
109	0.952389	0.875261	0.950561	{'C': 10000, 'solver': 'saga', 'fit_intercept': False, 'penalty': 'l2'}	MinMaxScaler()	
77	0.952168	0.875040	0.953082	{'C': 10000, 'solver': 'saga', 'fit_intercept': True, 'penalty': 'l2'}	MinMaxScaler()	

	v_avg_spec	v_avg_prec	v_avg_rec	v_Kwargs_hyp_para	scaler	v_
79	0.952168	0.875040	0.953082	{'C': 100000, 'solver': 'saga', 'fit_intercept': True, 'penalty': 'l2'}	MinMaxScaler()	
100	0.951727	0.874615	0.958121	{'C': 10000, 'solver': 'liblinear', 'fit_intercept': False, 'penalty': 'l2'}	False	
13	0.951728	0.874510	0.957177	{'C': 10000, 'solver': 'saga', 'fit_intercept': True, 'penalty': 'l2'}	MinMaxScaler()	
15	0.951728	0.874510	0.957177	{'C': 100000, 'solver': 'saga', 'fit_intercept': True, 'penalty': 'l2'}	MinMaxScaler()	
45	0.951507	0.874023	0.957177	{'C': 10000, 'solver': 'saga', 'fit_intercept': False, 'penalty': 'l2'}	MinMaxScaler()	
47	0.951507	0.874023	0.957177	{'C': 100000, 'solver': 'saga', 'fit_intercept': False, 'penalty': 'l2'}	MinMaxScaler()	
68	0.951507	0.873864	0.955604	{'C': 10000, 'solver': 'liblinear', 'fit_intercept': True, 'penalty': 'l2'}	False	
70	0.951397	0.873752	0.956862	{'C': 100000, 'solver': 'liblinear', 'fit_intercept': True, 'penalty': 'l2'}	False	
14	0.950735	0.872207	0.956547	{'C': 100000, 'solver': 'liblinear', 'fit_intercept': True, 'penalty': 'l2'}	MinMaxScaler()	
12	0.950625	0.872040	0.957177	{'C': 10000, 'solver': 'liblinear', 'fit_intercept': True, 'penalty': 'l2'}	MinMaxScaler()	
46	0.950515	0.871736	0.956546	{'C': 100000, 'solver': 'liblinear', 'fit_intercept': False, 'penalty': 'l2'}	MinMaxScaler()	
22	0.957237	0.871619	0.824937	{'C': 100000, 'solver': 'liblinear', 'fit_intercept': True, 'penalty': 'l2'}	False	
44	0.950405	0.871515	0.956546	{'C': 10000, 'solver': 'liblinear', 'fit_intercept': False, 'penalty': 'l2'}	MinMaxScaler()	
50	0.956907	0.870824	0.824938	{'C': 10, 'solver': 'liblinear',	False	

	v_avg_spec	v_avg_prec	v_avg_rec	v_Kwargs_hyp_para	scaler	v_
				'fit_intercept': False, 'penalty': 'l2'}		
48	0.956576	0.869910	0.824308	{'C': 1, 'solver': 'liblinear', 'fit_intercept': False, 'penalty': 'l2'}	False	
75	0.950295	0.869766	0.944580	{'C': 10, 'solver': 'saga', 'fit_intercept': True, 'penalty': 'l2'}	MinMaxScaler()	
74	0.950075	0.869184	0.943320	{'C': 10, 'solver': 'liblinear', 'fit_intercept': True, 'penalty': 'l2'}	MinMaxScaler()	
20	0.956024	0.868510	0.824937	{'C': 10000, 'solver': 'liblinear', 'fit_intercept': True, 'penalty': 'l2'}	False	
106	0.949524	0.868005	0.943950	{'C': 10, 'solver': 'liblinear', 'fit_intercept': False, 'penalty': 'l2'}	MinMaxScaler()	
107	0.949524	0.868005	0.943950	{'C': 10, 'solver': 'saga', 'fit_intercept': False, 'penalty': 'l2'}	MinMaxScaler()	
10	0.948973	0.867942	0.954026	{'C': 10, 'solver': 'liblinear', 'fit_intercept': True, 'penalty': 'l2'}	MinMaxScaler()	
11	0.948752	0.867398	0.953396	{'C': 10, 'solver': 'saga', 'fit_intercept': True, 'penalty': 'l2'}	MinMaxScaler()	
43	0.948642	0.867190	0.953710	{'C': 10, 'solver': 'saga', 'fit_intercept': False, 'penalty': 'l2'}	MinMaxScaler()	
42	0.948531	0.866965	0.954026	{'C': 10, 'solver': 'liblinear', 'fit_intercept': False, 'penalty': 'l2'}	MinMaxScaler()	
54	0.955032	0.865769	0.824623	{'C': 100000, 'solver': 'liblinear', 'fit_intercept': False, 'penalty': 'l2'}	False	
52	0.954923	0.865738	0.824936	{'C': 10000, 'solver': 'liblinear', 'fit_intercept': False, 'penalty': 'l2'}	False	
18	0.954702	0.864949	0.824624	{'C': 10, 'solver': 'liblinear', 'fit_intercept': True, 'penalty': 'l2'}	False	

	v_avg_spec	v_avg_prec	v_avg_rec	v_Kwargs_hyp_para	scaler	v_
16	0.954482	0.864325	0.824938	{'C': 1, 'solver': 'liblinear', 'fit_intercept': True, 'penalty': 'l2'}	False	
81	0.967265	0.859113	0.570519	{'C': 1, 'solver': 'saga', 'fit_intercept': True, 'penalty': 'l2'}	False	
9	0.943241	0.854465	0.948044	{'C': 1, 'solver': 'saga', 'fit_intercept': True, 'penalty': 'l2'}	MinMaxScaler()	
8	0.942580	0.852775	0.946786	{'C': 1, 'solver': 'liblinear', 'fit_intercept': True, 'penalty': 'l2'}	MinMaxScaler()	
40	0.942139	0.851846	0.947101	{'C': 1, 'solver': 'liblinear', 'fit_intercept': False, 'penalty': 'l2'}	MinMaxScaler()	
41	0.942139	0.851846	0.947101	{'C': 1, 'solver': 'saga', 'fit_intercept': False, 'penalty': 'l2'}	MinMaxScaler()	
73	0.938501	0.842059	0.933246	{'C': 1, 'solver': 'saga', 'fit_intercept': True, 'penalty': 'l2'}	MinMaxScaler()	
72	0.938501	0.841801	0.930416	{'C': 1, 'solver': 'liblinear', 'fit_intercept': True, 'penalty': 'l2'}	MinMaxScaler()	
112	0.963076	0.841277	0.558243	{'C': 1, 'solver': 'liblinear', 'fit_intercept': False, 'penalty': 'l2'}	False	
104	0.937289	0.839103	0.929469	{'C': 1, 'solver': 'liblinear', 'fit_intercept': False, 'penalty': 'l2'}	MinMaxScaler()	
105	0.937289	0.839103	0.929469	{'C': 1, 'solver': 'saga', 'fit_intercept': False, 'penalty': 'l2'}	MinMaxScaler()	
83	0.959440	0.836688	0.592869	{'C': 10, 'solver': 'saga', 'fit_intercept': True, 'penalty': 'l2'}	False	
85	0.958999	0.835893	0.596019	{'C': 10000, 'solver': 'saga', 'fit_intercept': True, 'penalty': 'l2'}	False	
87	0.958999	0.835893	0.596019	{'C': 100000, 'solver': 'saga', 'fit_intercept': True, 'penalty': 'l2'}	False	

	v_avg_spec	v_avg_prec	v_avg_rec	v_Kwargs_hyp_para	scaler	v_
66	0.932439	0.830608	0.942058	{'C': 10, 'solver': 'liblinear', 'fit_intercept': True, 'penalty': 'l2'}	False	
98	0.918111	0.800238	0.934504	{'C': 10, 'solver': 'liblinear', 'fit_intercept': False, 'penalty': 'l2'}	False	
115	0.950401	0.783874	0.513218	{'C': 10, 'solver': 'saga', 'fit_intercept': False, 'penalty': 'l2'}	False	
113	0.955361	0.782958	0.459058	{'C': 1, 'solver': 'saga', 'fit_intercept': False, 'penalty': 'l2'}	False	
117	0.949299	0.781768	0.518253	{'C': 10000, 'solver': 'saga', 'fit_intercept': False, 'penalty': 'l2'}	False	
119	0.949299	0.781768	0.518253	{'C': 100000, 'solver': 'saga', 'fit_intercept': False, 'penalty': 'l2'}	False	
4	0.904884	0.771019	0.913092	{'C': 10000, 'solver': 'liblinear', 'fit_intercept': True, 'penalty': 'l2'}	False	
34	0.904774	0.770814	0.913092	{'C': 10, 'solver': 'liblinear', 'fit_intercept': False, 'penalty': 'l2'}	False	
38	0.904774	0.770814	0.913092	{'C': 100000, 'solver': 'liblinear', 'fit_intercept': False, 'penalty': 'l2'}	False	
36	0.904774	0.770812	0.913092	{'C': 10000, 'solver': 'liblinear', 'fit_intercept': False, 'penalty': 'l2'}	False	
6	0.904663	0.770610	0.913092	{'C': 100000, 'solver': 'liblinear', 'fit_intercept': True, 'penalty': 'l2'}	False	
0	0.904663	0.770589	0.913092	{'C': 1, 'solver': 'liblinear', 'fit_intercept': True, 'penalty': 'l2'}	False	
32	0.904553	0.770384	0.913092	{'C': 1, 'solver': 'liblinear', 'fit_intercept': False, 'penalty': 'l2'}	False	
2	0.903230	0.767993	0.913092	{'C': 10, 'solver': 'liblinear',	False	

	v_avg_spec	v_avg_prec	v_avg_rec	v_Kwargs_hyp_para	scaler	v_
				'fit_intercept': True, 'penalty': 'l2'}		
64	0.860357	0.695361	0.909005	{'C': 1, 'solver': 'liblinear', 'fit_intercept': True, 'penalty': 'l2'}	False	
69	0.832693	0.649186	0.883191	{'C': 10000, 'solver': 'saga', 'fit_intercept': True, 'penalty': 'l2'}	False	
71	0.832693	0.649186	0.883191	{'C': 100000, 'solver': 'saga', 'fit_intercept': True, 'penalty': 'l2'}	False	
67	0.832032	0.648361	0.883507	{'C': 10, 'solver': 'saga', 'fit_intercept': True, 'penalty': 'l2'}	False	
65	0.829386	0.646352	0.889174	{'C': 1, 'solver': 'saga', 'fit_intercept': True, 'penalty': 'l2'}	False	
96	0.824096	0.639505	0.889802	{'C': 1, 'solver': 'liblinear', 'fit_intercept': False, 'penalty': 'l2'}	False	
101	0.798304	0.601226	0.867760	{'C': 10000, 'solver': 'saga', 'fit_intercept': False, 'penalty': 'l2'}	False	
103	0.798304	0.601226	0.867760	{'C': 100000, 'solver': 'saga', 'fit_intercept': False, 'penalty': 'l2'}	False	
99	0.797532	0.600600	0.868705	{'C': 10, 'solver': 'saga', 'fit_intercept': False, 'penalty': 'l2'}	False	
97	0.789265	0.592964	0.875631	{'C': 1, 'solver': 'saga', 'fit_intercept': False, 'penalty': 'l2'}	False	
17	1.000000	0.000000	0.000000	{'C': 1, 'solver': 'saga', 'fit_intercept': True, 'penalty': 'l2'}	False	
19	1.000000	0.000000	0.000000	{'C': 10, 'solver': 'saga', 'fit_intercept': True, 'penalty': 'l2'}	False	
21	1.000000	0.000000	0.000000	{'C': 10000, 'solver': 'saga', 'fit_intercept': True, 'penalty': 'l2'}	False	
23	1.000000	0.000000	0.000000	{'C': 100000, 'solver': 'saga', 'fit_intercept': True, 'penalty': 'l2'}	False	

	v_avg_spec	v_avg_prec	v_avg_rec	v_Kwargs_hyp_para	scaler	v_
49	1.000000	0.000000	0.000000	{'C': 1, 'solver': 'saga', 'fit_intercept': False, 'penalty': 'l2'}	False	
51	1.000000	0.000000	0.000000	{'C': 10, 'solver': 'saga', 'fit_intercept': False, 'penalty': 'l2'}	False	
53	1.000000	0.000000	0.000000	{'C': 10000, 'solver': 'saga', 'fit_intercept': False, 'penalty': 'l2'}	False	
55	1.000000	0.000000	0.000000	{'C': 100000, 'solver': 'saga', 'fit_intercept': False, 'penalty': 'l2'}	False	

This seemingly just gets us to our above-desired instance faster, displaying the same called-out optimized instance that we just called out above. We will use this call to look for the optimized Decision Tree results instead of sorting by specificity.

Display the results of the optimized Logistic Regression model and compare to previous best model

In [30]:

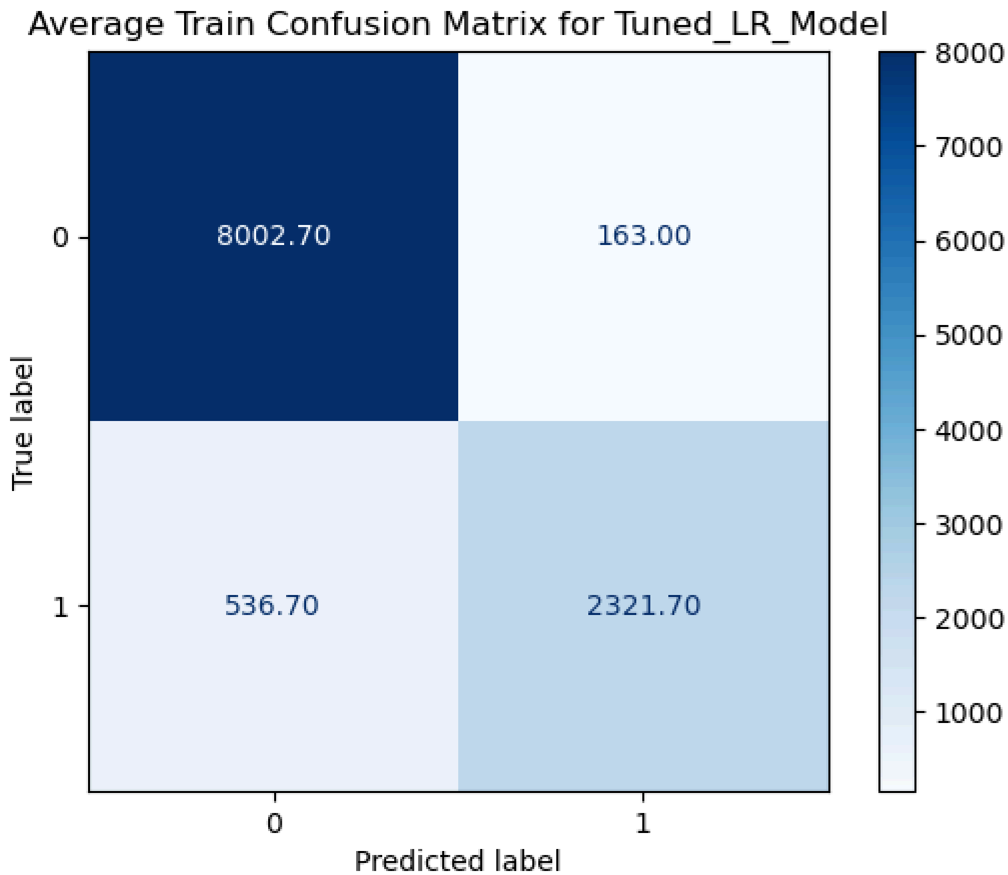
```
model_kwargs= {'C': 10, 'solver': 'liblinear', 'fit_intercept': True, 'penal
print(model_kwargs)

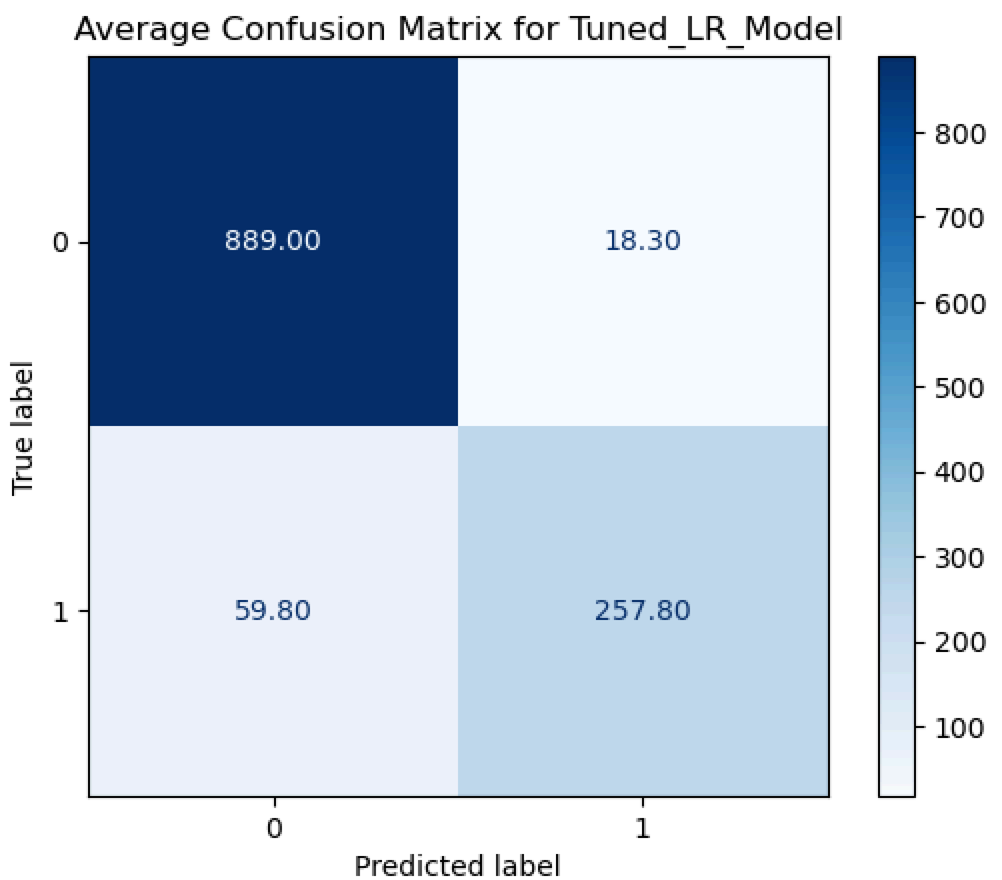
Tuned_LR_Model_Results= ModelWithCV(model_instantiator= LogisticRegression,
                  model_name= 'Tuned_LR_Model',
                  X= X_train_Norm,
                  y= y_train,
                  scaler= False,
                  smote_and_rand_und= False,
                  model_kwargs= model_kwargs)

Tuned_LR_Model_Results.plot_avg_conf_matrix()

print('results for Tuned LR:')
Tuned_LR_Model_Results.print_cv_summary()
print()
print('results for DT baseline (previous best model):')
DT_Baseline_Results.print_cv_summary()
```

```
{'C': 10, 'solver': 'liblinear', 'fit_intercept': True, 'penalty': 'l2'}
```


Average Train Confusion Matrix for Tuned_LR_Model
8002.70
163.00
536.70
2321.70
True label
Predicted label
0
1
8000
7000
6000
5000
4000
3000
2000
1000


Average Confusion Matrix for Tuned_LR_Model
889.00
18.30
59.80
257.80
True label
Predicted label
0
1
800
700
600
500
400
300
200
100

```
results for Tuned LR:
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 0.98004
Average precision: 0.93440
Average recall: 0.81224
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 0.97983
Average precision: 0.93396
Average recall: 0.81172

results for DT baseline (previous best model):
###TRAIN###
CV results for DT_Base_Model model:Average specificity: 1.00000
Average precision: 1.00000
Average recall: 1.00000
###VAL###
CV results for DT_Base_Model model:Average specificity: 0.96352
Average precision: 0.89575
Average recall: 0.89389
```

Out[30]:
```
(0.9635192992340533, 0.8957492446149351, 0.8938872686149635, {}, False, Fal
se)
```

We can see that this new tuned Logistic regression model is performing better than the previous most effective model (Baseline Decision Tree). This new LR model's validation specificity improved by almost 2%, and its precision improved by almost 4% over the previous best model. The only downside is that recal took about an 8% hit, but given the manufacturer's context for efficiency (maximize specificity and precision), this is an acceptable loss.

This is now considered the most effective model given the context.

Now let's run an optimization grid search on the Decision tree to see if it can out perform the tunes Logistic Regression model.

Run a grid search for preprocessing and hyperparameter tuning the Decision Tree model

I would like to note that here too this search scale has been narrowed down to parameters previously discovered to be effective, while still demonstrating the effectiveness and utility of the code. This has been done because previous wider searches have proven to be too computationally expensive for my current computer to handle, and cause the notebook to significantly slow down and-or crash. The original grid search parameters are noted above the current ones for reference. One potential way to mitigate this problem could be to split up the grid search and tune for one parameter at a time.

In [22]:
```
#store iteration results
dt_metric_tracker= []
dt_data_and_scaler= []

#iterable options

#as shown below (data distribution normalization does not
#do much for decision trees)
data_sets= [X_train]

#list(range(1,33))
max_depths= [2,3,4,5]

#np.linspace(0.1, 1.0, 10, endpoint= True)
min_samples_splits = [0.05, 0.1, 0.15]

#['gini', 'entropy', 'log_loss']
criterions = ['gini']

#np.linspace(0.1, 0.5, 10, endpoint= True)
min_samples_leafs = [.1225, .1325, .1425]

#list(range(1, X_train.shape[1]))
max_feature_num = [2, 3, 4, 5]

#[True, False]
smote= [True]

#as shown below (data scaling does not
#do much for decision trees)
scaler= [False]


#nested for loops to iterate through all the above options
for data, data_name in zip(data_sets, ["X_train", "X_train_Norm"]):
    for depth in max_depths:
        for sm in smote:
            for sc in scaler:
                for fit in int_fit:
                    for samp_split in min_samples_splits:
                        for solver in solvers:
                            for crit in criterions:
                                for samp_leafs in min_samples_leafs:
                                    for num_feat in max_feature_num:
                                        model_kwargs= {'max_depth': depth, '
                                                        'criterion': crit, '
                                                        'max_features': num_
                                        print(model_kwargs)
                                        #instantiate the class
                                        temp= ModelWithCV(model_instantiator
```

```
                                        )

                        dt_metric_tracker.append(temp.print_
                        dt_data_and_scaler.append(data_name)

                        print()
                        print('#### NEXT ITERATION###')
```

```
{'max_depth': 2, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1225, 'max_features': 2}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.89003
Average precision: 0.89234
Average recall: 0.91087
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.88956
Average precision: 0.73643
Average recall: 0.88066

#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1225, 'max_features': 3}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.97821
Average precision: 0.97489
Average recall: 0.84579
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.97851
Average precision: 0.93219
Average recall: 0.84100

#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1225, 'max_features': 4}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98119
Average precision: 0.97833
Average recall: 0.84892
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98137
Average precision: 0.94095
Average recall: 0.84289

#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1225, 'max_features': 5}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.79301
Average precision: 0.82581
Average recall: 0.98083
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.79180
Average precision: 0.62231
Average recall: 0.97418

#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1325, 'max_features': 2}
SMOTEing and Randomly Undersampling
###TRAIN###
```

```
CV results for Tuned_DT_Model model:Average specificity: 0.89373
Average precision: 0.89390
Average recall: 0.89475
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.89309
Average precision: 0.73832
Average recall: 0.86114

#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1325, 'max_features': 3}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98108
Average precision: 0.97768
Average recall: 0.82869
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98104
Average precision: 0.93870
Average recall: 0.82558

#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1325, 'max_features': 4}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98408
Average precision: 0.98122
Average recall: 0.83150
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98391
Average precision: 0.94762
Average recall: 0.82526

#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1325, 'max_features': 5}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.79301
Average precision: 0.82581
Average recall: 0.98083
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.79180
Average precision: 0.62231
Average recall: 0.97418

#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1425, 'max_features': 2}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.89742
Average precision: 0.89549
Average recall: 0.87833
###VAL###
```

```
CV results for Tuned_DT_Model model:Average specificity: 0.89673
Average precision: 0.74059
Average recall: 0.84130

#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1425, 'max_features': 3}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98381
Average precision: 0.98044
Average recall: 0.81137
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98391
Average precision: 0.94643
Average recall: 0.80700

#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1425, 'max_features': 4}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98668
Average precision: 0.98390
Average recall: 0.81428
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98677
Average precision: 0.95563
Average recall: 0.80668

#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1425, 'max_features': 5}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.79301
Average precision: 0.82581
Average recall: 0.98083
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.79180
Average precision: 0.62231
Average recall: 0.97418

#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1225, 'max_features': 2}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.89003
Average precision: 0.89234
Average recall: 0.91087
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.88956
Average precision: 0.73643
Average recall: 0.88066
```

```
#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1225, 'max_features': 3}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.97821
Average precision: 0.97489
Average recall: 0.84579
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.97851
Average precision: 0.93219
Average recall: 0.84100

#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1225, 'max_features': 4}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98119
Average precision: 0.97833
Average recall: 0.84892
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98137
Average precision: 0.94095
Average recall: 0.84289

#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1225, 'max_features': 5}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.79301
Average precision: 0.82581
Average recall: 0.98083
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.79180
Average precision: 0.62231
Average recall: 0.97418

#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1325, 'max_features': 2}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.89373
Average precision: 0.89390
Average recall: 0.89475
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.89309
Average precision: 0.73832
Average recall: 0.86114

#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1325, 'max_features': 3}
SMOTEing and Randomly Undersampling
```

```
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98108
Average precision: 0.97768
Average recall: 0.82869
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98104
Average precision: 0.93870
Average recall: 0.82558

#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1325, 'max_features': 4}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98408
Average precision: 0.98122
Average recall: 0.83150
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98391
Average precision: 0.94762
Average recall: 0.82526

#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1325, 'max_features': 5}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.79301
Average precision: 0.82581
Average recall: 0.98083
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.79180
Average precision: 0.62231
Average recall: 0.97418

#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1425, 'max_features': 2}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.89742
Average precision: 0.89549
Average recall: 0.87833
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.89673
Average precision: 0.74059
Average recall: 0.84130

#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1425, 'max_features': 3}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98381
Average precision: 0.98044
Average recall: 0.81137
```

```
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98391
Average precision: 0.94643
Average recall: 0.80700

#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1425, 'max_features': 4}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98668
Average precision: 0.98390
Average recall: 0.81428
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98677
Average precision: 0.95563
Average recall: 0.80668

#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1425, 'max_features': 5}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.79301
Average precision: 0.82581
Average recall: 0.98083
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.79180
Average precision: 0.62231
Average recall: 0.97418

#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1225, 'max_features': 2}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.89003
Average precision: 0.89234
Average recall: 0.91087
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.88956
Average precision: 0.73643
Average recall: 0.88066

#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1225, 'max_features': 3}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.97821
Average precision: 0.97489
Average recall: 0.84579
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.97851
Average precision: 0.93219
Average recall: 0.84100
```

```
#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1225, 'max_features': 4}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98119
Average precision: 0.97833
Average recall: 0.84892
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98137
Average precision: 0.94095
Average recall: 0.84289

#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1225, 'max_features': 5}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.79301
Average precision: 0.82581
Average recall: 0.98083
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.79180
Average precision: 0.62231
Average recall: 0.97418

#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1325, 'max_features': 2}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.89373
Average precision: 0.89390
Average recall: 0.89475
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.89309
Average precision: 0.73832
Average recall: 0.86114

#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1325, 'max_features': 3}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98108
Average precision: 0.97768
Average recall: 0.82869
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98104
Average precision: 0.93870
Average recall: 0.82558

#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1325, 'max_features': 4}
```

```
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98408
Average precision: 0.98122
Average recall: 0.83150
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98391
Average precision: 0.94762
Average recall: 0.82526

#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1325, 'max_features': 5}
SMOTEing and Randomly Undersampling
###TRAIN###
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###VAL###
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Average precision: 0.62231
Average recall: 0.97418

#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1425, 'max_features': 2}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.89742
Average precision: 0.89549
Average recall: 0.87833
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.89673
Average precision: 0.74059
Average recall: 0.84130

#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1425, 'max_features': 3}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98381
Average precision: 0.98044
Average recall: 0.81137
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98391
Average precision: 0.94643
Average recall: 0.80700

#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1425, 'max_features': 4}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98668
Average precision: 0.98390
```

```
Average recall: 0.81428
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98677
Average precision: 0.95563
Average recall: 0.80668

#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1425, 'max_features': 5}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.79301
Average precision: 0.82581
Average recall: 0.98083
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.79180
Average precision: 0.62231
Average recall: 0.97418

#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1225, 'max_features': 2}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.89003
Average precision: 0.89234
Average recall: 0.91087
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.88956
Average precision: 0.73643
Average recall: 0.88066

#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1225, 'max_features': 3}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.97821
Average precision: 0.97489
Average recall: 0.84579
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.97851
Average precision: 0.93219
Average recall: 0.84100

#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1225, 'max_features': 4}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98119
Average precision: 0.97833
Average recall: 0.84892
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98137
Average precision: 0.94095
```

```
Average recall: 0.84289

#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1225, 'max_features': 5}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.79301
Average precision: 0.82581
Average recall: 0.98083
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.79180
Average precision: 0.62231
Average recall: 0.97418

#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1325, 'max_features': 2}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.89373
Average precision: 0.89390
Average recall: 0.89475
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.89309
Average precision: 0.73832
Average recall: 0.86114

#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1325, 'max_features': 3}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98108
Average precision: 0.97768
Average recall: 0.82869
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98104
Average precision: 0.93870
Average recall: 0.82558

#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1325, 'max_features': 4}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98408
Average precision: 0.98122
Average recall: 0.83150
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98391
Average precision: 0.94762
Average recall: 0.82526

#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
```

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_leaf': 0.1325, 'max_features': 5}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.79301
Average precision: 0.82581
Average recall: 0.98083
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.79180
Average precision: 0.62231
Average recall: 0.97418

#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1425, 'max_features': 2}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.89742
Average precision: 0.89549
Average recall: 0.87833
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.89673
Average precision: 0.74059
Average recall: 0.84130

#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1425, 'max_features': 3}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98381
Average precision: 0.98044
Average recall: 0.81137
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98391
Average precision: 0.94643
Average recall: 0.80700

#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1425, 'max_features': 4}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98668
Average precision: 0.98390
Average recall: 0.81428
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98677
Average precision: 0.95563
Average recall: 0.80668

#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1425, 'max_features': 5}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.79301
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Average precision: 0.82581
Average recall: 0.98083
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.79180
Average precision: 0.62231
Average recall: 0.97418

#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
s_leaf': 0.1225, 'max_features': 2}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.89003
Average precision: 0.89234
Average recall: 0.91087
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.88956
Average precision: 0.73643
Average recall: 0.88066

#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
s_leaf': 0.1225, 'max_features': 3}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.97821
Average precision: 0.97489
Average recall: 0.84579
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.97851
Average precision: 0.93219
Average recall: 0.84100

#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
s_leaf': 0.1225, 'max_features': 4}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98119
Average precision: 0.97833
Average recall: 0.84892
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98137
Average precision: 0.94095
Average recall: 0.84289

#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
s_leaf': 0.1225, 'max_features': 5}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.79301
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###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.79180
```

```
Average precision: 0.62231
Average recall: 0.97418

#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
s_leaf': 0.1325, 'max_features': 2}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.89373
Average precision: 0.89390
Average recall: 0.89475
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.89309
Average precision: 0.73832
Average recall: 0.86114

#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
s_leaf': 0.1325, 'max_features': 3}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98108
Average precision: 0.97768
Average recall: 0.82869
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98104
Average precision: 0.93870
Average recall: 0.82558

#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
s_leaf': 0.1325, 'max_features': 4}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98408
Average precision: 0.98122
Average recall: 0.83150
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98391
Average precision: 0.94762
Average recall: 0.82526

#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
s_leaf': 0.1325, 'max_features': 5}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.79301
Average precision: 0.82581
Average recall: 0.98083
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.79180
Average precision: 0.62231
Average recall: 0.97418

#### NEXT ITERATION###
```

```
{'max_depth': 2, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
s_leaf': 0.1425, 'max_features': 2}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.89742
Average precision: 0.89549
Average recall: 0.87833
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.89673
Average precision: 0.74059
Average recall: 0.84130

#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
s_leaf': 0.1425, 'max_features': 3}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98381
Average precision: 0.98044
Average recall: 0.81137
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98391
Average precision: 0.94643
Average recall: 0.80700

#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
s_leaf': 0.1425, 'max_features': 4}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98668
Average precision: 0.98390
Average recall: 0.81428
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98677
Average precision: 0.95563
Average recall: 0.80668

#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
s_leaf': 0.1425, 'max_features': 5}
SMOTEing and Randomly Undersampling
###TRAIN###
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#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
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SMOTEing and Randomly Undersampling
###TRAIN###
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Average precision: 0.89234
Average recall: 0.91087
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.88956
Average precision: 0.73643
Average recall: 0.88066

#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
s_leaf': 0.1225, 'max_features': 3}
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CV results for Tuned_DT_Model model:Average specificity: 0.97821
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#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
s_leaf': 0.1225, 'max_features': 4}
SMOTEing and Randomly Undersampling
###TRAIN###
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Average precision: 0.97833
Average recall: 0.84892
###VAL###
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Average precision: 0.94095
Average recall: 0.84289

#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
s_leaf': 0.1225, 'max_features': 5}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.79301
Average precision: 0.82581
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#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
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###TRAIN###
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Average precision: 0.89390
Average recall: 0.89475
###VAL###
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CV results for Tuned_DT_Model model:Average specificity: 0.89309
Average precision: 0.73832
Average recall: 0.86114

#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
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###TRAIN###
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Average precision: 0.97768
Average recall: 0.82869
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98104
Average precision: 0.93870
Average recall: 0.82558

#### NEXT ITERATION###
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Average recall: 0.83150
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98391
Average precision: 0.94762
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#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
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#### NEXT ITERATION###
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###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.89673
Average precision: 0.74059
Average recall: 0.84130
```

```
#### NEXT ITERATION###
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###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98391
Average precision: 0.94643
Average recall: 0.80700

#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
s_leaf': 0.1425, 'max_features': 4}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98668
Average precision: 0.98390
Average recall: 0.81428
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98677
Average precision: 0.95563
Average recall: 0.80668

#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
s_leaf': 0.1425, 'max_features': 5}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.79301
Average precision: 0.82581
Average recall: 0.98083
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.79180
Average precision: 0.62231
Average recall: 0.97418

#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1225, 'max_features': 2}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.89003
Average precision: 0.89234
Average recall: 0.91087
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.88956
Average precision: 0.73643
Average recall: 0.88066

#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1225, 'max_features': 3}
SMOTEing and Randomly Undersampling
```

```
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.97821
Average precision: 0.97489
Average recall: 0.84579
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.97851
Average precision: 0.93219
Average recall: 0.84100

#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1225, 'max_features': 4}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98119
Average precision: 0.97833
Average recall: 0.84892
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98137
Average precision: 0.94095
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#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1225, 'max_features': 5}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.79301
Average precision: 0.82581
Average recall: 0.98083
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.79180
Average precision: 0.62231
Average recall: 0.97418

#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1325, 'max_features': 2}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.89373
Average precision: 0.89390
Average recall: 0.89475
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.89309
Average precision: 0.73832
Average recall: 0.86114

#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1325, 'max_features': 3}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98108
Average precision: 0.97768
Average recall: 0.82869
```

```
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98104
Average precision: 0.93870
Average recall: 0.82558

#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1325, 'max_features': 4}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98408
Average precision: 0.98122
Average recall: 0.83150
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98391
Average precision: 0.94762
Average recall: 0.82526

#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1325, 'max_features': 5}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.79301
Average precision: 0.82581
Average recall: 0.98083
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.79180
Average precision: 0.62231
Average recall: 0.97418

#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1425, 'max_features': 2}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.89742
Average precision: 0.89549
Average recall: 0.87833
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.89673
Average precision: 0.74059
Average recall: 0.84130

#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1425, 'max_features': 3}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98381
Average precision: 0.98044
Average recall: 0.81137
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98391
Average precision: 0.94643
Average recall: 0.80700
```

```
#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1425, 'max_features': 4}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98668
Average precision: 0.98390
Average recall: 0.81428
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98677
Average precision: 0.95563
Average recall: 0.80668

#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1425, 'max_features': 5}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.79301
Average precision: 0.82581
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#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1225, 'max_features': 2}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.89003
Average precision: 0.89234
Average recall: 0.91087
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.88956
Average precision: 0.73643
Average recall: 0.88066

#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1225, 'max_features': 3}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.97821
Average precision: 0.97489
Average recall: 0.84579
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.97851
Average precision: 0.93219
Average recall: 0.84100

#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1225, 'max_features': 4}
```

```
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98119
Average precision: 0.97833
Average recall: 0.84892
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98137
Average precision: 0.94095
Average recall: 0.84289

#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1225, 'max_features': 5}
SMOTEing and Randomly Undersampling
###TRAIN###
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Average precision: 0.82581
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Average precision: 0.62231
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{'max_depth': 2, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
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SMOTEing and Randomly Undersampling
###TRAIN###
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Average precision: 0.89390
Average recall: 0.89475
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.89309
Average precision: 0.73832
Average recall: 0.86114

#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
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SMOTEing and Randomly Undersampling
###TRAIN###
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Average recall: 0.82869
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98104
Average precision: 0.93870
Average recall: 0.82558

#### NEXT ITERATION###
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SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98408
Average precision: 0.98122
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Average recall: 0.83150
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98391
Average precision: 0.94762
Average recall: 0.82526

#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
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SMOTEing and Randomly Undersampling
###TRAIN###
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###VAL###
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Average precision: 0.62231
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#### NEXT ITERATION###
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SMOTEing and Randomly Undersampling
###TRAIN###
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Average precision: 0.89549
Average recall: 0.87833
###VAL###
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Average precision: 0.74059
Average recall: 0.84130

#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
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SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98381
Average precision: 0.98044
Average recall: 0.81137
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98391
Average precision: 0.94643
Average recall: 0.80700

#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1425, 'max_features': 4}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98668
Average precision: 0.98390
Average recall: 0.81428
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98677
Average precision: 0.95563
```

```
Average recall: 0.80668

#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1425, 'max_features': 5}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.79301
Average precision: 0.82581
Average recall: 0.98083
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.79180
Average precision: 0.62231
Average recall: 0.97418

#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1225, 'max_features': 2}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.89003
Average precision: 0.89234
Average recall: 0.91087
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.88956
Average precision: 0.73643
Average recall: 0.88066

#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1225, 'max_features': 3}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.97821
Average precision: 0.97489
Average recall: 0.84579
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.97851
Average precision: 0.93219
Average recall: 0.84100

#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1225, 'max_features': 4}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98119
Average precision: 0.97833
Average recall: 0.84892
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98137
Average precision: 0.94095
Average recall: 0.84289

#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
```

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_leaf': 0.1225, 'max_features': 5}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.79301
Average precision: 0.82581
Average recall: 0.98083
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.79180
Average precision: 0.62231
Average recall: 0.97418

#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1325, 'max_features': 2}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.89373
Average precision: 0.89390
Average recall: 0.89475
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.89309
Average precision: 0.73832
Average recall: 0.86114

#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1325, 'max_features': 3}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98108
Average precision: 0.97768
Average recall: 0.82869
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98104
Average precision: 0.93870
Average recall: 0.82558

#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1325, 'max_features': 4}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98408
Average precision: 0.98122
Average recall: 0.83150
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98391
Average precision: 0.94762
Average recall: 0.82526

#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1325, 'max_features': 5}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.79301
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Average recall: 0.97418

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{'max_depth': 2, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1425, 'max_features': 2}
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###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.89742
Average precision: 0.89549
Average recall: 0.87833
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.89673
Average precision: 0.74059
Average recall: 0.84130

#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1425, 'max_features': 3}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98381
Average precision: 0.98044
Average recall: 0.81137
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98391
Average precision: 0.94643
Average recall: 0.80700

#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1425, 'max_features': 4}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98668
Average precision: 0.98390
Average recall: 0.81428
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98677
Average precision: 0.95563
Average recall: 0.80668

#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1425, 'max_features': 5}
SMOTEing and Randomly Undersampling
###TRAIN###
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###VAL###
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Average precision: 0.62231
Average recall: 0.97418

#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1225, 'max_features': 2}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.89003
Average precision: 0.89234
Average recall: 0.91087
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.88956
Average precision: 0.73643
Average recall: 0.88066

#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1225, 'max_features': 3}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.97821
Average precision: 0.97489
Average recall: 0.84579
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.97851
Average precision: 0.93219
Average recall: 0.84100

#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1225, 'max_features': 4}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98119
Average precision: 0.97833
Average recall: 0.84892
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98137
Average precision: 0.94095
Average recall: 0.84289

#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1225, 'max_features': 5}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.79301
Average precision: 0.82581
Average recall: 0.98083
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.79180
Average precision: 0.62231
Average recall: 0.97418

#### NEXT ITERATION###
```

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{'max_depth': 2, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1325, 'max_features': 2}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.89373
Average precision: 0.89390
Average recall: 0.89475
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.89309
Average precision: 0.73832
Average recall: 0.86114

#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1325, 'max_features': 3}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98108
Average precision: 0.97768
Average recall: 0.82869
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98104
Average precision: 0.93870
Average recall: 0.82558

#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1325, 'max_features': 4}
SMOTEing and Randomly Undersampling
###TRAIN###
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###VAL###
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#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1325, 'max_features': 5}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.79301
Average precision: 0.82581
Average recall: 0.98083
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.79180
Average precision: 0.62231
Average recall: 0.97418

#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
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SMOTEing and Randomly Undersampling
###TRAIN###
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CV results for Tuned_DT_Model model:Average specificity: 0.89742
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###VAL###
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#### NEXT ITERATION###
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#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
s_leaf': 0.1225, 'max_features': 2}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.89003
Average precision: 0.89234
Average recall: 0.91087
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CV results for Tuned_DT_Model model:Average specificity: 0.88956
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#### NEXT ITERATION###
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#### NEXT ITERATION###
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Average recall: 0.84892
###VAL###
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Average recall: 0.84289

#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
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SMOTEing and Randomly Undersampling
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###VAL###
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Average precision: 0.62231
Average recall: 0.97418

#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
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###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.89309
Average precision: 0.73832
Average recall: 0.86114
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#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
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###TRAIN###
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Average recall: 0.82869
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Average precision: 0.93870
Average recall: 0.82558

#### NEXT ITERATION###
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SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98408
Average precision: 0.98122
Average recall: 0.83150
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98391
Average precision: 0.94762
Average recall: 0.82526

#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
s_leaf': 0.1325, 'max_features': 5}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.79301
Average precision: 0.82581
Average recall: 0.98083
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.79180
Average precision: 0.62231
Average recall: 0.97418

#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
s_leaf': 0.1425, 'max_features': 2}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.89742
Average precision: 0.89549
Average recall: 0.87833
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.89673
Average precision: 0.74059
Average recall: 0.84130

#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
s_leaf': 0.1425, 'max_features': 3}
SMOTEing and Randomly Undersampling
```

```
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98381
Average precision: 0.98044
Average recall: 0.81137
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98391
Average precision: 0.94643
Average recall: 0.80700

#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
s_leaf': 0.1425, 'max_features': 4}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98668
Average precision: 0.98390
Average recall: 0.81428
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98677
Average precision: 0.95563
Average recall: 0.80668

#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
s_leaf': 0.1425, 'max_features': 5}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.79301
Average precision: 0.82581
Average recall: 0.98083
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.79180
Average precision: 0.62231
Average recall: 0.97418

#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
s_leaf': 0.1225, 'max_features': 2}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.89003
Average precision: 0.89234
Average recall: 0.91087
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.88956
Average precision: 0.73643
Average recall: 0.88066

#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
s_leaf': 0.1225, 'max_features': 3}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.97821
Average precision: 0.97489
Average recall: 0.84579
```

```
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.97851
Average precision: 0.93219
Average recall: 0.84100

#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
s_leaf': 0.1225, 'max_features': 4}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98119
Average precision: 0.97833
Average recall: 0.84892
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98137
Average precision: 0.94095
Average recall: 0.84289

#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
s_leaf': 0.1225, 'max_features': 5}
SMOTEing and Randomly Undersampling
###TRAIN###
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#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
s_leaf': 0.1325, 'max_features': 2}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.89373
Average precision: 0.89390
Average recall: 0.89475
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.89309
Average precision: 0.73832
Average recall: 0.86114

#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
s_leaf': 0.1325, 'max_features': 3}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98108
Average precision: 0.97768
Average recall: 0.82869
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98104
Average precision: 0.93870
Average recall: 0.82558
```

```
#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
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###VAL###
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Average precision: 0.94762
Average recall: 0.82526

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CV results for Tuned_DT_Model model:Average specificity: 0.89673
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#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
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SMOTEing and Randomly Undersampling
###TRAIN###
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###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98391
Average precision: 0.94643
Average recall: 0.80700

#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
s_leaf': 0.1425, 'max_features': 4}
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SMOTEing and Randomly Undersampling
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CV results for Tuned_DT_Model model:Average specificity: 0.98668
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Average recall: 0.81428
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98677
Average precision: 0.95563
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#### NEXT ITERATION###
{'max_depth': 2, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
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SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.79301
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###VAL###
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Average precision: 0.62231
Average recall: 0.97418

#### NEXT ITERATION###
{'max_depth': 3, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1225, 'max_features': 2}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.89003
Average precision: 0.89234
Average recall: 0.91087
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.88956
Average precision: 0.73643
Average recall: 0.88066

#### NEXT ITERATION###
{'max_depth': 3, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
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SMOTEing and Randomly Undersampling
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CV results for Tuned_DT_Model model:Average specificity: 0.97821
Average precision: 0.97489
Average recall: 0.84579
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.97851
Average precision: 0.93219
Average recall: 0.84100

#### NEXT ITERATION###
{'max_depth': 3, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1225, 'max_features': 4}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98119
Average precision: 0.97833
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Average recall: 0.84892
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98137
Average precision: 0.94095
Average recall: 0.84289

#### NEXT ITERATION###
{'max_depth': 3, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1225, 'max_features': 5}
SMOTEing and Randomly Undersampling
###TRAIN###
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Average recall: 0.98083
###VAL###
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Average precision: 0.62231
Average recall: 0.97418

#### NEXT ITERATION###
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SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.89373
Average precision: 0.89390
Average recall: 0.89475
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.89309
Average precision: 0.73832
Average recall: 0.86114

#### NEXT ITERATION###
{'max_depth': 3, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
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###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98391
Average precision: 0.94762
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Average recall: 0.82526

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SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.89742
Average precision: 0.89549
Average recall: 0.87833
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.89673
Average precision: 0.74059
Average recall: 0.84130

#### NEXT ITERATION###
{'max_depth': 3, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
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SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98381
Average precision: 0.98044
Average recall: 0.81137
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98391
Average precision: 0.94643
Average recall: 0.80700

#### NEXT ITERATION###
{'max_depth': 3, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1425, 'max_features': 4}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98668
Average precision: 0.98390
Average recall: 0.81428
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98677
Average precision: 0.95563
Average recall: 0.80668

#### NEXT ITERATION###
{'max_depth': 3, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
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s_leaf': 0.1425, 'max_features': 5}
SMOTEing and Randomly Undersampling
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{'max_depth': 3, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1225, 'max_features': 2}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.89003
Average precision: 0.89234
Average recall: 0.91087
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.88956
Average precision: 0.73643
Average recall: 0.88066

#### NEXT ITERATION###
{'max_depth': 3, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1225, 'max_features': 3}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.97821
Average precision: 0.97489
Average recall: 0.84579
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.97851
Average precision: 0.93219
Average recall: 0.84100

#### NEXT ITERATION###
{'max_depth': 3, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1225, 'max_features': 4}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98119
Average precision: 0.97833
Average recall: 0.84892
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98137
Average precision: 0.94095
Average recall: 0.84289

#### NEXT ITERATION###
{'max_depth': 3, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1225, 'max_features': 5}
SMOTEing and Randomly Undersampling
###TRAIN###
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{'max_depth': 3, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1325, 'max_features': 2}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.89373
Average precision: 0.89390
Average recall: 0.89475
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.89309
Average precision: 0.73832
Average recall: 0.86114

#### NEXT ITERATION###
{'max_depth': 3, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1325, 'max_features': 3}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98108
Average precision: 0.97768
Average recall: 0.82869
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98104
Average precision: 0.93870
Average recall: 0.82558

#### NEXT ITERATION###
{'max_depth': 3, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1325, 'max_features': 4}
SMOTEing and Randomly Undersampling
###TRAIN###
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###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98391
Average precision: 0.94762
Average recall: 0.82526

#### NEXT ITERATION###
{'max_depth': 3, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1325, 'max_features': 5}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.79301
Average precision: 0.82581
Average recall: 0.98083
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.79180
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Average precision: 0.62231
Average recall: 0.97418

#### NEXT ITERATION###
{'max_depth': 3, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1425, 'max_features': 2}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.89742
Average precision: 0.89549
Average recall: 0.87833
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.89673
Average precision: 0.74059
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#### NEXT ITERATION###
{'max_depth': 3, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1425, 'max_features': 3}
SMOTEing and Randomly Undersampling
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###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98391
Average precision: 0.94643
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#### NEXT ITERATION###
{'max_depth': 3, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1425, 'max_features': 4}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98668
Average precision: 0.98390
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###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98677
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#### NEXT ITERATION###
{'max_depth': 3, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1425, 'max_features': 5}
SMOTEing and Randomly Undersampling
###TRAIN###
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Average recall: 0.98083
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Average precision: 0.62231
Average recall: 0.97418

#### NEXT ITERATION###
```

```
{'max_depth': 3, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1225, 'max_features': 2}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.89003
Average precision: 0.89234
Average recall: 0.91087
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.88956
Average precision: 0.73643
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#### NEXT ITERATION###
{'max_depth': 3, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1225, 'max_features': 3}
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#### NEXT ITERATION###
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#### NEXT ITERATION###
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Average recall: 0.98083
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Average precision: 0.62231
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#### NEXT ITERATION###
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{'max_depth': 3, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1425, 'max_features': 3}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98381
Average precision: 0.98044
Average recall: 0.81137
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98391
Average precision: 0.94643
Average recall: 0.80700

#### NEXT ITERATION###
{'max_depth': 3, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1425, 'max_features': 4}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98668
Average precision: 0.98390
Average recall: 0.81428
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98677
Average precision: 0.95563
Average recall: 0.80668

#### NEXT ITERATION###
{'max_depth': 3, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1425, 'max_features': 5}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.79301
Average precision: 0.82581
Average recall: 0.98083
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.79180
Average precision: 0.62231
Average recall: 0.97418

#### NEXT ITERATION###
{'max_depth': 3, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1225, 'max_features': 2}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.89003
Average precision: 0.89234
Average recall: 0.91087
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.88956
Average precision: 0.73643
Average recall: 0.88066
```

```
#### NEXT ITERATION###
{'max_depth': 3, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1225, 'max_features': 3}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.97821
Average precision: 0.97489
Average recall: 0.84579
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.97851
Average precision: 0.93219
Average recall: 0.84100

#### NEXT ITERATION###
{'max_depth': 3, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1225, 'max_features': 4}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98119
Average precision: 0.97833
Average recall: 0.84892
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98137
Average precision: 0.94095
Average recall: 0.84289

#### NEXT ITERATION###
{'max_depth': 3, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1225, 'max_features': 5}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.79301
Average precision: 0.82581
Average recall: 0.98083
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.79180
Average precision: 0.62231
Average recall: 0.97418

#### NEXT ITERATION###
{'max_depth': 3, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1325, 'max_features': 2}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.89373
Average precision: 0.89390
Average recall: 0.89475
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.89309
Average precision: 0.73832
Average recall: 0.86114

#### NEXT ITERATION###
{'max_depth': 3, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1325, 'max_features': 3}
SMOTEing and Randomly Undersampling
```

```
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98108
Average precision: 0.97768
Average recall: 0.82869
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98104
Average precision: 0.93870
Average recall: 0.82558

#### NEXT ITERATION###
{'max_depth': 3, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1325, 'max_features': 4}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98408
Average precision: 0.98122
Average recall: 0.83150
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98391
Average precision: 0.94762
Average recall: 0.82526

#### NEXT ITERATION###
{'max_depth': 3, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1325, 'max_features': 5}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.79301
Average precision: 0.82581
Average recall: 0.98083
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.79180
Average precision: 0.62231
Average recall: 0.97418

#### NEXT ITERATION###
{'max_depth': 3, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1425, 'max_features': 2}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.89742
Average precision: 0.89549
Average recall: 0.87833
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.89673
Average precision: 0.74059
Average recall: 0.84130

#### NEXT ITERATION###
{'max_depth': 3, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1425, 'max_features': 3}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98381
Average precision: 0.98044
Average recall: 0.81137
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###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98391
Average precision: 0.94643
Average recall: 0.80700

#### NEXT ITERATION###
{'max_depth': 3, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1425, 'max_features': 4}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98668
Average precision: 0.98390
Average recall: 0.81428
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98677
Average precision: 0.95563
Average recall: 0.80668

#### NEXT ITERATION###
{'max_depth': 3, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1425, 'max_features': 5}
SMOTEing and Randomly Undersampling
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CV results for Tuned_DT_Model model:Average specificity: 0.79301
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###VAL###
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Average precision: 0.62231
Average recall: 0.97418

#### NEXT ITERATION###
{'max_depth': 3, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
s_leaf': 0.1225, 'max_features': 2}
SMOTEing and Randomly Undersampling
###TRAIN###
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Average precision: 0.89234
Average recall: 0.91087
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.88956
Average precision: 0.73643
Average recall: 0.88066

#### NEXT ITERATION###
{'max_depth': 3, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
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SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.97821
Average precision: 0.97489
Average recall: 0.84579
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.97851
Average precision: 0.93219
Average recall: 0.84100
```

```
#### NEXT ITERATION###
{'max_depth': 3, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
s_leaf': 0.1225, 'max_features': 4}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98119
Average precision: 0.97833
Average recall: 0.84892
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98137
Average precision: 0.94095
Average recall: 0.84289

#### NEXT ITERATION###
{'max_depth': 3, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
s_leaf': 0.1225, 'max_features': 5}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.79301
Average precision: 0.82581
Average recall: 0.98083
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.79180
Average precision: 0.62231
Average recall: 0.97418

#### NEXT ITERATION###
{'max_depth': 3, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
s_leaf': 0.1325, 'max_features': 2}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.89373
Average precision: 0.89390
Average recall: 0.89475
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.89309
Average precision: 0.73832
Average recall: 0.86114

#### NEXT ITERATION###
{'max_depth': 3, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
s_leaf': 0.1325, 'max_features': 3}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98108
Average precision: 0.97768
Average recall: 0.82869
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98104
Average precision: 0.93870
Average recall: 0.82558

#### NEXT ITERATION###
{'max_depth': 3, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
s_leaf': 0.1325, 'max_features': 4}
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SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98408
Average precision: 0.98122
Average recall: 0.83150
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98391
Average precision: 0.94762
Average recall: 0.82526

#### NEXT ITERATION###
{'max_depth': 3, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
s_leaf': 0.1325, 'max_features': 5}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.79301
Average precision: 0.82581
Average recall: 0.98083
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.79180
Average precision: 0.62231
Average recall: 0.97418

#### NEXT ITERATION###
{'max_depth': 3, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
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SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.89742
Average precision: 0.89549
Average recall: 0.87833
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.89673
Average precision: 0.74059
Average recall: 0.84130

#### NEXT ITERATION###
{'max_depth': 3, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
s_leaf': 0.1425, 'max_features': 3}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98381
Average precision: 0.98044
Average recall: 0.81137
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98391
Average precision: 0.94643
Average recall: 0.80700

#### NEXT ITERATION###
{'max_depth': 3, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
s_leaf': 0.1425, 'max_features': 4}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98668
Average precision: 0.98390
```

```
Average recall: 0.81428
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98677
Average precision: 0.95563
Average recall: 0.80668

#### NEXT ITERATION###
{'max_depth': 3, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
s_leaf': 0.1425, 'max_features': 5}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.79301
Average precision: 0.82581
Average recall: 0.98083
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.79180
Average precision: 0.62231
Average recall: 0.97418

#### NEXT ITERATION###
{'max_depth': 3, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
s_leaf': 0.1225, 'max_features': 2}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.89003
Average precision: 0.89234
Average recall: 0.91087
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.88956
Average precision: 0.73643
Average recall: 0.88066

#### NEXT ITERATION###
{'max_depth': 3, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
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SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.97821
Average precision: 0.97489
Average recall: 0.84579
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.97851
Average precision: 0.93219
Average recall: 0.84100

#### NEXT ITERATION###
{'max_depth': 3, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
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SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98119
Average precision: 0.97833
Average recall: 0.84892
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98137
Average precision: 0.94095
```

```
Average recall: 0.84289

#### NEXT ITERATION###
{'max_depth': 3, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
s_leaf': 0.1225, 'max_features': 5}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.79301
Average precision: 0.82581
Average recall: 0.98083
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.79180
Average precision: 0.62231
Average recall: 0.97418

#### NEXT ITERATION###
{'max_depth': 3, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
s_leaf': 0.1325, 'max_features': 2}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.89373
Average precision: 0.89390
Average recall: 0.89475
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.89309
Average precision: 0.73832
Average recall: 0.86114

#### NEXT ITERATION###
{'max_depth': 3, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
s_leaf': 0.1325, 'max_features': 3}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98108
Average precision: 0.97768
Average recall: 0.82869
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98104
Average precision: 0.93870
Average recall: 0.82558

#### NEXT ITERATION###
{'max_depth': 3, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
s_leaf': 0.1325, 'max_features': 4}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98408
Average precision: 0.98122
Average recall: 0.83150
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98391
Average precision: 0.94762
Average recall: 0.82526

#### NEXT ITERATION###
{'max_depth': 3, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
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s_leaf': 0.1325, 'max_features': 5}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.79301
Average precision: 0.82581
Average recall: 0.98083
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.79180
Average precision: 0.62231
Average recall: 0.97418

#### NEXT ITERATION###
{'max_depth': 3, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
s_leaf': 0.1425, 'max_features': 2}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.89742
Average precision: 0.89549
Average recall: 0.87833
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.89673
Average precision: 0.74059
Average recall: 0.84130

#### NEXT ITERATION###
{'max_depth': 3, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
s_leaf': 0.1425, 'max_features': 3}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98381
Average precision: 0.98044
Average recall: 0.81137
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98391
Average precision: 0.94643
Average recall: 0.80700

#### NEXT ITERATION###
{'max_depth': 3, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
s_leaf': 0.1425, 'max_features': 4}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98668
Average precision: 0.98390
Average recall: 0.81428
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98677
Average precision: 0.95563
Average recall: 0.80668

#### NEXT ITERATION###
{'max_depth': 3, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
s_leaf': 0.1425, 'max_features': 5}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.79301
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Average precision: 0.82581
Average recall: 0.98083
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.79180
Average precision: 0.62231
Average recall: 0.97418

#### NEXT ITERATION###
{'max_depth': 3, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1225, 'max_features': 2}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.89003
Average precision: 0.89234
Average recall: 0.91087
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.88956
Average precision: 0.73643
Average recall: 0.88066

#### NEXT ITERATION###
{'max_depth': 3, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1225, 'max_features': 3}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.97821
Average precision: 0.97489
Average recall: 0.84579
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.97851
Average precision: 0.93219
Average recall: 0.84100

#### NEXT ITERATION###
{'max_depth': 3, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1225, 'max_features': 4}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98119
Average precision: 0.97833
Average recall: 0.84892
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98137
Average precision: 0.94095
Average recall: 0.84289

#### NEXT ITERATION###
{'max_depth': 3, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1225, 'max_features': 5}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.79301
Average precision: 0.82581
Average recall: 0.98083
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.79180
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```
Average precision: 0.62231
Average recall: 0.97418

#### NEXT ITERATION###
{'max_depth': 3, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1325, 'max_features': 2}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.89373
Average precision: 0.89390
Average recall: 0.89475
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.89309
Average precision: 0.73832
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#### NEXT ITERATION###
{'max_depth': 3, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1325, 'max_features': 3}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98108
Average precision: 0.97768
Average recall: 0.82869
###VAL###
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Average precision: 0.93870
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#### NEXT ITERATION###
{'max_depth': 3, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
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Average recall: 0.83150
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98391
Average precision: 0.94762
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#### NEXT ITERATION###
{'max_depth': 3, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
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SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.79301
Average precision: 0.82581
Average recall: 0.98083
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.79180
Average precision: 0.62231
Average recall: 0.97418

#### NEXT ITERATION###
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{'max_depth': 3, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
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###TRAIN###
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Average precision: 0.89549
Average recall: 0.87833
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.89673
Average precision: 0.74059
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#### NEXT ITERATION###
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CV results for Tuned_DT_Model model:Average specificity: 0.98381
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Average recall: 0.81137
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98391
Average precision: 0.94643
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#### NEXT ITERATION###
{'max_depth': 3, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
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###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98668
Average precision: 0.98390
Average recall: 0.81428
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Average precision: 0.62231
Average recall: 0.97418

#### NEXT ITERATION###
{'max_depth': 3, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1225, 'max_features': 2}
SMOTEing and Randomly Undersampling
###TRAIN###
```

```
CV results for Tuned_DT_Model model:Average specificity: 0.89003
Average precision: 0.89234
Average recall: 0.91087
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.88956
Average precision: 0.73643
Average recall: 0.88066

#### NEXT ITERATION###
{'max_depth': 3, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1225, 'max_features': 3}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.97821
Average precision: 0.97489
Average recall: 0.84579
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.97851
Average precision: 0.93219
Average recall: 0.84100

#### NEXT ITERATION###
{'max_depth': 3, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1225, 'max_features': 4}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98119
Average precision: 0.97833
Average recall: 0.84892
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98137
Average precision: 0.94095
Average recall: 0.84289

#### NEXT ITERATION###
{'max_depth': 3, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1225, 'max_features': 5}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.79301
Average precision: 0.82581
Average recall: 0.98083
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.79180
Average precision: 0.62231
Average recall: 0.97418

#### NEXT ITERATION###
{'max_depth': 3, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1325, 'max_features': 2}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.89373
Average precision: 0.89390
Average recall: 0.89475
###VAL###
```

```
CV results for Tuned_DT_Model model:Average specificity: 0.89309
Average precision: 0.73832
Average recall: 0.86114

#### NEXT ITERATION###
{'max_depth': 3, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1325, 'max_features': 3}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98108
Average precision: 0.97768
Average recall: 0.82869
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98104
Average precision: 0.93870
Average recall: 0.82558

#### NEXT ITERATION###
{'max_depth': 3, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1325, 'max_features': 4}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98408
Average precision: 0.98122
Average recall: 0.83150
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98391
Average precision: 0.94762
Average recall: 0.82526

#### NEXT ITERATION###
{'max_depth': 3, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1325, 'max_features': 5}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.79301
Average precision: 0.82581
Average recall: 0.98083
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.79180
Average precision: 0.62231
Average recall: 0.97418

#### NEXT ITERATION###
{'max_depth': 3, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1425, 'max_features': 2}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.89742
Average precision: 0.89549
Average recall: 0.87833
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.89673
Average precision: 0.74059
Average recall: 0.84130
```

```
#### NEXT ITERATION###
{'max_depth': 3, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1425, 'max_features': 3}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98381
Average precision: 0.98044
Average recall: 0.81137
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98391
Average precision: 0.94643
Average recall: 0.80700

#### NEXT ITERATION###
{'max_depth': 3, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1425, 'max_features': 4}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98668
Average precision: 0.98390
Average recall: 0.81428
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98677
Average precision: 0.95563
Average recall: 0.80668

#### NEXT ITERATION###
{'max_depth': 3, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1425, 'max_features': 5}
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#### NEXT ITERATION###
{'max_depth': 3, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1225, 'max_features': 2}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.89003
Average precision: 0.89234
Average recall: 0.91087
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.88956
Average precision: 0.73643
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{'max_depth': 3, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1225, 'max_features': 3}
SMOTEing and Randomly Undersampling
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###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.97821
Average precision: 0.97489
Average recall: 0.84579
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.97851
Average precision: 0.93219
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CV results for Tuned_DT_Model model:Average specificity: 0.98119
Average precision: 0.97833
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###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98137
Average precision: 0.94095
Average recall: 0.84289

#### NEXT ITERATION###
{'max_depth': 3, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
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SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.89373
Average precision: 0.89390
Average recall: 0.89475
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.89309
Average precision: 0.73832
Average recall: 0.86114

#### NEXT ITERATION###
{'max_depth': 3, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1325, 'max_features': 3}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98108
Average precision: 0.97768
Average recall: 0.82869
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###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98104
Average precision: 0.93870
Average recall: 0.82558

#### NEXT ITERATION###
{'max_depth': 3, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1325, 'max_features': 4}
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###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98408
Average precision: 0.98122
Average recall: 0.83150
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98391
Average precision: 0.94762
Average recall: 0.82526

#### NEXT ITERATION###
{'max_depth': 3, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1325, 'max_features': 5}
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Average recall: 0.98083
###VAL###
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Average precision: 0.62231
Average recall: 0.97418

#### NEXT ITERATION###
{'max_depth': 3, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
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###TRAIN###
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Average recall: 0.87833
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.89673
Average precision: 0.74059
Average recall: 0.84130

#### NEXT ITERATION###
{'max_depth': 3, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1425, 'max_features': 3}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98381
Average precision: 0.98044
Average recall: 0.81137
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98391
Average precision: 0.94643
Average recall: 0.80700
```

```
#### NEXT ITERATION###
{'max_depth': 3, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1425, 'max_features': 4}
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###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98668
Average precision: 0.98390
Average recall: 0.81428
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98677
Average precision: 0.95563
Average recall: 0.80668

#### NEXT ITERATION###
{'max_depth': 3, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1425, 'max_features': 5}
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###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.79301
Average precision: 0.82581
Average recall: 0.98083
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.79180
Average precision: 0.62231
Average recall: 0.97418

#### NEXT ITERATION###
{'max_depth': 3, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1225, 'max_features': 2}
SMOTEing and Randomly Undersampling
###TRAIN###
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Average precision: 0.89234
Average recall: 0.91087
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.88956
Average precision: 0.73643
Average recall: 0.88066

#### NEXT ITERATION###
{'max_depth': 3, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1225, 'max_features': 3}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.97821
Average precision: 0.97489
Average recall: 0.84579
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.97851
Average precision: 0.93219
Average recall: 0.84100

#### NEXT ITERATION###
{'max_depth': 3, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1225, 'max_features': 4}
```

```
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98119
Average precision: 0.97833
Average recall: 0.84892
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98137
Average precision: 0.94095
Average recall: 0.84289

#### NEXT ITERATION###
{'max_depth': 3, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1225, 'max_features': 5}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.79301
Average precision: 0.82581
Average recall: 0.98083
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.79180
Average precision: 0.62231
Average recall: 0.97418

#### NEXT ITERATION###
{'max_depth': 3, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1325, 'max_features': 2}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.89373
Average precision: 0.89390
Average recall: 0.89475
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.89309
Average precision: 0.73832
Average recall: 0.86114

#### NEXT ITERATION###
{'max_depth': 3, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1325, 'max_features': 3}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98108
Average precision: 0.97768
Average recall: 0.82869
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98104
Average precision: 0.93870
Average recall: 0.82558

#### NEXT ITERATION###
{'max_depth': 3, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1325, 'max_features': 4}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98408
Average precision: 0.98122
```

```
Average recall: 0.83150
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98391
Average precision: 0.94762
Average recall: 0.82526

#### NEXT ITERATION###
{'max_depth': 3, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1325, 'max_features': 5}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.79301
Average precision: 0.82581
Average recall: 0.98083
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.79180
Average precision: 0.62231
Average recall: 0.97418

#### NEXT ITERATION###
{'max_depth': 3, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1425, 'max_features': 2}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.89742
Average precision: 0.89549
Average recall: 0.87833
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.89673
Average precision: 0.74059
Average recall: 0.84130

#### NEXT ITERATION###
{'max_depth': 3, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1425, 'max_features': 3}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98381
Average precision: 0.98044
Average recall: 0.81137
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98391
Average precision: 0.94643
Average recall: 0.80700

#### NEXT ITERATION###
{'max_depth': 3, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1425, 'max_features': 4}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98668
Average precision: 0.98390
Average recall: 0.81428
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98677
Average precision: 0.95563
```

```
Average recall: 0.80668

#### NEXT ITERATION###
{'max_depth': 3, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1425, 'max_features': 5}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.79301
Average precision: 0.82581
Average recall: 0.98083
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.79180
Average precision: 0.62231
Average recall: 0.97418

#### NEXT ITERATION###
{'max_depth': 3, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
s_leaf': 0.1225, 'max_features': 2}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.89003
Average precision: 0.89234
Average recall: 0.91087
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.88956
Average precision: 0.73643
Average recall: 0.88066

#### NEXT ITERATION###
{'max_depth': 3, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
s_leaf': 0.1225, 'max_features': 3}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.97821
Average precision: 0.97489
Average recall: 0.84579
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.97851
Average precision: 0.93219
Average recall: 0.84100

#### NEXT ITERATION###
{'max_depth': 3, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
s_leaf': 0.1225, 'max_features': 4}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98119
Average precision: 0.97833
Average recall: 0.84892
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98137
Average precision: 0.94095
Average recall: 0.84289

#### NEXT ITERATION###
{'max_depth': 3, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
```

```
s_leaf': 0.1225, 'max_features': 5}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.79301
Average precision: 0.82581
Average recall: 0.98083
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.79180
Average precision: 0.62231
Average recall: 0.97418

#### NEXT ITERATION###
{'max_depth': 3, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
s_leaf': 0.1325, 'max_features': 2}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.89373
Average precision: 0.89390
Average recall: 0.89475
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.89309
Average precision: 0.73832
Average recall: 0.86114

#### NEXT ITERATION###
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SMOTEing and Randomly Undersampling
###TRAIN###
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###VAL###
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###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98391
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#### NEXT ITERATION###
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Average recall: 0.84289

#### NEXT ITERATION###
{'max_depth': 3, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
s_leaf': 0.1225, 'max_features': 5}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.79301
Average precision: 0.82581
Average recall: 0.98083
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.79180
Average precision: 0.62231
Average recall: 0.97418

#### NEXT ITERATION###
```

```
{'max_depth': 3, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
s_leaf': 0.1325, 'max_features': 2}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.89373
Average precision: 0.89390
Average recall: 0.89475
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.89309
Average precision: 0.73832
Average recall: 0.86114

#### NEXT ITERATION###
{'max_depth': 3, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
s_leaf': 0.1325, 'max_features': 3}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98108
Average precision: 0.97768
Average recall: 0.82869
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98104
Average precision: 0.93870
Average recall: 0.82558

#### NEXT ITERATION###
{'max_depth': 3, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
s_leaf': 0.1325, 'max_features': 4}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98408
Average precision: 0.98122
Average recall: 0.83150
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98391
Average precision: 0.94762
Average recall: 0.82526

#### NEXT ITERATION###
{'max_depth': 3, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
s_leaf': 0.1325, 'max_features': 5}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.79301
Average precision: 0.82581
Average recall: 0.98083
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.79180
Average precision: 0.62231
Average recall: 0.97418

#### NEXT ITERATION###
{'max_depth': 3, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
s_leaf': 0.1425, 'max_features': 2}
SMOTEing and Randomly Undersampling
###TRAIN###
```

```
CV results for Tuned_DT_Model model:Average specificity: 0.89742
Average precision: 0.89549
Average recall: 0.87833
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.89673
Average precision: 0.74059
Average recall: 0.84130

#### NEXT ITERATION###
{'max_depth': 3, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
s_leaf': 0.1425, 'max_features': 3}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98381
Average precision: 0.98044
Average recall: 0.81137
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98391
Average precision: 0.94643
Average recall: 0.80700

#### NEXT ITERATION###
{'max_depth': 3, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
s_leaf': 0.1425, 'max_features': 4}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98668
Average precision: 0.98390
Average recall: 0.81428
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98677
Average precision: 0.95563
Average recall: 0.80668

#### NEXT ITERATION###
{'max_depth': 3, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
s_leaf': 0.1425, 'max_features': 5}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.79301
Average precision: 0.82581
Average recall: 0.98083
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.79180
Average precision: 0.62231
Average recall: 0.97418

#### NEXT ITERATION###
{'max_depth': 4, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1225, 'max_features': 2}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.89003
Average precision: 0.89234
Average recall: 0.91087
###VAL###
```

```
CV results for Tuned_DT_Model model:Average specificity: 0.88956
Average precision: 0.73643
Average recall: 0.88066

#### NEXT ITERATION###
{'max_depth': 4, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1225, 'max_features': 3}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.97821
Average precision: 0.97489
Average recall: 0.84579
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.97851
Average precision: 0.93219
Average recall: 0.84100

#### NEXT ITERATION###
{'max_depth': 4, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1225, 'max_features': 4}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98119
Average precision: 0.97833
Average recall: 0.84892
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98137
Average precision: 0.94095
Average recall: 0.84289

#### NEXT ITERATION###
{'max_depth': 4, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1225, 'max_features': 5}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.79301
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###VAL###
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Average precision: 0.62231
Average recall: 0.97418

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SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.89373
Average precision: 0.89390
Average recall: 0.89475
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.89309
Average precision: 0.73832
Average recall: 0.86114
```

```
#### NEXT ITERATION###
{'max_depth': 4, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1325, 'max_features': 3}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98108
Average precision: 0.97768
Average recall: 0.82869
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98104
Average precision: 0.93870
Average recall: 0.82558

#### NEXT ITERATION###
{'max_depth': 4, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1325, 'max_features': 4}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98408
Average precision: 0.98122
Average recall: 0.83150
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98391
Average precision: 0.94762
Average recall: 0.82526

#### NEXT ITERATION###
{'max_depth': 4, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1325, 'max_features': 5}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.79301
Average precision: 0.82581
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###VAL###
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Average precision: 0.62231
Average recall: 0.97418

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{'max_depth': 4, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1425, 'max_features': 2}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.89742
Average precision: 0.89549
Average recall: 0.87833
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.89673
Average precision: 0.74059
Average recall: 0.84130

#### NEXT ITERATION###
{'max_depth': 4, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1425, 'max_features': 3}
SMOTEing and Randomly Undersampling
```

```
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98381
Average precision: 0.98044
Average recall: 0.81137
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98391
Average precision: 0.94643
Average recall: 0.80700

#### NEXT ITERATION###
{'max_depth': 4, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
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SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98668
Average precision: 0.98390
Average recall: 0.81428
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98677
Average precision: 0.95563
Average recall: 0.80668

#### NEXT ITERATION###
{'max_depth': 4, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
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SMOTEing and Randomly Undersampling
###TRAIN###
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###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.79180
Average precision: 0.62231
Average recall: 0.97418

#### NEXT ITERATION###
{'max_depth': 4, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1225, 'max_features': 2}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.89003
Average precision: 0.89234
Average recall: 0.91087
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.88956
Average precision: 0.73643
Average recall: 0.88066

#### NEXT ITERATION###
{'max_depth': 4, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1225, 'max_features': 3}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.97821
Average precision: 0.97489
Average recall: 0.84579
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```
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.97851
Average precision: 0.93219
Average recall: 0.84100

#### NEXT ITERATION###
{'max_depth': 4, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
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SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98119
Average precision: 0.97833
Average recall: 0.84892
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98137
Average precision: 0.94095
Average recall: 0.84289

#### NEXT ITERATION###
{'max_depth': 4, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1225, 'max_features': 5}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.79301
Average precision: 0.82581
Average recall: 0.98083
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.79180
Average precision: 0.62231
Average recall: 0.97418

#### NEXT ITERATION###
{'max_depth': 4, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1325, 'max_features': 2}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.89373
Average precision: 0.89390
Average recall: 0.89475
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.89309
Average precision: 0.73832
Average recall: 0.86114

#### NEXT ITERATION###
{'max_depth': 4, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1325, 'max_features': 3}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98108
Average precision: 0.97768
Average recall: 0.82869
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98104
Average precision: 0.93870
Average recall: 0.82558
```

```
#### NEXT ITERATION###
{'max_depth': 4, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1325, 'max_features': 4}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98408
Average precision: 0.98122
Average recall: 0.83150
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98391
Average precision: 0.94762
Average recall: 0.82526

#### NEXT ITERATION###
{'max_depth': 4, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1325, 'max_features': 5}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.79301
Average precision: 0.82581
Average recall: 0.98083
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.79180
Average precision: 0.62231
Average recall: 0.97418

#### NEXT ITERATION###
{'max_depth': 4, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1425, 'max_features': 2}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.89742
Average precision: 0.89549
Average recall: 0.87833
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.89673
Average precision: 0.74059
Average recall: 0.84130

#### NEXT ITERATION###
{'max_depth': 4, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1425, 'max_features': 3}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98381
Average precision: 0.98044
Average recall: 0.81137
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98391
Average precision: 0.94643
Average recall: 0.80700

#### NEXT ITERATION###
{'max_depth': 4, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1425, 'max_features': 4}
```

```
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98668
Average precision: 0.98390
Average recall: 0.81428
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98677
Average precision: 0.95563
Average recall: 0.80668

#### NEXT ITERATION###
{'max_depth': 4, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1425, 'max_features': 5}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.79301
Average precision: 0.82581
Average recall: 0.98083
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.79180
Average precision: 0.62231
Average recall: 0.97418

#### NEXT ITERATION###
{'max_depth': 4, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1225, 'max_features': 2}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.89003
Average precision: 0.89234
Average recall: 0.91087
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.88956
Average precision: 0.73643
Average recall: 0.88066

#### NEXT ITERATION###
{'max_depth': 4, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1225, 'max_features': 3}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.97821
Average precision: 0.97489
Average recall: 0.84579
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.97851
Average precision: 0.93219
Average recall: 0.84100

#### NEXT ITERATION###
{'max_depth': 4, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1225, 'max_features': 4}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98119
Average precision: 0.97833
```

```
Average recall: 0.84892
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98137
Average precision: 0.94095
Average recall: 0.84289

#### NEXT ITERATION###
{'max_depth': 4, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1225, 'max_features': 5}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.79301
Average precision: 0.82581
Average recall: 0.98083
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.79180
Average precision: 0.62231
Average recall: 0.97418

#### NEXT ITERATION###
{'max_depth': 4, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1325, 'max_features': 2}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.89373
Average precision: 0.89390
Average recall: 0.89475
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.89309
Average precision: 0.73832
Average recall: 0.86114

#### NEXT ITERATION###
{'max_depth': 4, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1325, 'max_features': 3}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98108
Average precision: 0.97768
Average recall: 0.82869
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98104
Average precision: 0.93870
Average recall: 0.82558

#### NEXT ITERATION###
{'max_depth': 4, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1325, 'max_features': 4}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98408
Average precision: 0.98122
Average recall: 0.83150
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98391
Average precision: 0.94762
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Average recall: 0.82526

#### NEXT ITERATION###
{'max_depth': 4, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1325, 'max_features': 5}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.79301
Average precision: 0.82581
Average recall: 0.98083
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.79180
Average precision: 0.62231
Average recall: 0.97418

#### NEXT ITERATION###
{'max_depth': 4, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1425, 'max_features': 2}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.89742
Average precision: 0.89549
Average recall: 0.87833
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.89673
Average precision: 0.74059
Average recall: 0.84130

#### NEXT ITERATION###
{'max_depth': 4, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1425, 'max_features': 3}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98381
Average precision: 0.98044
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###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98391
Average precision: 0.94643
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#### NEXT ITERATION###
{'max_depth': 4, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1425, 'max_features': 4}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98668
Average precision: 0.98390
Average recall: 0.81428
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98677
Average precision: 0.95563
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#### NEXT ITERATION###
{'max_depth': 4, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
```

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_leaf': 0.1425, 'max_features': 5}
SMOTEing and Randomly Undersampling
###TRAIN###
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Average precision: 0.82581
Average recall: 0.98083
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_leaf': 0.1225, 'max_features': 2}
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###TRAIN###
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###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.88956
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#### NEXT ITERATION###
{'max_depth': 4, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1225, 'max_features': 3}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.97821
Average precision: 0.97489
Average recall: 0.84579
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.97851
Average precision: 0.93219
Average recall: 0.84100

#### NEXT ITERATION###
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###TRAIN###
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Average precision: 0.97833
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###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98137
Average precision: 0.94095
Average recall: 0.84289

#### NEXT ITERATION###
{'max_depth': 4, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1225, 'max_features': 5}
SMOTEing and Randomly Undersampling
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CV results for Tuned_DT_Model model:Average specificity: 0.79301
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Average precision: 0.82581
Average recall: 0.98083
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.79180
Average precision: 0.62231
Average recall: 0.97418

#### NEXT ITERATION###
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###VAL###
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#### NEXT ITERATION###
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CV results for Tuned_DT_Model model:Average specificity: 0.98108
Average precision: 0.97768
Average recall: 0.82869
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98104
Average precision: 0.93870
Average recall: 0.82558

#### NEXT ITERATION###
{'max_depth': 4, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1325, 'max_features': 4}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98408
Average precision: 0.98122
Average recall: 0.83150
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98391
Average precision: 0.94762
Average recall: 0.82526

#### NEXT ITERATION###
{'max_depth': 4, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1325, 'max_features': 5}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.79301
Average precision: 0.82581
Average recall: 0.98083
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.79180
```

```
Average precision: 0.62231
Average recall: 0.97418

#### NEXT ITERATION###
{'max_depth': 4, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1425, 'max_features': 2}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.89742
Average precision: 0.89549
Average recall: 0.87833
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.89673
Average precision: 0.74059
Average recall: 0.84130

#### NEXT ITERATION###
{'max_depth': 4, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1425, 'max_features': 3}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98381
Average precision: 0.98044
Average recall: 0.81137
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98391
Average precision: 0.94643
Average recall: 0.80700

#### NEXT ITERATION###
{'max_depth': 4, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1425, 'max_features': 4}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98668
Average precision: 0.98390
Average recall: 0.81428
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98677
Average precision: 0.95563
Average recall: 0.80668

#### NEXT ITERATION###
{'max_depth': 4, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1425, 'max_features': 5}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.79301
Average precision: 0.82581
Average recall: 0.98083
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.79180
Average precision: 0.62231
Average recall: 0.97418

#### NEXT ITERATION###
```

```
{'max_depth': 4, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
s_leaf': 0.1225, 'max_features': 2}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.89003
Average precision: 0.89234
Average recall: 0.91087
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.88956
Average precision: 0.73643
Average recall: 0.88066

#### NEXT ITERATION###
{'max_depth': 4, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
s_leaf': 0.1225, 'max_features': 3}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.97821
Average precision: 0.97489
Average recall: 0.84579
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.97851
Average precision: 0.93219
Average recall: 0.84100

#### NEXT ITERATION###
{'max_depth': 4, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
s_leaf': 0.1225, 'max_features': 4}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98119
Average precision: 0.97833
Average recall: 0.84892
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98137
Average precision: 0.94095
Average recall: 0.84289

#### NEXT ITERATION###
{'max_depth': 4, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
s_leaf': 0.1225, 'max_features': 5}
SMOTEing and Randomly Undersampling
###TRAIN###
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#### NEXT ITERATION###
{'max_depth': 4, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
s_leaf': 0.1325, 'max_features': 2}
SMOTEing and Randomly Undersampling
###TRAIN###
```

```
CV results for Tuned_DT_Model model:Average specificity: 0.89373
Average precision: 0.89390
Average recall: 0.89475
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.89309
Average precision: 0.73832
Average recall: 0.86114

#### NEXT ITERATION###
{'max_depth': 4, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
s_leaf': 0.1325, 'max_features': 3}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98108
Average precision: 0.97768
Average recall: 0.82869
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98104
Average precision: 0.93870
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{'max_depth': 4, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
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###TRAIN###
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###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98391
Average precision: 0.94762
Average recall: 0.82526

#### NEXT ITERATION###
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SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.89742
Average precision: 0.89549
Average recall: 0.87833
###VAL###
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CV results for Tuned_DT_Model model:Average specificity: 0.89673
Average precision: 0.74059
Average recall: 0.84130

#### NEXT ITERATION###
{'max_depth': 4, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
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SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98381
Average precision: 0.98044
Average recall: 0.81137
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98391
Average precision: 0.94643
Average recall: 0.80700

#### NEXT ITERATION###
{'max_depth': 4, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
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SMOTEing and Randomly Undersampling
###TRAIN###
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Average precision: 0.98390
Average recall: 0.81428
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98677
Average precision: 0.95563
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#### NEXT ITERATION###
{'max_depth': 4, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
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Average precision: 0.62231
Average recall: 0.97418

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Average precision: 0.89234
Average recall: 0.91087
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.88956
Average precision: 0.73643
Average recall: 0.88066
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#### NEXT ITERATION###
{'max_depth': 4, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
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SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.97821
Average precision: 0.97489
Average recall: 0.84579
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.97851
Average precision: 0.93219
Average recall: 0.84100

#### NEXT ITERATION###
{'max_depth': 4, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
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SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98119
Average precision: 0.97833
Average recall: 0.84892
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98137
Average precision: 0.94095
Average recall: 0.84289

#### NEXT ITERATION###
{'max_depth': 4, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
s_leaf': 0.1225, 'max_features': 5}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.79301
Average precision: 0.82581
Average recall: 0.98083
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.79180
Average precision: 0.62231
Average recall: 0.97418

#### NEXT ITERATION###
{'max_depth': 4, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
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SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.89373
Average precision: 0.89390
Average recall: 0.89475
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.89309
Average precision: 0.73832
Average recall: 0.86114

#### NEXT ITERATION###
{'max_depth': 4, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
s_leaf': 0.1325, 'max_features': 3}
SMOTEing and Randomly Undersampling
```

```
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98108
Average precision: 0.97768
Average recall: 0.82869
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98104
Average precision: 0.93870
Average recall: 0.82558

#### NEXT ITERATION###
{'max_depth': 4, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
s_leaf': 0.1325, 'max_features': 4}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98408
Average precision: 0.98122
Average recall: 0.83150
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98391
Average precision: 0.94762
Average recall: 0.82526

#### NEXT ITERATION###
{'max_depth': 4, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
s_leaf': 0.1325, 'max_features': 5}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.79301
Average precision: 0.82581
Average recall: 0.98083
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.79180
Average precision: 0.62231
Average recall: 0.97418

#### NEXT ITERATION###
{'max_depth': 4, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
s_leaf': 0.1425, 'max_features': 2}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.89742
Average precision: 0.89549
Average recall: 0.87833
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.89673
Average precision: 0.74059
Average recall: 0.84130

#### NEXT ITERATION###
{'max_depth': 4, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
s_leaf': 0.1425, 'max_features': 3}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98381
Average precision: 0.98044
Average recall: 0.81137
```

```
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98391
Average precision: 0.94643
Average recall: 0.80700

#### NEXT ITERATION###
{'max_depth': 4, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
s_leaf': 0.1425, 'max_features': 4}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98668
Average precision: 0.98390
Average recall: 0.81428
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98677
Average precision: 0.95563
Average recall: 0.80668

#### NEXT ITERATION###
{'max_depth': 4, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
s_leaf': 0.1425, 'max_features': 5}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.79301
Average precision: 0.82581
Average recall: 0.98083
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.79180
Average precision: 0.62231
Average recall: 0.97418

#### NEXT ITERATION###
{'max_depth': 4, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1225, 'max_features': 2}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.89003
Average precision: 0.89234
Average recall: 0.91087
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.88956
Average precision: 0.73643
Average recall: 0.88066

#### NEXT ITERATION###
{'max_depth': 4, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1225, 'max_features': 3}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.97821
Average precision: 0.97489
Average recall: 0.84579
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.97851
Average precision: 0.93219
Average recall: 0.84100
```

```
#### NEXT ITERATION###
{'max_depth': 4, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1225, 'max_features': 4}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98119
Average precision: 0.97833
Average recall: 0.84892
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98137
Average precision: 0.94095
Average recall: 0.84289

#### NEXT ITERATION###
{'max_depth': 4, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1225, 'max_features': 5}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.79301
Average precision: 0.82581
Average recall: 0.98083
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.79180
Average precision: 0.62231
Average recall: 0.97418

#### NEXT ITERATION###
{'max_depth': 4, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1325, 'max_features': 2}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.89373
Average precision: 0.89390
Average recall: 0.89475
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.89309
Average precision: 0.73832
Average recall: 0.86114

#### NEXT ITERATION###
{'max_depth': 4, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1325, 'max_features': 3}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98108
Average precision: 0.97768
Average recall: 0.82869
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98104
Average precision: 0.93870
Average recall: 0.82558

#### NEXT ITERATION###
{'max_depth': 4, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1325, 'max_features': 4}
```

```
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98408
Average precision: 0.98122
Average recall: 0.83150
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98391
Average precision: 0.94762
Average recall: 0.82526

#### NEXT ITERATION###
{'max_depth': 4, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1325, 'max_features': 5}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.79301
Average precision: 0.82581
Average recall: 0.98083
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.79180
Average precision: 0.62231
Average recall: 0.97418

#### NEXT ITERATION###
{'max_depth': 4, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1425, 'max_features': 2}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.89742
Average precision: 0.89549
Average recall: 0.87833
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.89673
Average precision: 0.74059
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#### NEXT ITERATION###
{'max_depth': 4, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1425, 'max_features': 3}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98381
Average precision: 0.98044
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###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98391
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#### NEXT ITERATION###
{'max_depth': 4, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
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###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98668
Average precision: 0.98390
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Average recall: 0.81428
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Average recall: 0.84289

#### NEXT ITERATION###
{'max_depth': 4, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
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#### NEXT ITERATION###
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Average recall: 0.98083
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Average precision: 0.62231
Average recall: 0.97418

#### NEXT ITERATION###
{'max_depth': 4, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
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###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.89673
Average precision: 0.74059
Average recall: 0.84130

#### NEXT ITERATION###
{'max_depth': 4, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1425, 'max_features': 3}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98381
Average precision: 0.98044
Average recall: 0.81137
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98391
Average precision: 0.94643
Average recall: 0.80700

#### NEXT ITERATION###
{'max_depth': 4, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1425, 'max_features': 4}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98668
Average precision: 0.98390
Average recall: 0.81428
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98677
Average precision: 0.95563
Average recall: 0.80668

#### NEXT ITERATION###
{'max_depth': 4, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1425, 'max_features': 5}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.79301
```

```
Average precision: 0.82581
Average recall: 0.98083
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.79180
Average precision: 0.62231
Average recall: 0.97418

#### NEXT ITERATION###
{'max_depth': 4, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1225, 'max_features': 2}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.89003
Average precision: 0.89234
Average recall: 0.91087
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.88956
Average precision: 0.73643
Average recall: 0.88066

#### NEXT ITERATION###
{'max_depth': 4, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1225, 'max_features': 3}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.97821
Average precision: 0.97489
Average recall: 0.84579
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.97851
Average precision: 0.93219
Average recall: 0.84100

#### NEXT ITERATION###
{'max_depth': 4, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1225, 'max_features': 4}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98119
Average precision: 0.97833
Average recall: 0.84892
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98137
Average precision: 0.94095
Average recall: 0.84289

#### NEXT ITERATION###
{'max_depth': 4, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1225, 'max_features': 5}
SMOTEing and Randomly Undersampling
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Average precision: 0.62231
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{'max_depth': 4, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1325, 'max_features': 2}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.89373
Average precision: 0.89390
Average recall: 0.89475
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.89309
Average precision: 0.73832
Average recall: 0.86114

#### NEXT ITERATION###
{'max_depth': 4, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1325, 'max_features': 3}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98108
Average precision: 0.97768
Average recall: 0.82869
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98104
Average precision: 0.93870
Average recall: 0.82558

#### NEXT ITERATION###
{'max_depth': 4, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1325, 'max_features': 4}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98408
Average precision: 0.98122
Average recall: 0.83150
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98391
Average precision: 0.94762
Average recall: 0.82526

#### NEXT ITERATION###
{'max_depth': 4, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
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Average precision: 0.97489
Average recall: 0.84579
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.97851
Average precision: 0.93219
Average recall: 0.84100

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Average precision: 0.94095
Average recall: 0.84289

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Average precision: 0.89390
Average recall: 0.89475
###VAL###
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CV results for Tuned_DT_Model model:Average specificity: 0.89309
Average precision: 0.73832
Average recall: 0.86114

#### NEXT ITERATION###
{'max_depth': 4, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
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CV results for Tuned_DT_Model model:Average specificity: 0.98108
Average precision: 0.97768
Average recall: 0.82869
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98104
Average precision: 0.93870
Average recall: 0.82558

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###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98391
Average precision: 0.94762
Average recall: 0.82526

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Average recall: 0.87833
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.89673
Average precision: 0.74059
Average recall: 0.84130
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#### NEXT ITERATION###
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###TRAIN###
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Average precision: 0.98044
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###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98391
Average precision: 0.94643
Average recall: 0.80700

#### NEXT ITERATION###
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###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98677
Average precision: 0.95563
Average recall: 0.80668

#### NEXT ITERATION###
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#### NEXT ITERATION###
{'max_depth': 4, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
s_leaf': 0.1225, 'max_features': 2}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.89003
Average precision: 0.89234
Average recall: 0.91087
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.88956
Average precision: 0.73643
Average recall: 0.88066

#### NEXT ITERATION###
{'max_depth': 4, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
s_leaf': 0.1225, 'max_features': 3}
SMOTEing and Randomly Undersampling
```

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###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.97821
Average precision: 0.97489
Average recall: 0.84579
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.97851
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#### NEXT ITERATION###
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SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98119
Average precision: 0.97833
Average recall: 0.84892
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98137
Average precision: 0.94095
Average recall: 0.84289

#### NEXT ITERATION###
{'max_depth': 4, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
s_leaf': 0.1225, 'max_features': 5}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.79301
Average precision: 0.82581
Average recall: 0.98083
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.79180
Average precision: 0.62231
Average recall: 0.97418

#### NEXT ITERATION###
{'max_depth': 4, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
s_leaf': 0.1325, 'max_features': 2}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.89373
Average precision: 0.89390
Average recall: 0.89475
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.89309
Average precision: 0.73832
Average recall: 0.86114

#### NEXT ITERATION###
{'max_depth': 4, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
s_leaf': 0.1325, 'max_features': 3}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98108
Average precision: 0.97768
Average recall: 0.82869
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###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98104
Average precision: 0.93870
Average recall: 0.82558

#### NEXT ITERATION###
{'max_depth': 4, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
s_leaf': 0.1325, 'max_features': 4}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98408
Average precision: 0.98122
Average recall: 0.83150
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98391
Average precision: 0.94762
Average recall: 0.82526

#### NEXT ITERATION###
{'max_depth': 4, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
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SMOTEing and Randomly Undersampling
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Average precision: 0.82581
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###VAL###
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#### NEXT ITERATION###
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SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.89742
Average precision: 0.89549
Average recall: 0.87833
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.89673
Average precision: 0.74059
Average recall: 0.84130

#### NEXT ITERATION###
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SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98381
Average precision: 0.98044
Average recall: 0.81137
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98391
Average precision: 0.94643
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#### NEXT ITERATION###
{'max_depth': 4, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
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###VAL###
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#### NEXT ITERATION###
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Average recall: 0.98083
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.79180
Average precision: 0.62231
Average recall: 0.97418

#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1225, 'max_features': 2}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.89003
Average precision: 0.89234
Average recall: 0.91087
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.88956
Average precision: 0.73643
Average recall: 0.88066

#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1225, 'max_features': 3}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.97821
Average precision: 0.97489
Average recall: 0.84579
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.97851
Average precision: 0.93219
Average recall: 0.84100

#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1225, 'max_features': 4}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98119
Average precision: 0.97833
Average recall: 0.84892
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98137
Average precision: 0.94095
Average recall: 0.84289

#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
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s_leaf': 0.1225, 'max_features': 5}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.79301
Average precision: 0.82581
Average recall: 0.98083
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.79180
Average precision: 0.62231
Average recall: 0.97418

#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1325, 'max_features': 2}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.89373
Average precision: 0.89390
Average recall: 0.89475
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.89309
Average precision: 0.73832
Average recall: 0.86114

#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1325, 'max_features': 3}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98108
Average precision: 0.97768
Average recall: 0.82869
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98104
Average precision: 0.93870
Average recall: 0.82558

#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1325, 'max_features': 4}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98408
Average precision: 0.98122
Average recall: 0.83150
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98391
Average precision: 0.94762
Average recall: 0.82526

#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1325, 'max_features': 5}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.79301
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Average precision: 0.82581
Average recall: 0.98083
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.79180
Average precision: 0.62231
Average recall: 0.97418

#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1425, 'max_features': 2}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.89742
Average precision: 0.89549
Average recall: 0.87833
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.89673
Average precision: 0.74059
Average recall: 0.84130

#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1425, 'max_features': 3}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98381
Average precision: 0.98044
Average recall: 0.81137
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98391
Average precision: 0.94643
Average recall: 0.80700

#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1425, 'max_features': 4}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98668
Average precision: 0.98390
Average recall: 0.81428
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98677
Average precision: 0.95563
Average recall: 0.80668

#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1425, 'max_features': 5}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.79301
Average precision: 0.82581
Average recall: 0.98083
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.79180
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Average precision: 0.62231
Average recall: 0.97418

#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1225, 'max_features': 2}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.89003
Average precision: 0.89234
Average recall: 0.91087
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.88956
Average precision: 0.73643
Average recall: 0.88066

#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1225, 'max_features': 3}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.97821
Average precision: 0.97489
Average recall: 0.84579
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.97851
Average precision: 0.93219
Average recall: 0.84100

#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1225, 'max_features': 4}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98119
Average precision: 0.97833
Average recall: 0.84892
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98137
Average precision: 0.94095
Average recall: 0.84289

#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1225, 'max_features': 5}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.79301
Average precision: 0.82581
Average recall: 0.98083
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.79180
Average precision: 0.62231
Average recall: 0.97418

#### NEXT ITERATION###
```

```
{'max_depth': 5, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1325, 'max_features': 2}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.89373
Average precision: 0.89390
Average recall: 0.89475
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.89309
Average precision: 0.73832
Average recall: 0.86114

#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1325, 'max_features': 3}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98108
Average precision: 0.97768
Average recall: 0.82869
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98104
Average precision: 0.93870
Average recall: 0.82558

#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1325, 'max_features': 4}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98408
Average precision: 0.98122
Average recall: 0.83150
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98391
Average precision: 0.94762
Average recall: 0.82526

#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1325, 'max_features': 5}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.79301
Average precision: 0.82581
Average recall: 0.98083
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.79180
Average precision: 0.62231
Average recall: 0.97418

#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1425, 'max_features': 2}
SMOTEing and Randomly Undersampling
###TRAIN###
```

```
CV results for Tuned_DT_Model model:Average specificity: 0.89742
Average precision: 0.89549
Average recall: 0.87833
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.89673
Average precision: 0.74059
Average recall: 0.84130

#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1425, 'max_features': 3}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98381
Average precision: 0.98044
Average recall: 0.81137
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98391
Average precision: 0.94643
Average recall: 0.80700

#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1425, 'max_features': 4}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98668
Average precision: 0.98390
Average recall: 0.81428
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98677
Average precision: 0.95563
Average recall: 0.80668

#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1425, 'max_features': 5}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.79301
Average precision: 0.82581
Average recall: 0.98083
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.79180
Average precision: 0.62231
Average recall: 0.97418

#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1225, 'max_features': 2}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.89003
Average precision: 0.89234
Average recall: 0.91087
###VAL###
```

```
CV results for Tuned_DT_Model model:Average specificity: 0.88956
Average precision: 0.73643
Average recall: 0.88066

#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1225, 'max_features': 3}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.97821
Average precision: 0.97489
Average recall: 0.84579
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.97851
Average precision: 0.93219
Average recall: 0.84100

#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1225, 'max_features': 4}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98119
Average precision: 0.97833
Average recall: 0.84892
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98137
Average precision: 0.94095
Average recall: 0.84289

#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1225, 'max_features': 5}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.79301
Average precision: 0.82581
Average recall: 0.98083
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.79180
Average precision: 0.62231
Average recall: 0.97418

#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1325, 'max_features': 2}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.89373
Average precision: 0.89390
Average recall: 0.89475
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.89309
Average precision: 0.73832
Average recall: 0.86114
```

```
#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1325, 'max_features': 3}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98108
Average precision: 0.97768
Average recall: 0.82869
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98104
Average precision: 0.93870
Average recall: 0.82558

#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1325, 'max_features': 4}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98408
Average precision: 0.98122
Average recall: 0.83150
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98391
Average precision: 0.94762
Average recall: 0.82526

#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1325, 'max_features': 5}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.79301
Average precision: 0.82581
Average recall: 0.98083
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.79180
Average precision: 0.62231
Average recall: 0.97418

#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1425, 'max_features': 2}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.89742
Average precision: 0.89549
Average recall: 0.87833
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.89673
Average precision: 0.74059
Average recall: 0.84130

#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1425, 'max_features': 3}
SMOTEing and Randomly Undersampling
```

```
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98381
Average precision: 0.98044
Average recall: 0.81137
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98391
Average precision: 0.94643
Average recall: 0.80700

#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1425, 'max_features': 4}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98668
Average precision: 0.98390
Average recall: 0.81428
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98677
Average precision: 0.95563
Average recall: 0.80668

#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1425, 'max_features': 5}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.79301
Average precision: 0.82581
Average recall: 0.98083
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.79180
Average precision: 0.62231
Average recall: 0.97418

#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1225, 'max_features': 2}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.89003
Average precision: 0.89234
Average recall: 0.91087
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.88956
Average precision: 0.73643
Average recall: 0.88066

#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1225, 'max_features': 3}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.97821
Average precision: 0.97489
Average recall: 0.84579
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```
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.97851
Average precision: 0.93219
Average recall: 0.84100

#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1225, 'max_features': 4}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98119
Average precision: 0.97833
Average recall: 0.84892
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98137
Average precision: 0.94095
Average recall: 0.84289

#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1225, 'max_features': 5}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.79301
Average precision: 0.82581
Average recall: 0.98083
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.79180
Average precision: 0.62231
Average recall: 0.97418

#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1325, 'max_features': 2}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.89373
Average precision: 0.89390
Average recall: 0.89475
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.89309
Average precision: 0.73832
Average recall: 0.86114

#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1325, 'max_features': 3}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98108
Average precision: 0.97768
Average recall: 0.82869
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98104
Average precision: 0.93870
Average recall: 0.82558
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```
#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1325, 'max_features': 4}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98408
Average precision: 0.98122
Average recall: 0.83150
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98391
Average precision: 0.94762
Average recall: 0.82526

#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1325, 'max_features': 5}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.79301
Average precision: 0.82581
Average recall: 0.98083
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.79180
Average precision: 0.62231
Average recall: 0.97418

#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1425, 'max_features': 2}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.89742
Average precision: 0.89549
Average recall: 0.87833
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.89673
Average precision: 0.74059
Average recall: 0.84130

#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1425, 'max_features': 3}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98381
Average precision: 0.98044
Average recall: 0.81137
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98391
Average precision: 0.94643
Average recall: 0.80700

#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1425, 'max_features': 4}
```

```
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98668
Average precision: 0.98390
Average recall: 0.81428
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98677
Average precision: 0.95563
Average recall: 0.80668

#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1425, 'max_features': 5}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.79301
Average precision: 0.82581
Average recall: 0.98083
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.79180
Average precision: 0.62231
Average recall: 0.97418

#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
s_leaf': 0.1225, 'max_features': 2}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.89003
Average precision: 0.89234
Average recall: 0.91087
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.88956
Average precision: 0.73643
Average recall: 0.88066

#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
s_leaf': 0.1225, 'max_features': 3}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.97821
Average precision: 0.97489
Average recall: 0.84579
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.97851
Average precision: 0.93219
Average recall: 0.84100

#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
s_leaf': 0.1225, 'max_features': 4}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98119
Average precision: 0.97833
```

```
Average recall: 0.84892
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98137
Average precision: 0.94095
Average recall: 0.84289

#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
s_leaf': 0.1225, 'max_features': 5}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.79301
Average precision: 0.82581
Average recall: 0.98083
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.79180
Average precision: 0.62231
Average recall: 0.97418

#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
s_leaf': 0.1325, 'max_features': 2}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.89373
Average precision: 0.89390
Average recall: 0.89475
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.89309
Average precision: 0.73832
Average recall: 0.86114

#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
s_leaf': 0.1325, 'max_features': 3}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98108
Average precision: 0.97768
Average recall: 0.82869
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98104
Average precision: 0.93870
Average recall: 0.82558

#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
s_leaf': 0.1325, 'max_features': 4}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98408
Average precision: 0.98122
Average recall: 0.83150
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98391
Average precision: 0.94762
```

```
Average recall: 0.82526

#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
s_leaf': 0.1325, 'max_features': 5}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.79301
Average precision: 0.82581
Average recall: 0.98083
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.79180
Average precision: 0.62231
Average recall: 0.97418

#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
s_leaf': 0.1425, 'max_features': 2}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.89742
Average precision: 0.89549
Average recall: 0.87833
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.89673
Average precision: 0.74059
Average recall: 0.84130

#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
s_leaf': 0.1425, 'max_features': 3}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98381
Average precision: 0.98044
Average recall: 0.81137
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98391
Average precision: 0.94643
Average recall: 0.80700

#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
s_leaf': 0.1425, 'max_features': 4}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98668
Average precision: 0.98390
Average recall: 0.81428
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98677
Average precision: 0.95563
Average recall: 0.80668

#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
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s_leaf': 0.1425, 'max_features': 5}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.79301
Average precision: 0.82581
Average recall: 0.98083
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.79180
Average precision: 0.62231
Average recall: 0.97418

#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
s_leaf': 0.1225, 'max_features': 2}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.89003
Average precision: 0.89234
Average recall: 0.91087
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.88956
Average precision: 0.73643
Average recall: 0.88066

#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
s_leaf': 0.1225, 'max_features': 3}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.97821
Average precision: 0.97489
Average recall: 0.84579
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.97851
Average precision: 0.93219
Average recall: 0.84100

#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
s_leaf': 0.1225, 'max_features': 4}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98119
Average precision: 0.97833
Average recall: 0.84892
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98137
Average precision: 0.94095
Average recall: 0.84289

#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
s_leaf': 0.1225, 'max_features': 5}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.79301
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Average precision: 0.82581
Average recall: 0.98083
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.79180
Average precision: 0.62231
Average recall: 0.97418

#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
s_leaf': 0.1325, 'max_features': 2}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.89373
Average precision: 0.89390
Average recall: 0.89475
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.89309
Average precision: 0.73832
Average recall: 0.86114

#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
s_leaf': 0.1325, 'max_features': 3}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98108
Average precision: 0.97768
Average recall: 0.82869
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98104
Average precision: 0.93870
Average recall: 0.82558

#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
s_leaf': 0.1325, 'max_features': 4}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98408
Average precision: 0.98122
Average recall: 0.83150
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98391
Average precision: 0.94762
Average recall: 0.82526

#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
s_leaf': 0.1325, 'max_features': 5}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.79301
Average precision: 0.82581
Average recall: 0.98083
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.79180
```

```
Average precision: 0.62231
Average recall: 0.97418

#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
s_leaf': 0.1425, 'max_features': 2}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.89742
Average precision: 0.89549
Average recall: 0.87833
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.89673
Average precision: 0.74059
Average recall: 0.84130

#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
s_leaf': 0.1425, 'max_features': 3}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98381
Average precision: 0.98044
Average recall: 0.81137
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98391
Average precision: 0.94643
Average recall: 0.80700

#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
s_leaf': 0.1425, 'max_features': 4}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98668
Average precision: 0.98390
Average recall: 0.81428
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98677
Average precision: 0.95563
Average recall: 0.80668

#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
s_leaf': 0.1425, 'max_features': 5}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.79301
Average precision: 0.82581
Average recall: 0.98083
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.79180
Average precision: 0.62231
Average recall: 0.97418

#### NEXT ITERATION###
```

```
{'max_depth': 5, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1225, 'max_features': 2}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.89003
Average precision: 0.89234
Average recall: 0.91087
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.88956
Average precision: 0.73643
Average recall: 0.88066

#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1225, 'max_features': 3}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.97821
Average precision: 0.97489
Average recall: 0.84579
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.97851
Average precision: 0.93219
Average recall: 0.84100

#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1225, 'max_features': 4}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98119
Average precision: 0.97833
Average recall: 0.84892
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98137
Average precision: 0.94095
Average recall: 0.84289

#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1225, 'max_features': 5}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.79301
Average precision: 0.82581
Average recall: 0.98083
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.79180
Average precision: 0.62231
Average recall: 0.97418

#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1325, 'max_features': 2}
SMOTEing and Randomly Undersampling
###TRAIN###
```

```
CV results for Tuned_DT_Model model:Average specificity: 0.89373
Average precision: 0.89390
Average recall: 0.89475
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.89309
Average precision: 0.73832
Average recall: 0.86114

#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1325, 'max_features': 3}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98108
Average precision: 0.97768
Average recall: 0.82869
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98104
Average precision: 0.93870
Average recall: 0.82558

#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1325, 'max_features': 4}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98408
Average precision: 0.98122
Average recall: 0.83150
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98391
Average precision: 0.94762
Average recall: 0.82526

#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1325, 'max_features': 5}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.79301
Average precision: 0.82581
Average recall: 0.98083
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.79180
Average precision: 0.62231
Average recall: 0.97418

#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1425, 'max_features': 2}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.89742
Average precision: 0.89549
Average recall: 0.87833
###VAL###
```

```
CV results for Tuned_DT_Model model:Average specificity: 0.89673
Average precision: 0.74059
Average recall: 0.84130

#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1425, 'max_features': 3}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98381
Average precision: 0.98044
Average recall: 0.81137
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98391
Average precision: 0.94643
Average recall: 0.80700

#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1425, 'max_features': 4}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98668
Average precision: 0.98390
Average recall: 0.81428
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98677
Average precision: 0.95563
Average recall: 0.80668

#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1425, 'max_features': 5}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.79301
Average precision: 0.82581
Average recall: 0.98083
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.79180
Average precision: 0.62231
Average recall: 0.97418

#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1225, 'max_features': 2}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.89003
Average precision: 0.89234
Average recall: 0.91087
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.88956
Average precision: 0.73643
Average recall: 0.88066
```

```
#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1225, 'max_features': 3}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.97821
Average precision: 0.97489
Average recall: 0.84579
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.97851
Average precision: 0.93219
Average recall: 0.84100

#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1225, 'max_features': 4}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98119
Average precision: 0.97833
Average recall: 0.84892
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98137
Average precision: 0.94095
Average recall: 0.84289

#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1225, 'max_features': 5}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.79301
Average precision: 0.82581
Average recall: 0.98083
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.79180
Average precision: 0.62231
Average recall: 0.97418

#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1325, 'max_features': 2}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.89373
Average precision: 0.89390
Average recall: 0.89475
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.89309
Average precision: 0.73832
Average recall: 0.86114

#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1325, 'max_features': 3}
SMOTEing and Randomly Undersampling
```

```
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98108
Average precision: 0.97768
Average recall: 0.82869
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98104
Average precision: 0.93870
Average recall: 0.82558

#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1325, 'max_features': 4}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98408
Average precision: 0.98122
Average recall: 0.83150
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98391
Average precision: 0.94762
Average recall: 0.82526

#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1325, 'max_features': 5}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.79301
Average precision: 0.82581
Average recall: 0.98083
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.79180
Average precision: 0.62231
Average recall: 0.97418

#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1425, 'max_features': 2}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.89742
Average precision: 0.89549
Average recall: 0.87833
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.89673
Average precision: 0.74059
Average recall: 0.84130

#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1425, 'max_features': 3}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98381
Average precision: 0.98044
Average recall: 0.81137
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```
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98391
Average precision: 0.94643
Average recall: 0.80700

#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1425, 'max_features': 4}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98668
Average precision: 0.98390
Average recall: 0.81428
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98677
Average precision: 0.95563
Average recall: 0.80668

#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1425, 'max_features': 5}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.79301
Average precision: 0.82581
Average recall: 0.98083
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.79180
Average precision: 0.62231
Average recall: 0.97418

#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1225, 'max_features': 2}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.89003
Average precision: 0.89234
Average recall: 0.91087
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.88956
Average precision: 0.73643
Average recall: 0.88066

#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1225, 'max_features': 3}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.97821
Average precision: 0.97489
Average recall: 0.84579
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.97851
Average precision: 0.93219
Average recall: 0.84100
```

```
#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1225, 'max_features': 4}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98119
Average precision: 0.97833
Average recall: 0.84892
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98137
Average precision: 0.94095
Average recall: 0.84289

#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1225, 'max_features': 5}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.79301
Average precision: 0.82581
Average recall: 0.98083
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.79180
Average precision: 0.62231
Average recall: 0.97418

#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1325, 'max_features': 2}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.89373
Average precision: 0.89390
Average recall: 0.89475
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.89309
Average precision: 0.73832
Average recall: 0.86114

#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1325, 'max_features': 3}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98108
Average precision: 0.97768
Average recall: 0.82869
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98104
Average precision: 0.93870
Average recall: 0.82558

#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1325, 'max_features': 4}
```

```
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98408
Average precision: 0.98122
Average recall: 0.83150
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98391
Average precision: 0.94762
Average recall: 0.82526

#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1325, 'max_features': 5}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.79301
Average precision: 0.82581
Average recall: 0.98083
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.79180
Average precision: 0.62231
Average recall: 0.97418

#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1425, 'max_features': 2}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.89742
Average precision: 0.89549
Average recall: 0.87833
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.89673
Average precision: 0.74059
Average recall: 0.84130

#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1425, 'max_features': 3}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98381
Average precision: 0.98044
Average recall: 0.81137
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98391
Average precision: 0.94643
Average recall: 0.80700

#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1425, 'max_features': 4}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98668
Average precision: 0.98390
```

```
Average recall: 0.81428
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98677
Average precision: 0.95563
Average recall: 0.80668

#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1425, 'max_features': 5}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.79301
Average precision: 0.82581
Average recall: 0.98083
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.79180
Average precision: 0.62231
Average recall: 0.97418

#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1225, 'max_features': 2}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.89003
Average precision: 0.89234
Average recall: 0.91087
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.88956
Average precision: 0.73643
Average recall: 0.88066

#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1225, 'max_features': 3}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.97821
Average precision: 0.97489
Average recall: 0.84579
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.97851
Average precision: 0.93219
Average recall: 0.84100

#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1225, 'max_features': 4}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98119
Average precision: 0.97833
Average recall: 0.84892
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98137
Average precision: 0.94095
```

```
Average recall: 0.84289

#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1225, 'max_features': 5}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.79301
Average precision: 0.82581
Average recall: 0.98083
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.79180
Average precision: 0.62231
Average recall: 0.97418

#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1325, 'max_features': 2}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.89373
Average precision: 0.89390
Average recall: 0.89475
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.89309
Average precision: 0.73832
Average recall: 0.86114

#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1325, 'max_features': 3}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98108
Average precision: 0.97768
Average recall: 0.82869
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98104
Average precision: 0.93870
Average recall: 0.82558

#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1325, 'max_features': 4}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98408
Average precision: 0.98122
Average recall: 0.83150
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98391
Average precision: 0.94762
Average recall: 0.82526

#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
```

```
_leaf': 0.1325, 'max_features': 5}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.79301
Average precision: 0.82581
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###VAL###
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Average precision: 0.89549
Average recall: 0.87833
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.89673
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Average recall: 0.84130

#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1425, 'max_features': 3}
SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98381
Average precision: 0.98044
Average recall: 0.81137
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98391
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Average recall: 0.80700

#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
_leaf': 0.1425, 'max_features': 4}
SMOTEing and Randomly Undersampling
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Average precision: 0.98390
Average recall: 0.81428
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98677
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Average recall: 0.80668

#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples
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SMOTEing and Randomly Undersampling
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Average precision: 0.82581
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#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
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SMOTEing and Randomly Undersampling
###TRAIN###
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Average precision: 0.89234
Average recall: 0.91087
###VAL###
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Average precision: 0.73643
Average recall: 0.88066

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{'max_depth': 5, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
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SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.97821
Average precision: 0.97489
Average recall: 0.84579
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.97851
Average precision: 0.93219
Average recall: 0.84100

#### NEXT ITERATION###
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SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98119
Average precision: 0.97833
Average recall: 0.84892
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98137
Average precision: 0.94095
Average recall: 0.84289

#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
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###VAL###
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Average precision: 0.62231
Average recall: 0.97418

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SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.89373
Average precision: 0.89390
Average recall: 0.89475
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.89309
Average precision: 0.73832
Average recall: 0.86114

#### NEXT ITERATION###
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Average precision: 0.98122
Average recall: 0.83150
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98391
Average precision: 0.94762
Average recall: 0.82526

#### NEXT ITERATION###
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###VAL###
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Average recall: 0.97418

#### NEXT ITERATION###
```

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{'max_depth': 5, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
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###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.89742
Average precision: 0.89549
Average recall: 0.87833
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.89673
Average precision: 0.74059
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#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
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SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98381
Average precision: 0.98044
Average recall: 0.81137
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98391
Average precision: 0.94643
Average recall: 0.80700

#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
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###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98668
Average precision: 0.98390
Average recall: 0.81428
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98677
Average precision: 0.95563
Average recall: 0.80668

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#### NEXT ITERATION###
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SMOTEing and Randomly Undersampling
###TRAIN###
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###VAL###
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Average precision: 0.73643
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#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
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SMOTEing and Randomly Undersampling
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98119
Average precision: 0.97833
Average recall: 0.84892
###VAL###
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Average precision: 0.94095
Average recall: 0.84289

#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
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Average recall: 0.89475
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CV results for Tuned_DT_Model model:Average specificity: 0.89309
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#### NEXT ITERATION###
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SMOTEing and Randomly Undersampling
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Average precision: 0.97768
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###VAL###
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s_leaf': 0.1325, 'max_features': 4}
SMOTEing and Randomly Undersampling
###TRAIN###
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###VAL###
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#### NEXT ITERATION###
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SMOTEing and Randomly Undersampling
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###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.89673
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Average recall: 0.84130
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#### NEXT ITERATION###
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#### NEXT ITERATION###
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###TRAIN###
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Average recall: 0.81428
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98677
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#### NEXT ITERATION###
{'max_depth': 5, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_sample
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SMOTEing and Randomly Undersampling
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Average precision: 0.82581
Average recall: 0.98083
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.79180
Average precision: 0.62231
Average recall: 0.97418

#### NEXT ITERATION###
```

In [23]:

```
#merge the outputted data from the two lists into one data frame
dt_metrics_df= pd.DataFrame(dt_metric_tracker)
dt_data_scaler_df= pd.DataFrame(dt_data_and_scaler)
dt_tuned_results_df = pd.merge(dt_metrics_df, dt_data_scaler_df, left_index=

#print the length of the new data frame so we know how many model variations
print(len(dt_tuned_results_df))

#update the column names of the dataset so they make sense
dt_new_col_names= ['v_avg_spec', 'v_avg_prec', 'v_avg_rec', 'v_hyp_para', 's
dt_tuned_results_df.columns= dt_new_col_names

#preview the new dataset
dt_tuned_results_df.head()
```

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Out[23]:

	v_avg_spec	v_avg_prec	v_avg_rec	v_hyp_para	scaler	v_SM_RU	no
0	0.889562	0.736433	0.880659	{'max_depth': 2, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 2}	False	True	
1	0.978508	0.932186	0.841001	{'max_depth': 2, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 3}	False	True	
2	0.981374	0.940948	0.842891	{'max_depth': 2, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 4}	False	True	
3	0.791801	0.622309	0.974177	{'max_depth': 2, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 5}	False	True	
4	0.893090	0.738324	0.861139	{'max_depth': 2, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 2}	False	True	

In [24]:

```
#sort by highest precision rate
dt_tuned_grid_search_prec_sorted = dt_tuned_results_df.sort_values(\
    by=['v_avg_prec', 'v_avg_spec', 'v_avg_rec'], ascending=[False, False, F

dt_tuned_grid_search_prec_sorted
```

Out[24]:

	v_avg_spec	v_avg_prec	v_avg_rec	v_hyp_para	scaler	v_SM_RU
10	0.986774	0.955633	0.806682	{'max_depth': 2, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 4}	False	True
22	0.986774	0.955633	0.806682	{'max_depth': 2, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 4}	False	True
34	0.986774	0.955633	0.806682	{'max_depth': 2, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 4}	False	True
46	0.986774	0.955633	0.806682	{'max_depth': 2, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 4}	False	True
58	0.986774	0.955633	0.806682	{'max_depth': 2, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 4}	False	True
70	0.986774	0.955633	0.806682	{'max_depth': 2, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 4}	False	True
82	0.986774	0.955633	0.806682	{'max_depth': 2, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 4}	False	True
94	0.986774	0.955633	0.806682	{'max_depth': 2, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf':	False	True

	v_avg_spec	v_avg_prec	v_avg_rec	v_hyp_para	scaler	v_SM_RU
				0.1425, 'max_features': 4}		
106	0.986774	0.955633	0.806682	{'max_depth': 2, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 4}	False	True
118	0.986774	0.955633	0.806682	{'max_depth': 2, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 4}	False	True
130	0.986774	0.955633	0.806682	{'max_depth': 2, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 4}	False	True
142	0.986774	0.955633	0.806682	{'max_depth': 2, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 4}	False	True
154	0.986774	0.955633	0.806682	{'max_depth': 3, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 4}	False	True
166	0.986774	0.955633	0.806682	{'max_depth': 3, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 4}	False	True
178	0.986774	0.955633	0.806682	{'max_depth': 3, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 4}	False	True
190	0.986774	0.955633	0.806682	{'max_depth': 3, 'min_samples_split': 0.1, 'criterion': 'gini',	False	True

	v_avg_spec	v_avg_prec	v_avg_rec	v_hyp_para	scaler	v_SM_RU
				'min_samples_leaf': 0.1425, 'max_features': 4}		
202	0.986774	0.955633	0.806682	{'max_depth': 3, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 4}	False	True
214	0.986774	0.955633	0.806682	{'max_depth': 3, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 4}	False	True
226	0.986774	0.955633	0.806682	{'max_depth': 3, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 4}	False	True
238	0.986774	0.955633	0.806682	{'max_depth': 3, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 4}	False	True
250	0.986774	0.955633	0.806682	{'max_depth': 3, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 4}	False	True
262	0.986774	0.955633	0.806682	{'max_depth': 3, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 4}	False	True
274	0.986774	0.955633	0.806682	{'max_depth': 3, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 4}	False	True
286	0.986774	0.955633	0.806682	{'max_depth': 3, 'min_samples_split': 0.15, 'criterion':	False	True

	v_avg_spec	v_avg_prec	v_avg_rec	v_hyp_para	scaler	v_SM_RU
				'gini', 'min_samples_leaf': 0.1425, 'max_features': 4}		
298	0.986774	0.955633	0.806682	{'max_depth': 4, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 4}	False	True
310	0.986774	0.955633	0.806682	{'max_depth': 4, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 4}	False	True
322	0.986774	0.955633	0.806682	{'max_depth': 4, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 4}	False	True
334	0.986774	0.955633	0.806682	{'max_depth': 4, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 4}	False	True
346	0.986774	0.955633	0.806682	{'max_depth': 4, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 4}	False	True
358	0.986774	0.955633	0.806682	{'max_depth': 4, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 4}	False	True
370	0.986774	0.955633	0.806682	{'max_depth': 4, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 4}	False	True
382	0.986774	0.955633	0.806682	{'max_depth': 4, 'min_samples_split':	False	True

	v_avg_spec	v_avg_prec	v_avg_rec	v_hyp_para	scaler	v_SM_RU
				0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 4}		
394	0.986774	0.955633	0.806682	{'max_depth': 4, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 4}	False	True
406	0.986774	0.955633	0.806682	{'max_depth': 4, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 4}	False	True
418	0.986774	0.955633	0.806682	{'max_depth': 4, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 4}	False	True
430	0.986774	0.955633	0.806682	{'max_depth': 4, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 4}	False	True
442	0.986774	0.955633	0.806682	{'max_depth': 5, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 4}	False	True
454	0.986774	0.955633	0.806682	{'max_depth': 5, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 4}	False	True
466	0.986774	0.955633	0.806682	{'max_depth': 5, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 4}	False	True

	v_avg_spec	v_avg_prec	v_avg_rec	v_hyp_para	scaler	v_SM_RU
478	0.986774	0.955633	0.806682	{'max_depth': 5, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 4}	False	True
490	0.986774	0.955633	0.806682	{'max_depth': 5, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 4}	False	True
502	0.986774	0.955633	0.806682	{'max_depth': 5, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 4}	False	True
514	0.986774	0.955633	0.806682	{'max_depth': 5, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 4}	False	True
526	0.986774	0.955633	0.806682	{'max_depth': 5, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 4}	False	True
538	0.986774	0.955633	0.806682	{'max_depth': 5, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 4}	False	True
550	0.986774	0.955633	0.806682	{'max_depth': 5, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 4}	False	True
562	0.986774	0.955633	0.806682	{'max_depth': 5, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf':	False	True

	v_avg_spec	v_avg_prec	v_avg_rec	v_hyp_para	scaler	v_SM_RU
				0.1425, 'max_features': 4}		
574	0.986774	0.955633	0.806682	{'max_depth': 5, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 4}	False	True
6	0.983909	0.947625	0.825255	{'max_depth': 2, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 4}	False	True
18	0.983909	0.947625	0.825255	{'max_depth': 2, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 4}	False	True
30	0.983909	0.947625	0.825255	{'max_depth': 2, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 4}	False	True
42	0.983909	0.947625	0.825255	{'max_depth': 2, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 4}	False	True
54	0.983909	0.947625	0.825255	{'max_depth': 2, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 4}	False	True
66	0.983909	0.947625	0.825255	{'max_depth': 2, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 4}	False	True
78	0.983909	0.947625	0.825255	{'max_depth': 2, 'min_samples_split': 0.05, 'criterion': 'gini',	False	True

	v_avg_spec	v_avg_prec	v_avg_rec	v_hyp_para	scaler	v_SM_RU
				'min_samples_leaf': 0.1325, 'max_features': 4}		
90	0.983909	0.947625	0.825255	{'max_depth': 2, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 4}	False	True
102	0.983909	0.947625	0.825255	{'max_depth': 2, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 4}	False	True
114	0.983909	0.947625	0.825255	{'max_depth': 2, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 4}	False	True
126	0.983909	0.947625	0.825255	{'max_depth': 2, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 4}	False	True
138	0.983909	0.947625	0.825255	{'max_depth': 2, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 4}	False	True
150	0.983909	0.947625	0.825255	{'max_depth': 3, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 4}	False	True
162	0.983909	0.947625	0.825255	{'max_depth': 3, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 4}	False	True
174	0.983909	0.947625	0.825255	{'max_depth': 3, 'min_samples_split': 0.1, 'criterion':	False	True

	v_avg_spec	v_avg_prec	v_avg_rec	v_hyp_para	scaler	v_SM_RU
				'gini', 'min_samples_leaf': 0.1325, 'max_features': 4}		
186	0.983909	0.947625	0.825255	{'max_depth': 3, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 4}	False	True
198	0.983909	0.947625	0.825255	{'max_depth': 3, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 4}	False	True
210	0.983909	0.947625	0.825255	{'max_depth': 3, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 4}	False	True
222	0.983909	0.947625	0.825255	{'max_depth': 3, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 4}	False	True
234	0.983909	0.947625	0.825255	{'max_depth': 3, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 4}	False	True
246	0.983909	0.947625	0.825255	{'max_depth': 3, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 4}	False	True
258	0.983909	0.947625	0.825255	{'max_depth': 3, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 4}	False	True
270	0.983909	0.947625	0.825255	{'max_depth': 3, 'min_samples_split':	False	True

	v_avg_spec	v_avg_prec	v_avg_rec	v_hyp_para	scaler	v_SM_RU
				0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 4}		
282	0.983909	0.947625	0.825255	{'max_depth': 3, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 4}	False	True
294	0.983909	0.947625	0.825255	{'max_depth': 4, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 4}	False	True
306	0.983909	0.947625	0.825255	{'max_depth': 4, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 4}	False	True
318	0.983909	0.947625	0.825255	{'max_depth': 4, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 4}	False	True
330	0.983909	0.947625	0.825255	{'max_depth': 4, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 4}	False	True
342	0.983909	0.947625	0.825255	{'max_depth': 4, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 4}	False	True
354	0.983909	0.947625	0.825255	{'max_depth': 4, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 4}	False	True

	v_avg_spec	v_avg_prec	v_avg_rec	v_hyp_para	scaler	v_SM_RU
366	0.983909	0.947625	0.825255	{'max_depth': 4, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 4}	False	True
378	0.983909	0.947625	0.825255	{'max_depth': 4, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 4}	False	True
390	0.983909	0.947625	0.825255	{'max_depth': 4, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 4}	False	True
402	0.983909	0.947625	0.825255	{'max_depth': 4, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 4}	False	True
414	0.983909	0.947625	0.825255	{'max_depth': 4, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 4}	False	True
426	0.983909	0.947625	0.825255	{'max_depth': 4, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 4}	False	True
438	0.983909	0.947625	0.825255	{'max_depth': 5, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 4}	False	True
450	0.983909	0.947625	0.825255	{'max_depth': 5, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf':	False	True

	v_avg_spec	v_avg_prec	v_avg_rec	v_hyp_para	scaler	v_SM_RU
				0.1325, 'max_features': 4}		
462	0.983909	0.947625	0.825255	{'max_depth': 5, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 4}	False	True
474	0.983909	0.947625	0.825255	{'max_depth': 5, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 4}	False	True
486	0.983909	0.947625	0.825255	{'max_depth': 5, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 4}	False	True
498	0.983909	0.947625	0.825255	{'max_depth': 5, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 4}	False	True
510	0.983909	0.947625	0.825255	{'max_depth': 5, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 4}	False	True
522	0.983909	0.947625	0.825255	{'max_depth': 5, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 4}	False	True
534	0.983909	0.947625	0.825255	{'max_depth': 5, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 4}	False	True
546	0.983909	0.947625	0.825255	{'max_depth': 5, 'min_samples_split': 0.1, 'criterion': 'gini',	False	True

	v_avg_spec	v_avg_prec	v_avg_rec	v_hyp_para	scaler	v_SM_RU
				'min_samples_leaf': 0.1325, 'max_features': 4}		
558	0.983909	0.947625	0.825255	{'max_depth': 5, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 4}	False	True
570	0.983909	0.947625	0.825255	{'max_depth': 5, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 4}	False	True
9	0.983909	0.946426	0.806998	{'max_depth': 2, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 3}	False	True
21	0.983909	0.946426	0.806998	{'max_depth': 2, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 3}	False	True
33	0.983909	0.946426	0.806998	{'max_depth': 2, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 3}	False	True
45	0.983909	0.946426	0.806998	{'max_depth': 2, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 3}	False	True
57	0.983909	0.946426	0.806998	{'max_depth': 2, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 3}	False	True
69	0.983909	0.946426	0.806998	{'max_depth': 2, 'min_samples_split': 0.15, 'criterion':	False	True

	v_avg_spec	v_avg_prec	v_avg_rec	v_hyp_para	scaler	v_SM_RU
				'gini', 'min_samples_leaf': 0.1425, 'max_features': 3}		
81	0.983909	0.946426	0.806998	{'max_depth': 2, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 3}	False	True
93	0.983909	0.946426	0.806998	{'max_depth': 2, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 3}	False	True
105	0.983909	0.946426	0.806998	{'max_depth': 2, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 3}	False	True
117	0.983909	0.946426	0.806998	{'max_depth': 2, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 3}	False	True
129	0.983909	0.946426	0.806998	{'max_depth': 2, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 3}	False	True
141	0.983909	0.946426	0.806998	{'max_depth': 2, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 3}	False	True
153	0.983909	0.946426	0.806998	{'max_depth': 3, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 3}	False	True
165	0.983909	0.946426	0.806998	{'max_depth': 3, 'min_samples_split':	False	True

	v_avg_spec	v_avg_prec	v_avg_rec	v_hyp_para	scaler	v_SM_RU
				0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 3}		
177	0.983909	0.946426	0.806998	{'max_depth': 3, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 3}	False	True
189	0.983909	0.946426	0.806998	{'max_depth': 3, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 3}	False	True
201	0.983909	0.946426	0.806998	{'max_depth': 3, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 3}	False	True
213	0.983909	0.946426	0.806998	{'max_depth': 3, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 3}	False	True
225	0.983909	0.946426	0.806998	{'max_depth': 3, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 3}	False	True
237	0.983909	0.946426	0.806998	{'max_depth': 3, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 3}	False	True
249	0.983909	0.946426	0.806998	{'max_depth': 3, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 3}	False	True

	v_avg_spec	v_avg_prec	v_avg_rec	v_hyp_para	scaler	v_SM_RU
261	0.983909	0.946426	0.806998	{'max_depth': 3, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 3}	False	True
273	0.983909	0.946426	0.806998	{'max_depth': 3, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 3}	False	True
285	0.983909	0.946426	0.806998	{'max_depth': 3, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 3}	False	True
297	0.983909	0.946426	0.806998	{'max_depth': 4, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 3}	False	True
309	0.983909	0.946426	0.806998	{'max_depth': 4, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 3}	False	True
321	0.983909	0.946426	0.806998	{'max_depth': 4, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 3}	False	True
333	0.983909	0.946426	0.806998	{'max_depth': 4, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 3}	False	True
345	0.983909	0.946426	0.806998	{'max_depth': 4, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf':	False	True

	v_avg_spec	v_avg_prec	v_avg_rec	v_hyp_para	scaler	v_SM_RU
				0.1425, 'max_features': 3}		
357	0.983909	0.946426	0.806998	{'max_depth': 4, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 3}	False	True
369	0.983909	0.946426	0.806998	{'max_depth': 4, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 3}	False	True
381	0.983909	0.946426	0.806998	{'max_depth': 4, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 3}	False	True
393	0.983909	0.946426	0.806998	{'max_depth': 4, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 3}	False	True
405	0.983909	0.946426	0.806998	{'max_depth': 4, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 3}	False	True
417	0.983909	0.946426	0.806998	{'max_depth': 4, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 3}	False	True
429	0.983909	0.946426	0.806998	{'max_depth': 4, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 3}	False	True
441	0.983909	0.946426	0.806998	{'max_depth': 5, 'min_samples_split': 0.05, 'criterion': 'gini',	False	True

	v_avg_spec	v_avg_prec	v_avg_rec	v_hyp_para	scaler	v_SM_RU
				'min_samples_leaf': 0.1425, 'max_features': 3}		
453	0.983909	0.946426	0.806998	{'max_depth': 5, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 3}	False	True
465	0.983909	0.946426	0.806998	{'max_depth': 5, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 3}	False	True
477	0.983909	0.946426	0.806998	{'max_depth': 5, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 3}	False	True
489	0.983909	0.946426	0.806998	{'max_depth': 5, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 3}	False	True
501	0.983909	0.946426	0.806998	{'max_depth': 5, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 3}	False	True
513	0.983909	0.946426	0.806998	{'max_depth': 5, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 3}	False	True
525	0.983909	0.946426	0.806998	{'max_depth': 5, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 3}	False	True
537	0.983909	0.946426	0.806998	{'max_depth': 5, 'min_samples_split': 0.1, 'criterion':	False	True

	v_avg_spec	v_avg_prec	v_avg_rec	v_hyp_para	scaler	v_SM_RU
				'gini', 'min_samples_leaf': 0.1425, 'max_features': 3}		
549	0.983909	0.946426	0.806998	{'max_depth': 5, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 3}	False	True
561	0.983909	0.946426	0.806998	{'max_depth': 5, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 3}	False	True
573	0.983909	0.946426	0.806998	{'max_depth': 5, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 3}	False	True
2	0.981374	0.940948	0.842891	{'max_depth': 2, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 4}	False	True
14	0.981374	0.940948	0.842891	{'max_depth': 2, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 4}	False	True
26	0.981374	0.940948	0.842891	{'max_depth': 2, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 4}	False	True
38	0.981374	0.940948	0.842891	{'max_depth': 2, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 4}	False	True
50	0.981374	0.940948	0.842891	{'max_depth': 2, 'min_samples_split':	False	True

	v_avg_spec	v_avg_prec	v_avg_rec	v_hyp_para	scaler	v_SM_RU
				0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 4}		
62	0.981374	0.940948	0.842891	{'max_depth': 2, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 4}	False	True
74	0.981374	0.940948	0.842891	{'max_depth': 2, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 4}	False	True
86	0.981374	0.940948	0.842891	{'max_depth': 2, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 4}	False	True
98	0.981374	0.940948	0.842891	{'max_depth': 2, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 4}	False	True
110	0.981374	0.940948	0.842891	{'max_depth': 2, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 4}	False	True
122	0.981374	0.940948	0.842891	{'max_depth': 2, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 4}	False	True
134	0.981374	0.940948	0.842891	{'max_depth': 2, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 4}	False	True

	v_avg_spec	v_avg_prec	v_avg_rec	v_hyp_para	scaler	v_SM_RU
146	0.981374	0.940948	0.842891	{'max_depth': 3, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 4}	False	True
158	0.981374	0.940948	0.842891	{'max_depth': 3, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 4}	False	True
170	0.981374	0.940948	0.842891	{'max_depth': 3, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 4}	False	True
182	0.981374	0.940948	0.842891	{'max_depth': 3, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 4}	False	True
194	0.981374	0.940948	0.842891	{'max_depth': 3, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 4}	False	True
206	0.981374	0.940948	0.842891	{'max_depth': 3, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 4}	False	True
218	0.981374	0.940948	0.842891	{'max_depth': 3, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 4}	False	True
230	0.981374	0.940948	0.842891	{'max_depth': 3, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf':	False	True

	v_avg_spec	v_avg_prec	v_avg_rec	v_hyp_para	scaler	v_SM_RU
				0.1225, 'max_features': 4}		
242	0.981374	0.940948	0.842891	{'max_depth': 3, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 4}	False	True
254	0.981374	0.940948	0.842891	{'max_depth': 3, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 4}	False	True
266	0.981374	0.940948	0.842891	{'max_depth': 3, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 4}	False	True
278	0.981374	0.940948	0.842891	{'max_depth': 3, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 4}	False	True
290	0.981374	0.940948	0.842891	{'max_depth': 4, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 4}	False	True
302	0.981374	0.940948	0.842891	{'max_depth': 4, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 4}	False	True
314	0.981374	0.940948	0.842891	{'max_depth': 4, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 4}	False	True
326	0.981374	0.940948	0.842891	{'max_depth': 4, 'min_samples_split': 0.1, 'criterion': 'gini',	False	True

	v_avg_spec	v_avg_prec	v_avg_rec	v_hyp_para	scaler	v_SM_RU
				'min_samples_leaf': 0.1225, 'max_features': 4}		
338	0.981374	0.940948	0.842891	{'max_depth': 4, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 4}	False	True
350	0.981374	0.940948	0.842891	{'max_depth': 4, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 4}	False	True
362	0.981374	0.940948	0.842891	{'max_depth': 4, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 4}	False	True
374	0.981374	0.940948	0.842891	{'max_depth': 4, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 4}	False	True
386	0.981374	0.940948	0.842891	{'max_depth': 4, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 4}	False	True
398	0.981374	0.940948	0.842891	{'max_depth': 4, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 4}	False	True
410	0.981374	0.940948	0.842891	{'max_depth': 4, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 4}	False	True
422	0.981374	0.940948	0.842891	{'max_depth': 4, 'min_samples_split': 0.15, 'criterion':	False	True

	v_avg_spec	v_avg_prec	v_avg_rec	v_hyp_para	scaler	v_SM_RU
				'gini', 'min_samples_leaf': 0.1225, 'max_features': 4}		
434	0.981374	0.940948	0.842891	{'max_depth': 5, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 4}	False	True
446	0.981374	0.940948	0.842891	{'max_depth': 5, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 4}	False	True
458	0.981374	0.940948	0.842891	{'max_depth': 5, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 4}	False	True
470	0.981374	0.940948	0.842891	{'max_depth': 5, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 4}	False	True
482	0.981374	0.940948	0.842891	{'max_depth': 5, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 4}	False	True
494	0.981374	0.940948	0.842891	{'max_depth': 5, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 4}	False	True
506	0.981374	0.940948	0.842891	{'max_depth': 5, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 4}	False	True
518	0.981374	0.940948	0.842891	{'max_depth': 5, 'min_samples_split':	False	True

	v_avg_spec	v_avg_prec	v_avg_rec	v_hyp_para	scaler	v_SM_RU
				0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 4}		
530	0.981374	0.940948	0.842891	{'max_depth': 5, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 4}	False	True
542	0.981374	0.940948	0.842891	{'max_depth': 5, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 4}	False	True
554	0.981374	0.940948	0.842891	{'max_depth': 5, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 4}	False	True
566	0.981374	0.940948	0.842891	{'max_depth': 5, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 4}	False	True
5	0.981043	0.938699	0.825579	{'max_depth': 2, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 3}	False	True
17	0.981043	0.938699	0.825579	{'max_depth': 2, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 3}	False	True
29	0.981043	0.938699	0.825579	{'max_depth': 2, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 3}	False	True

	v_avg_spec	v_avg_prec	v_avg_rec	v_hyp_para	scaler	v_SM_RU
41	0.981043	0.938699	0.825579	{'max_depth': 2, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 3}	False	True
53	0.981043	0.938699	0.825579	{'max_depth': 2, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 3}	False	True
65	0.981043	0.938699	0.825579	{'max_depth': 2, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 3}	False	True
77	0.981043	0.938699	0.825579	{'max_depth': 2, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 3}	False	True
89	0.981043	0.938699	0.825579	{'max_depth': 2, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 3}	False	True
101	0.981043	0.938699	0.825579	{'max_depth': 2, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 3}	False	True
113	0.981043	0.938699	0.825579	{'max_depth': 2, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 3}	False	True
125	0.981043	0.938699	0.825579	{'max_depth': 2, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf':	False	True

	v_avg_spec	v_avg_prec	v_avg_rec	v_hyp_para	scaler	v_SM_RU
				0.1325, 'max_features': 3}		
137	0.981043	0.938699	0.825579	{'max_depth': 2, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 3}	False	True
149	0.981043	0.938699	0.825579	{'max_depth': 3, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 3}	False	True
161	0.981043	0.938699	0.825579	{'max_depth': 3, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 3}	False	True
173	0.981043	0.938699	0.825579	{'max_depth': 3, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 3}	False	True
185	0.981043	0.938699	0.825579	{'max_depth': 3, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 3}	False	True
197	0.981043	0.938699	0.825579	{'max_depth': 3, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 3}	False	True
209	0.981043	0.938699	0.825579	{'max_depth': 3, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 3}	False	True
221	0.981043	0.938699	0.825579	{'max_depth': 3, 'min_samples_split': 0.05, 'criterion': 'gini',	False	True

	v_avg_spec	v_avg_prec	v_avg_rec	v_hyp_para	scaler	v_SM_RU
				'min_samples_leaf': 0.1325, 'max_features': 3}		
233	0.981043	0.938699	0.825579	{'max_depth': 3, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 3}	False	True
245	0.981043	0.938699	0.825579	{'max_depth': 3, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 3}	False	True
257	0.981043	0.938699	0.825579	{'max_depth': 3, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 3}	False	True
269	0.981043	0.938699	0.825579	{'max_depth': 3, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 3}	False	True
281	0.981043	0.938699	0.825579	{'max_depth': 3, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 3}	False	True
293	0.981043	0.938699	0.825579	{'max_depth': 4, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 3}	False	True
305	0.981043	0.938699	0.825579	{'max_depth': 4, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 3}	False	True
317	0.981043	0.938699	0.825579	{'max_depth': 4, 'min_samples_split': 0.1, 'criterion':	False	True

	v_avg_spec	v_avg_prec	v_avg_rec	v_hyp_para	scaler	v_SM_RU
				'gini', 'min_samples_leaf': 0.1325, 'max_features': 3}		
329	0.981043	0.938699	0.825579	{'max_depth': 4, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 3}	False	True
341	0.981043	0.938699	0.825579	{'max_depth': 4, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 3}	False	True
353	0.981043	0.938699	0.825579	{'max_depth': 4, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 3}	False	True
365	0.981043	0.938699	0.825579	{'max_depth': 4, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 3}	False	True
377	0.981043	0.938699	0.825579	{'max_depth': 4, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 3}	False	True
389	0.981043	0.938699	0.825579	{'max_depth': 4, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 3}	False	True
401	0.981043	0.938699	0.825579	{'max_depth': 4, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 3}	False	True
413	0.981043	0.938699	0.825579	{'max_depth': 4, 'min_samples_split':	False	True

	v_avg_spec	v_avg_prec	v_avg_rec	v_hyp_para	scaler	v_SM_RU
				0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 3}		
425	0.981043	0.938699	0.825579	{'max_depth': 4, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 3}	False	True
437	0.981043	0.938699	0.825579	{'max_depth': 5, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 3}	False	True
449	0.981043	0.938699	0.825579	{'max_depth': 5, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 3}	False	True
461	0.981043	0.938699	0.825579	{'max_depth': 5, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 3}	False	True
473	0.981043	0.938699	0.825579	{'max_depth': 5, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 3}	False	True
485	0.981043	0.938699	0.825579	{'max_depth': 5, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 3}	False	True
497	0.981043	0.938699	0.825579	{'max_depth': 5, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 3}	False	True

	v_avg_spec	v_avg_prec	v_avg_rec	v_hyp_para	scaler	v_SM_RU
509	0.981043	0.938699	0.825579	{'max_depth': 5, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 3}	False	True
521	0.981043	0.938699	0.825579	{'max_depth': 5, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 3}	False	True
533	0.981043	0.938699	0.825579	{'max_depth': 5, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 3}	False	True
545	0.981043	0.938699	0.825579	{'max_depth': 5, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 3}	False	True
557	0.981043	0.938699	0.825579	{'max_depth': 5, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 3}	False	True
569	0.981043	0.938699	0.825579	{'max_depth': 5, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 3}	False	True
1	0.978508	0.932186	0.841001	{'max_depth': 2, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 3}	False	True
13	0.978508	0.932186	0.841001	{'max_depth': 2, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf':	False	True

	v_avg_spec	v_avg_prec	v_avg_rec	v_hyp_para	scaler	v_SM_RU
				0.1225, 'max_features': 3}		
25	0.978508	0.932186	0.841001	{'max_depth': 2, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 3}	False	True
37	0.978508	0.932186	0.841001	{'max_depth': 2, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 3}	False	True
49	0.978508	0.932186	0.841001	{'max_depth': 2, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 3}	False	True
61	0.978508	0.932186	0.841001	{'max_depth': 2, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 3}	False	True
73	0.978508	0.932186	0.841001	{'max_depth': 2, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 3}	False	True
85	0.978508	0.932186	0.841001	{'max_depth': 2, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 3}	False	True
97	0.978508	0.932186	0.841001	{'max_depth': 2, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 3}	False	True
109	0.978508	0.932186	0.841001	{'max_depth': 2, 'min_samples_split': 0.1, 'criterion': 'gini',	False	True

	v_avg_spec	v_avg_prec	v_avg_rec	v_hyp_para	scaler	v_SM_RU
				'min_samples_leaf': 0.1225, 'max_features': 3}		
121	0.978508	0.932186	0.841001	{'max_depth': 2, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 3}	False	True
133	0.978508	0.932186	0.841001	{'max_depth': 2, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 3}	False	True
145	0.978508	0.932186	0.841001	{'max_depth': 3, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 3}	False	True
157	0.978508	0.932186	0.841001	{'max_depth': 3, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 3}	False	True
169	0.978508	0.932186	0.841001	{'max_depth': 3, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 3}	False	True
181	0.978508	0.932186	0.841001	{'max_depth': 3, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 3}	False	True
193	0.978508	0.932186	0.841001	{'max_depth': 3, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 3}	False	True
205	0.978508	0.932186	0.841001	{'max_depth': 3, 'min_samples_split': 0.15, 'criterion':	False	True

	v_avg_spec	v_avg_prec	v_avg_rec	v_hyp_para	scaler	v_SM_RU
				'gini', 'min_samples_leaf': 0.1225, 'max_features': 3}		
217	0.978508	0.932186	0.841001	{'max_depth': 3, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 3}	False	True
229	0.978508	0.932186	0.841001	{'max_depth': 3, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 3}	False	True
241	0.978508	0.932186	0.841001	{'max_depth': 3, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 3}	False	True
253	0.978508	0.932186	0.841001	{'max_depth': 3, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 3}	False	True
265	0.978508	0.932186	0.841001	{'max_depth': 3, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 3}	False	True
277	0.978508	0.932186	0.841001	{'max_depth': 3, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 3}	False	True
289	0.978508	0.932186	0.841001	{'max_depth': 4, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 3}	False	True
301	0.978508	0.932186	0.841001	{'max_depth': 4, 'min_samples_split':	False	True

	v_avg_spec	v_avg_prec	v_avg_rec	v_hyp_para	scaler	v_SM_RU
				0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 3}		
313	0.978508	0.932186	0.841001	{'max_depth': 4, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 3}	False	True
325	0.978508	0.932186	0.841001	{'max_depth': 4, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 3}	False	True
337	0.978508	0.932186	0.841001	{'max_depth': 4, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 3}	False	True
349	0.978508	0.932186	0.841001	{'max_depth': 4, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 3}	False	True
361	0.978508	0.932186	0.841001	{'max_depth': 4, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 3}	False	True
373	0.978508	0.932186	0.841001	{'max_depth': 4, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 3}	False	True
385	0.978508	0.932186	0.841001	{'max_depth': 4, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 3}	False	True

	v_avg_spec	v_avg_prec	v_avg_rec	v_hyp_para	scaler	v_SM_RU
397	0.978508	0.932186	0.841001	{'max_depth': 4, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 3}	False	True
409	0.978508	0.932186	0.841001	{'max_depth': 4, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 3}	False	True
421	0.978508	0.932186	0.841001	{'max_depth': 4, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 3}	False	True
433	0.978508	0.932186	0.841001	{'max_depth': 5, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 3}	False	True
445	0.978508	0.932186	0.841001	{'max_depth': 5, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 3}	False	True
457	0.978508	0.932186	0.841001	{'max_depth': 5, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 3}	False	True
469	0.978508	0.932186	0.841001	{'max_depth': 5, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 3}	False	True
481	0.978508	0.932186	0.841001	{'max_depth': 5, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf':	False	True

	v_avg_spec	v_avg_prec	v_avg_rec	v_hyp_para	scaler	v_SM_RU
				0.1225, 'max_features': 3}		
493	0.978508	0.932186	0.841001	{'max_depth': 5, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 3}	False	True
505	0.978508	0.932186	0.841001	{'max_depth': 5, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 3}	False	True
517	0.978508	0.932186	0.841001	{'max_depth': 5, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 3}	False	True
529	0.978508	0.932186	0.841001	{'max_depth': 5, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 3}	False	True
541	0.978508	0.932186	0.841001	{'max_depth': 5, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 3}	False	True
553	0.978508	0.932186	0.841001	{'max_depth': 5, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 3}	False	True
565	0.978508	0.932186	0.841001	{'max_depth': 5, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 3}	False	True
8	0.896727	0.740587	0.841298	{'max_depth': 2, 'min_samples_split': 0.05, 'criterion': 'gini',	False	True

	v_avg_spec	v_avg_prec	v_avg_rec	v_hyp_para	scaler	v_SM_RU
				'min_samples_leaf': 0.1425, 'max_features': 2}		
20	0.896727	0.740587	0.841298	{'max_depth': 2, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 2}	False	True
32	0.896727	0.740587	0.841298	{'max_depth': 2, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 2}	False	True
44	0.896727	0.740587	0.841298	{'max_depth': 2, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 2}	False	True
56	0.896727	0.740587	0.841298	{'max_depth': 2, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 2}	False	True
68	0.896727	0.740587	0.841298	{'max_depth': 2, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 2}	False	True
80	0.896727	0.740587	0.841298	{'max_depth': 2, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 2}	False	True
92	0.896727	0.740587	0.841298	{'max_depth': 2, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 2}	False	True
104	0.896727	0.740587	0.841298	{'max_depth': 2, 'min_samples_split': 0.1, 'criterion':	False	True

	v_avg_spec	v_avg_prec	v_avg_rec	v_hyp_para	scaler	v_SM_RU
				'gini', 'min_samples_leaf': 0.1425, 'max_features': 2}		
116	0.896727	0.740587	0.841298	{'max_depth': 2, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 2}	False	True
128	0.896727	0.740587	0.841298	{'max_depth': 2, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 2}	False	True
140	0.896727	0.740587	0.841298	{'max_depth': 2, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 2}	False	True
152	0.896727	0.740587	0.841298	{'max_depth': 3, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 2}	False	True
164	0.896727	0.740587	0.841298	{'max_depth': 3, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 2}	False	True
176	0.896727	0.740587	0.841298	{'max_depth': 3, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 2}	False	True
188	0.896727	0.740587	0.841298	{'max_depth': 3, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 2}	False	True
200	0.896727	0.740587	0.841298	{'max_depth': 3, 'min_samples_split':	False	True

	v_avg_spec	v_avg_prec	v_avg_rec	v_hyp_para	scaler	v_SM_RU
				0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 2}		
212	0.896727	0.740587	0.841298	{'max_depth': 3, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 2}	False	True
224	0.896727	0.740587	0.841298	{'max_depth': 3, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 2}	False	True
236	0.896727	0.740587	0.841298	{'max_depth': 3, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 2}	False	True
248	0.896727	0.740587	0.841298	{'max_depth': 3, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 2}	False	True
260	0.896727	0.740587	0.841298	{'max_depth': 3, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 2}	False	True
272	0.896727	0.740587	0.841298	{'max_depth': 3, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 2}	False	True
284	0.896727	0.740587	0.841298	{'max_depth': 3, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 2}	False	True

	v_avg_spec	v_avg_prec	v_avg_rec	v_hyp_para	scaler	v_SM_RU
296	0.896727	0.740587	0.841298	{'max_depth': 4, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 2}	False	True
308	0.896727	0.740587	0.841298	{'max_depth': 4, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 2}	False	True
320	0.896727	0.740587	0.841298	{'max_depth': 4, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 2}	False	True
332	0.896727	0.740587	0.841298	{'max_depth': 4, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 2}	False	True
344	0.896727	0.740587	0.841298	{'max_depth': 4, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 2}	False	True
356	0.896727	0.740587	0.841298	{'max_depth': 4, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 2}	False	True
368	0.896727	0.740587	0.841298	{'max_depth': 4, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 2}	False	True
380	0.896727	0.740587	0.841298	{'max_depth': 4, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf':	False	True

	v_avg_spec	v_avg_prec	v_avg_rec	v_hyp_para	scaler	v_SM_RU
				0.1425, 'max_features': 2}		
392	0.896727	0.740587	0.841298	{'max_depth': 4, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 2}	False	True
404	0.896727	0.740587	0.841298	{'max_depth': 4, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 2}	False	True
416	0.896727	0.740587	0.841298	{'max_depth': 4, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 2}	False	True
428	0.896727	0.740587	0.841298	{'max_depth': 4, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 2}	False	True
440	0.896727	0.740587	0.841298	{'max_depth': 5, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 2}	False	True
452	0.896727	0.740587	0.841298	{'max_depth': 5, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 2}	False	True
464	0.896727	0.740587	0.841298	{'max_depth': 5, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 2}	False	True
476	0.896727	0.740587	0.841298	{'max_depth': 5, 'min_samples_split': 0.1, 'criterion': 'gini',	False	True

	v_avg_spec	v_avg_prec	v_avg_rec	v_hyp_para	scaler	v_SM_RU
				'min_samples_leaf': 0.1425, 'max_features': 2}		
488	0.896727	0.740587	0.841298	{'max_depth': 5, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 2}	False	True
500	0.896727	0.740587	0.841298	{'max_depth': 5, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 2}	False	True
512	0.896727	0.740587	0.841298	{'max_depth': 5, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 2}	False	True
524	0.896727	0.740587	0.841298	{'max_depth': 5, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 2}	False	True
536	0.896727	0.740587	0.841298	{'max_depth': 5, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 2}	False	True
548	0.896727	0.740587	0.841298	{'max_depth': 5, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 2}	False	True
560	0.896727	0.740587	0.841298	{'max_depth': 5, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 2}	False	True
572	0.896727	0.740587	0.841298	{'max_depth': 5, 'min_samples_split': 0.15, 'criterion':	False	True

	v_avg_spec	v_avg_prec	v_avg_rec	v_hyp_para	scaler	v_SM_RU
				'gini', 'min_samples_leaf': 0.1425, 'max_features': 2}		
4	0.893090	0.738324	0.861139	{'max_depth': 2, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 2}	False	True
16	0.893090	0.738324	0.861139	{'max_depth': 2, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 2}	False	True
28	0.893090	0.738324	0.861139	{'max_depth': 2, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 2}	False	True
40	0.893090	0.738324	0.861139	{'max_depth': 2, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 2}	False	True
52	0.893090	0.738324	0.861139	{'max_depth': 2, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 2}	False	True
64	0.893090	0.738324	0.861139	{'max_depth': 2, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 2}	False	True
76	0.893090	0.738324	0.861139	{'max_depth': 2, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 2}	False	True
88	0.893090	0.738324	0.861139	{'max_depth': 2, 'min_samples_split':	False	True

	v_avg_spec	v_avg_prec	v_avg_rec	v_hyp_para	scaler	v_SM_RU
				0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 2}		
100	0.893090	0.738324	0.861139	{'max_depth': 2, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 2}	False	True
112	0.893090	0.738324	0.861139	{'max_depth': 2, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 2}	False	True
124	0.893090	0.738324	0.861139	{'max_depth': 2, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 2}	False	True
136	0.893090	0.738324	0.861139	{'max_depth': 2, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 2}	False	True
148	0.893090	0.738324	0.861139	{'max_depth': 3, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 2}	False	True
160	0.893090	0.738324	0.861139	{'max_depth': 3, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 2}	False	True
172	0.893090	0.738324	0.861139	{'max_depth': 3, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 2}	False	True

	v_avg_spec	v_avg_prec	v_avg_rec	v_hyp_para	scaler	v_SM_RU
184	0.893090	0.738324	0.861139	{'max_depth': 3, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 2}	False	True
196	0.893090	0.738324	0.861139	{'max_depth': 3, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 2}	False	True
208	0.893090	0.738324	0.861139	{'max_depth': 3, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 2}	False	True
220	0.893090	0.738324	0.861139	{'max_depth': 3, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 2}	False	True
232	0.893090	0.738324	0.861139	{'max_depth': 3, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 2}	False	True
244	0.893090	0.738324	0.861139	{'max_depth': 3, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 2}	False	True
256	0.893090	0.738324	0.861139	{'max_depth': 3, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 2}	False	True
268	0.893090	0.738324	0.861139	{'max_depth': 3, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf':	False	True

	v_avg_spec	v_avg_prec	v_avg_rec	v_hyp_para	scaler	v_SM_RU
				0.1325, 'max_features': 2}		
280	0.893090	0.738324	0.861139	{'max_depth': 3, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 2}	False	True
292	0.893090	0.738324	0.861139	{'max_depth': 4, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 2}	False	True
304	0.893090	0.738324	0.861139	{'max_depth': 4, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 2}	False	True
316	0.893090	0.738324	0.861139	{'max_depth': 4, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 2}	False	True
328	0.893090	0.738324	0.861139	{'max_depth': 4, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 2}	False	True
340	0.893090	0.738324	0.861139	{'max_depth': 4, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 2}	False	True
352	0.893090	0.738324	0.861139	{'max_depth': 4, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 2}	False	True
364	0.893090	0.738324	0.861139	{'max_depth': 4, 'min_samples_split': 0.05, 'criterion': 'gini',	False	True

	v_avg_spec	v_avg_prec	v_avg_rec	v_hyp_para	scaler	v_SM_RU
				'min_samples_leaf': 0.1325, 'max_features': 2}		
376	0.893090	0.738324	0.861139	{'max_depth': 4, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 2}	False	True
388	0.893090	0.738324	0.861139	{'max_depth': 4, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 2}	False	True
400	0.893090	0.738324	0.861139	{'max_depth': 4, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 2}	False	True
412	0.893090	0.738324	0.861139	{'max_depth': 4, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 2}	False	True
424	0.893090	0.738324	0.861139	{'max_depth': 4, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 2}	False	True
436	0.893090	0.738324	0.861139	{'max_depth': 5, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 2}	False	True
448	0.893090	0.738324	0.861139	{'max_depth': 5, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 2}	False	True
460	0.893090	0.738324	0.861139	{'max_depth': 5, 'min_samples_split': 0.1, 'criterion':	False	True

	v_avg_spec	v_avg_prec	v_avg_rec	v_hyp_para	scaler	v_SM_RU
				'gini', 'min_samples_leaf': 0.1325, 'max_features': 2}		
472	0.893090	0.738324	0.861139	{'max_depth': 5, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 2}	False	True
484	0.893090	0.738324	0.861139	{'max_depth': 5, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 2}	False	True
496	0.893090	0.738324	0.861139	{'max_depth': 5, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 2}	False	True
508	0.893090	0.738324	0.861139	{'max_depth': 5, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 2}	False	True
520	0.893090	0.738324	0.861139	{'max_depth': 5, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 2}	False	True
532	0.893090	0.738324	0.861139	{'max_depth': 5, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 2}	False	True
544	0.893090	0.738324	0.861139	{'max_depth': 5, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 2}	False	True
556	0.893090	0.738324	0.861139	{'max_depth': 5, 'min_samples_split':	False	True

	v_avg_spec	v_avg_prec	v_avg_rec	v_hyp_para	scaler	v_SM_RU
				0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 2}		
568	0.893090	0.738324	0.861139	{'max_depth': 5, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 2}	False	True
0	0.889562	0.736433	0.880659	{'max_depth': 2, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 2}	False	True
12	0.889562	0.736433	0.880659	{'max_depth': 2, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 2}	False	True
24	0.889562	0.736433	0.880659	{'max_depth': 2, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 2}	False	True
36	0.889562	0.736433	0.880659	{'max_depth': 2, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 2}	False	True
48	0.889562	0.736433	0.880659	{'max_depth': 2, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 2}	False	True
60	0.889562	0.736433	0.880659	{'max_depth': 2, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 2}	False	True

	v_avg_spec	v_avg_prec	v_avg_rec	v_hyp_para	scaler	v_SM_RU
72	0.889562	0.736433	0.880659	{'max_depth': 2, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 2}	False	True
84	0.889562	0.736433	0.880659	{'max_depth': 2, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 2}	False	True
96	0.889562	0.736433	0.880659	{'max_depth': 2, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 2}	False	True
108	0.889562	0.736433	0.880659	{'max_depth': 2, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 2}	False	True
120	0.889562	0.736433	0.880659	{'max_depth': 2, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 2}	False	True
132	0.889562	0.736433	0.880659	{'max_depth': 2, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 2}	False	True
144	0.889562	0.736433	0.880659	{'max_depth': 3, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 2}	False	True
156	0.889562	0.736433	0.880659	{'max_depth': 3, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf':	False	True

	v_avg_spec	v_avg_prec	v_avg_rec	v_hyp_para	scaler	v_SM_RU
				0.1225, 'max_features': 2}		
168	0.889562	0.736433	0.880659	{'max_depth': 3, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 2}	False	True
180	0.889562	0.736433	0.880659	{'max_depth': 3, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 2}	False	True
192	0.889562	0.736433	0.880659	{'max_depth': 3, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 2}	False	True
204	0.889562	0.736433	0.880659	{'max_depth': 3, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 2}	False	True
216	0.889562	0.736433	0.880659	{'max_depth': 3, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 2}	False	True
228	0.889562	0.736433	0.880659	{'max_depth': 3, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 2}	False	True
240	0.889562	0.736433	0.880659	{'max_depth': 3, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 2}	False	True
252	0.889562	0.736433	0.880659	{'max_depth': 3, 'min_samples_split': 0.1, 'criterion': 'gini',	False	True

	v_avg_spec	v_avg_prec	v_avg_rec	v_hyp_para	scaler	v_SM_RU
				'min_samples_leaf': 0.1225, 'max_features': 2}		
264	0.889562	0.736433	0.880659	{'max_depth': 3, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 2}	False	True
276	0.889562	0.736433	0.880659	{'max_depth': 3, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 2}	False	True
288	0.889562	0.736433	0.880659	{'max_depth': 4, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 2}	False	True
300	0.889562	0.736433	0.880659	{'max_depth': 4, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 2}	False	True
312	0.889562	0.736433	0.880659	{'max_depth': 4, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 2}	False	True
324	0.889562	0.736433	0.880659	{'max_depth': 4, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 2}	False	True
336	0.889562	0.736433	0.880659	{'max_depth': 4, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 2}	False	True
348	0.889562	0.736433	0.880659	{'max_depth': 4, 'min_samples_split': 0.15, 'criterion':	False	True

	v_avg_spec	v_avg_prec	v_avg_rec	v_hyp_para	scaler	v_SM_RU
				'gini', 'min_samples_leaf': 0.1225, 'max_features': 2}		
360	0.889562	0.736433	0.880659	{'max_depth': 4, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 2}	False	True
372	0.889562	0.736433	0.880659	{'max_depth': 4, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 2}	False	True
384	0.889562	0.736433	0.880659	{'max_depth': 4, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 2}	False	True
396	0.889562	0.736433	0.880659	{'max_depth': 4, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 2}	False	True
408	0.889562	0.736433	0.880659	{'max_depth': 4, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 2}	False	True
420	0.889562	0.736433	0.880659	{'max_depth': 4, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 2}	False	True
432	0.889562	0.736433	0.880659	{'max_depth': 5, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 2}	False	True
444	0.889562	0.736433	0.880659	{'max_depth': 5, 'min_samples_split':	False	True

	v_avg_spec	v_avg_prec	v_avg_rec	v_hyp_para	scaler	v_SM_RU
				0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 2}		
456	0.889562	0.736433	0.880659	{'max_depth': 5, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 2}	False	True
468	0.889562	0.736433	0.880659	{'max_depth': 5, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 2}	False	True
480	0.889562	0.736433	0.880659	{'max_depth': 5, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 2}	False	True
492	0.889562	0.736433	0.880659	{'max_depth': 5, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 2}	False	True
504	0.889562	0.736433	0.880659	{'max_depth': 5, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 2}	False	True
516	0.889562	0.736433	0.880659	{'max_depth': 5, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 2}	False	True
528	0.889562	0.736433	0.880659	{'max_depth': 5, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 2}	False	True

	v_avg_spec	v_avg_prec	v_avg_rec	v_hyp_para	scaler	v_SM_RU
540	0.889562	0.736433	0.880659	{'max_depth': 5, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 2}	False	True
552	0.889562	0.736433	0.880659	{'max_depth': 5, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 2}	False	True
564	0.889562	0.736433	0.880659	{'max_depth': 5, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 2}	False	True
3	0.791801	0.622309	0.974177	{'max_depth': 2, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 5}	False	True
7	0.791801	0.622309	0.974177	{'max_depth': 2, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 5}	False	True
11	0.791801	0.622309	0.974177	{'max_depth': 2, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 5}	False	True
15	0.791801	0.622309	0.974177	{'max_depth': 2, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 5}	False	True
19	0.791801	0.622309	0.974177	{'max_depth': 2, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf':	False	True

	v_avg_spec	v_avg_prec	v_avg_rec	v_hyp_para	scaler	v_SM_RU
				0.1325, 'max_features': 5}		
23	0.791801	0.622309	0.974177	{'max_depth': 2, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 5}	False	True
27	0.791801	0.622309	0.974177	{'max_depth': 2, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 5}	False	True
31	0.791801	0.622309	0.974177	{'max_depth': 2, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 5}	False	True
35	0.791801	0.622309	0.974177	{'max_depth': 2, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 5}	False	True
39	0.791801	0.622309	0.974177	{'max_depth': 2, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 5}	False	True
43	0.791801	0.622309	0.974177	{'max_depth': 2, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 5}	False	True
47	0.791801	0.622309	0.974177	{'max_depth': 2, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 5}	False	True
51	0.791801	0.622309	0.974177	{'max_depth': 2, 'min_samples_split': 0.15, 'criterion': 'gini',	False	True

	v_avg_spec	v_avg_prec	v_avg_rec	v_hyp_para	scaler	v_SM_RU
				'min_samples_leaf': 0.1225, 'max_features': 5}		
55	0.791801	0.622309	0.974177	{'max_depth': 2, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 5}	False	True
59	0.791801	0.622309	0.974177	{'max_depth': 2, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 5}	False	True
63	0.791801	0.622309	0.974177	{'max_depth': 2, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 5}	False	True
67	0.791801	0.622309	0.974177	{'max_depth': 2, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 5}	False	True
71	0.791801	0.622309	0.974177	{'max_depth': 2, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 5}	False	True
75	0.791801	0.622309	0.974177	{'max_depth': 2, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 5}	False	True
79	0.791801	0.622309	0.974177	{'max_depth': 2, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 5}	False	True
83	0.791801	0.622309	0.974177	{'max_depth': 2, 'min_samples_split': 0.05, 'criterion':	False	True

	v_avg_spec	v_avg_prec	v_avg_rec	v_hyp_para	scaler	v_SM_RU
				'gini', 'min_samples_leaf': 0.1425, 'max_features': 5}		
87	0.791801	0.622309	0.974177	{'max_depth': 2, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 5}	False	True
91	0.791801	0.622309	0.974177	{'max_depth': 2, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 5}	False	True
95	0.791801	0.622309	0.974177	{'max_depth': 2, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 5}	False	True
99	0.791801	0.622309	0.974177	{'max_depth': 2, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 5}	False	True
103	0.791801	0.622309	0.974177	{'max_depth': 2, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 5}	False	True
107	0.791801	0.622309	0.974177	{'max_depth': 2, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 5}	False	True
111	0.791801	0.622309	0.974177	{'max_depth': 2, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 5}	False	True
115	0.791801	0.622309	0.974177	{'max_depth': 2, 'min_samples_split':	False	True

	v_avg_spec	v_avg_prec	v_avg_rec	v_hyp_para	scaler	v_SM_RU
				0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 5}		
119	0.791801	0.622309	0.974177	{'max_depth': 2, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 5}	False	True
123	0.791801	0.622309	0.974177	{'max_depth': 2, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 5}	False	True
127	0.791801	0.622309	0.974177	{'max_depth': 2, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 5}	False	True
131	0.791801	0.622309	0.974177	{'max_depth': 2, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 5}	False	True
135	0.791801	0.622309	0.974177	{'max_depth': 2, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 5}	False	True
139	0.791801	0.622309	0.974177	{'max_depth': 2, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 5}	False	True
143	0.791801	0.622309	0.974177	{'max_depth': 2, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 5}	False	True

	v_avg_spec	v_avg_prec	v_avg_rec	v_hyp_para	scaler	v_SM_RU
147	0.791801	0.622309	0.974177	{'max_depth': 3, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 5}	False	True
151	0.791801	0.622309	0.974177	{'max_depth': 3, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 5}	False	True
155	0.791801	0.622309	0.974177	{'max_depth': 3, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 5}	False	True
159	0.791801	0.622309	0.974177	{'max_depth': 3, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 5}	False	True
163	0.791801	0.622309	0.974177	{'max_depth': 3, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 5}	False	True
167	0.791801	0.622309	0.974177	{'max_depth': 3, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 5}	False	True
171	0.791801	0.622309	0.974177	{'max_depth': 3, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 5}	False	True
175	0.791801	0.622309	0.974177	{'max_depth': 3, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf':	False	True

	v_avg_spec	v_avg_prec	v_avg_rec	v_hyp_para	scaler	v_SM_RU
				0.1325, 'max_features': 5}		
179	0.791801	0.622309	0.974177	{'max_depth': 3, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 5}	False	True
183	0.791801	0.622309	0.974177	{'max_depth': 3, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 5}	False	True
187	0.791801	0.622309	0.974177	{'max_depth': 3, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 5}	False	True
191	0.791801	0.622309	0.974177	{'max_depth': 3, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 5}	False	True
195	0.791801	0.622309	0.974177	{'max_depth': 3, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 5}	False	True
199	0.791801	0.622309	0.974177	{'max_depth': 3, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 5}	False	True
203	0.791801	0.622309	0.974177	{'max_depth': 3, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 5}	False	True
207	0.791801	0.622309	0.974177	{'max_depth': 3, 'min_samples_split': 0.15, 'criterion': 'gini',	False	True

	v_avg_spec	v_avg_prec	v_avg_rec	v_hyp_para	scaler	v_SM_RU
				'min_samples_leaf': 0.1225, 'max_features': 5}		
211	0.791801	0.622309	0.974177	{'max_depth': 3, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 5}	False	True
215	0.791801	0.622309	0.974177	{'max_depth': 3, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 5}	False	True
219	0.791801	0.622309	0.974177	{'max_depth': 3, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 5}	False	True
223	0.791801	0.622309	0.974177	{'max_depth': 3, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 5}	False	True
227	0.791801	0.622309	0.974177	{'max_depth': 3, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 5}	False	True
231	0.791801	0.622309	0.974177	{'max_depth': 3, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 5}	False	True
235	0.791801	0.622309	0.974177	{'max_depth': 3, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 5}	False	True
239	0.791801	0.622309	0.974177	{'max_depth': 3, 'min_samples_split': 0.05, 'criterion':	False	True

	v_avg_spec	v_avg_prec	v_avg_rec	v_hyp_para	scaler	v_SM_RU
				'gini', 'min_samples_leaf': 0.1425, 'max_features': 5}		
243	0.791801	0.622309	0.974177	{'max_depth': 3, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 5}	False	True
247	0.791801	0.622309	0.974177	{'max_depth': 3, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 5}	False	True
251	0.791801	0.622309	0.974177	{'max_depth': 3, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 5}	False	True
255	0.791801	0.622309	0.974177	{'max_depth': 3, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 5}	False	True
259	0.791801	0.622309	0.974177	{'max_depth': 3, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 5}	False	True
263	0.791801	0.622309	0.974177	{'max_depth': 3, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 5}	False	True
267	0.791801	0.622309	0.974177	{'max_depth': 3, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 5}	False	True
271	0.791801	0.622309	0.974177	{'max_depth': 3, 'min_samples_split':	False	True

	v_avg_spec	v_avg_prec	v_avg_rec	v_hyp_para	scaler	v_SM_RU
				0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 5}		
275	0.791801	0.622309	0.974177	{'max_depth': 3, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 5}	False	True
279	0.791801	0.622309	0.974177	{'max_depth': 3, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 5}	False	True
283	0.791801	0.622309	0.974177	{'max_depth': 3, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 5}	False	True
287	0.791801	0.622309	0.974177	{'max_depth': 3, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 5}	False	True
291	0.791801	0.622309	0.974177	{'max_depth': 4, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 5}	False	True
295	0.791801	0.622309	0.974177	{'max_depth': 4, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 5}	False	True
299	0.791801	0.622309	0.974177	{'max_depth': 4, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 5}	False	True

	v_avg_spec	v_avg_prec	v_avg_rec	v_hyp_para	scaler	v_SM_RU
303	0.791801	0.622309	0.974177	{'max_depth': 4, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 5}	False	True
307	0.791801	0.622309	0.974177	{'max_depth': 4, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 5}	False	True
311	0.791801	0.622309	0.974177	{'max_depth': 4, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 5}	False	True
315	0.791801	0.622309	0.974177	{'max_depth': 4, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 5}	False	True
319	0.791801	0.622309	0.974177	{'max_depth': 4, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 5}	False	True
323	0.791801	0.622309	0.974177	{'max_depth': 4, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 5}	False	True
327	0.791801	0.622309	0.974177	{'max_depth': 4, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 5}	False	True
331	0.791801	0.622309	0.974177	{'max_depth': 4, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf':	False	True

	v_avg_spec	v_avg_prec	v_avg_rec	v_hyp_para	scaler	v_SM_RU
				0.1325, 'max_features': 5}		
335	0.791801	0.622309	0.974177	{'max_depth': 4, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 5}	False	True
339	0.791801	0.622309	0.974177	{'max_depth': 4, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 5}	False	True
343	0.791801	0.622309	0.974177	{'max_depth': 4, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 5}	False	True
347	0.791801	0.622309	0.974177	{'max_depth': 4, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 5}	False	True
351	0.791801	0.622309	0.974177	{'max_depth': 4, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 5}	False	True
355	0.791801	0.622309	0.974177	{'max_depth': 4, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 5}	False	True
359	0.791801	0.622309	0.974177	{'max_depth': 4, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 5}	False	True
363	0.791801	0.622309	0.974177	{'max_depth': 4, 'min_samples_split': 0.05, 'criterion': 'gini',	False	True

	v_avg_spec	v_avg_prec	v_avg_rec	v_hyp_para	scaler	v_SM_RU
				'min_samples_leaf': 0.1225, 'max_features': 5}		
367	0.791801	0.622309	0.974177	{'max_depth': 4, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 5}	False	True
371	0.791801	0.622309	0.974177	{'max_depth': 4, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 5}	False	True
375	0.791801	0.622309	0.974177	{'max_depth': 4, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 5}	False	True
379	0.791801	0.622309	0.974177	{'max_depth': 4, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 5}	False	True
383	0.791801	0.622309	0.974177	{'max_depth': 4, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 5}	False	True
387	0.791801	0.622309	0.974177	{'max_depth': 4, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 5}	False	True
391	0.791801	0.622309	0.974177	{'max_depth': 4, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 5}	False	True
395	0.791801	0.622309	0.974177	{'max_depth': 4, 'min_samples_split': 0.1, 'criterion':	False	True

	v_avg_spec	v_avg_prec	v_avg_rec	v_hyp_para	scaler	v_SM_RU
				'gini', 'min_samples_leaf': 0.1425, 'max_features': 5}		
399	0.791801	0.622309	0.974177	{'max_depth': 4, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 5}	False	True
403	0.791801	0.622309	0.974177	{'max_depth': 4, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 5}	False	True
407	0.791801	0.622309	0.974177	{'max_depth': 4, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 5}	False	True
411	0.791801	0.622309	0.974177	{'max_depth': 4, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 5}	False	True
415	0.791801	0.622309	0.974177	{'max_depth': 4, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 5}	False	True
419	0.791801	0.622309	0.974177	{'max_depth': 4, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 5}	False	True
423	0.791801	0.622309	0.974177	{'max_depth': 4, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 5}	False	True
427	0.791801	0.622309	0.974177	{'max_depth': 4, 'min_samples_split':	False	True

	v_avg_spec	v_avg_prec	v_avg_rec	v_hyp_para	scaler	v_SM_RU
				0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 5}		
431	0.791801	0.622309	0.974177	{'max_depth': 4, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 5}	False	True
435	0.791801	0.622309	0.974177	{'max_depth': 5, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 5}	False	True
439	0.791801	0.622309	0.974177	{'max_depth': 5, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 5}	False	True
443	0.791801	0.622309	0.974177	{'max_depth': 5, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 5}	False	True
447	0.791801	0.622309	0.974177	{'max_depth': 5, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 5}	False	True
451	0.791801	0.622309	0.974177	{'max_depth': 5, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 5}	False	True
455	0.791801	0.622309	0.974177	{'max_depth': 5, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 5}	False	True

	v_avg_spec	v_avg_prec	v_avg_rec	v_hyp_para	scaler	v_SM_RU
459	0.791801	0.622309	0.974177	{'max_depth': 5, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 5}	False	True
463	0.791801	0.622309	0.974177	{'max_depth': 5, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 5}	False	True
467	0.791801	0.622309	0.974177	{'max_depth': 5, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 5}	False	True
471	0.791801	0.622309	0.974177	{'max_depth': 5, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 5}	False	True
475	0.791801	0.622309	0.974177	{'max_depth': 5, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 5}	False	True
479	0.791801	0.622309	0.974177	{'max_depth': 5, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 5}	False	True
483	0.791801	0.622309	0.974177	{'max_depth': 5, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 5}	False	True
487	0.791801	0.622309	0.974177	{'max_depth': 5, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf':	False	True

	v_avg_spec	v_avg_prec	v_avg_rec	v_hyp_para	scaler	v_SM_RU
				0.1325, 'max_features': 5}		
491	0.791801	0.622309	0.974177	{'max_depth': 5, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 5}	False	True
495	0.791801	0.622309	0.974177	{'max_depth': 5, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 5}	False	True
499	0.791801	0.622309	0.974177	{'max_depth': 5, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 5}	False	True
503	0.791801	0.622309	0.974177	{'max_depth': 5, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 5}	False	True
507	0.791801	0.622309	0.974177	{'max_depth': 5, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 5}	False	True
511	0.791801	0.622309	0.974177	{'max_depth': 5, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 5}	False	True
515	0.791801	0.622309	0.974177	{'max_depth': 5, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 5}	False	True
519	0.791801	0.622309	0.974177	{'max_depth': 5, 'min_samples_split': 0.05, 'criterion': 'gini',	False	True

	v_avg_spec	v_avg_prec	v_avg_rec	v_hyp_para	scaler	v_SM_RU
				'min_samples_leaf': 0.1225, 'max_features': 5}		
523	0.791801	0.622309	0.974177	{'max_depth': 5, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 5}	False	True
527	0.791801	0.622309	0.974177	{'max_depth': 5, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 5}	False	True
531	0.791801	0.622309	0.974177	{'max_depth': 5, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 5}	False	True
535	0.791801	0.622309	0.974177	{'max_depth': 5, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 5}	False	True
539	0.791801	0.622309	0.974177	{'max_depth': 5, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 5}	False	True
543	0.791801	0.622309	0.974177	{'max_depth': 5, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 5}	False	True
547	0.791801	0.622309	0.974177	{'max_depth': 5, 'min_samples_split': 0.1, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 5}	False	True
551	0.791801	0.622309	0.974177	{'max_depth': 5, 'min_samples_split': 0.1, 'criterion':	False	True

	v_avg_spec	v_avg_prec	v_avg_rec	v_hyp_para	scaler	v_SM_RU
				'gini', 'min_samples_leaf': 0.1425, 'max_features': 5}		
555	0.791801	0.622309	0.974177	{'max_depth': 5, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 5}	False	True
559	0.791801	0.622309	0.974177	{'max_depth': 5, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 5}	False	True
563	0.791801	0.622309	0.974177	{'max_depth': 5, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 5}	False	True
567	0.791801	0.622309	0.974177	{'max_depth': 5, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1225, 'max_features': 5}	False	True
571	0.791801	0.622309	0.974177	{'max_depth': 5, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1325, 'max_features': 5}	False	True
575	0.791801	0.622309	0.974177	{'max_depth': 5, 'min_samples_split': 0.15, 'criterion': 'gini', 'min_samples_leaf': 0.1425, 'max_features': 5}	False	True

Sorting by precision immediately takes us to a well-balanced specificty/precision/recal instance.

Optimizing for Specificity and Precision, without sacrificing too much recall, we have located an instance where the following average validation set scores are achieved:

1. Specificity: 98.6774%
2. Precision: 95.5633%
3. Recal: 80.6682%

This was achieved through the following:

Data Preprocessing:

1. Scaler: None
2. Data distribution normalization through Box-Cox and Log transformation: False
3. Class imbalance redistribution through SMOTE and Random Undersampling: True

Model Hyperparameter Tuning:

1. max_depth= 2
2. min_samples_split= 0.05
3. criterion= gini
4. min_samples_leaf= 0.1425
5. max_features= 4

Display the results of the optimized Decision Tree model and compare to previous best model

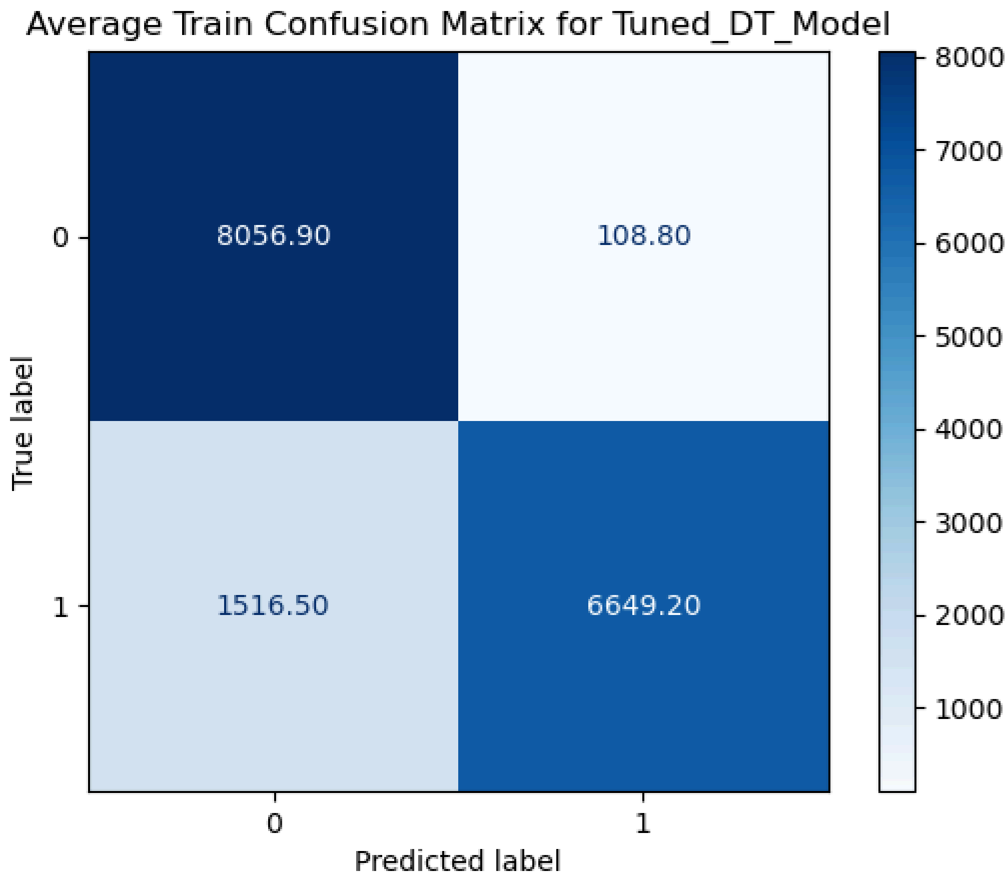
In [31]:
```
model_kwargs= {'max_depth': 2, 'min_samples_split': 0.05,
               'criterion': 'gini', 'min_samples_leaf': 0.1425,
               'max_features': 4}

print(model_kwargs)
#instantiate the class
Tuned_DT_Model_Results= ModelWithCV(model_instantiator= DecisionTreeClassifi
                    model_name= 'Tuned_DT_Model',
                    X= X_train,
                    y= y_train,
                    scaler= False,
                    smote_and_rand_und= True,
                    model_kwargs= model_kwargs)

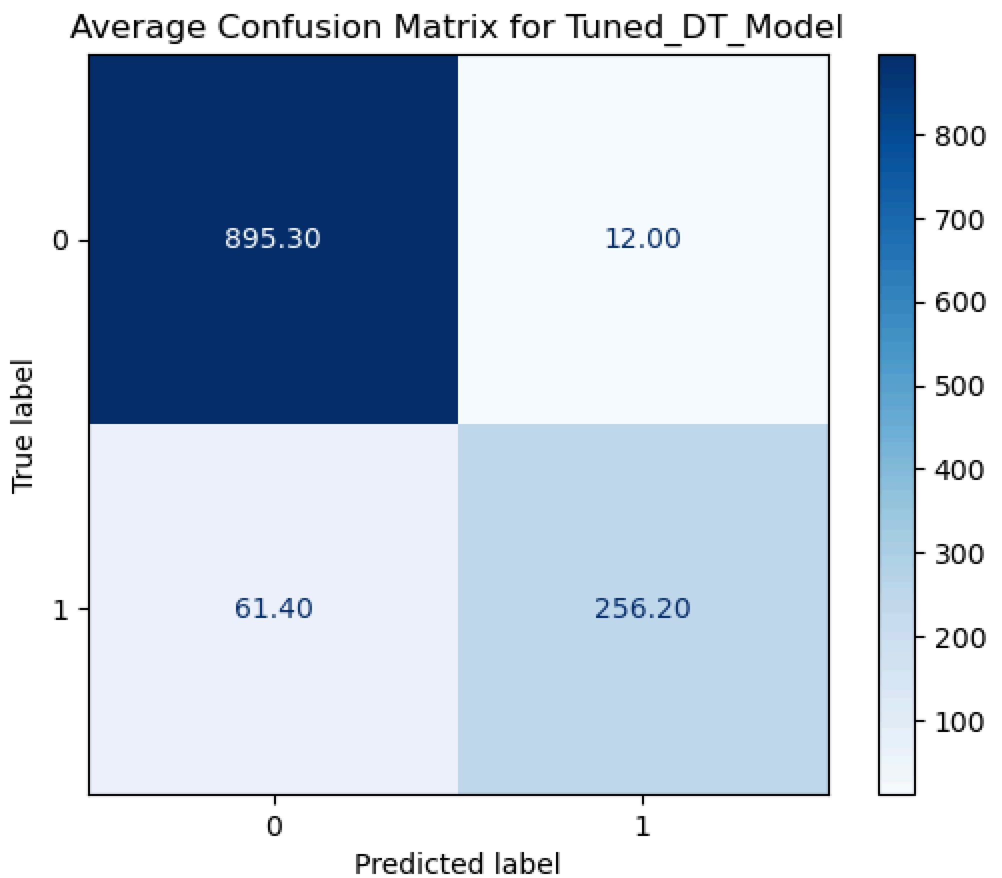
Tuned_DT_Model_Results.plot_avg_conf_matrix()

print('results for Tuned DT:')
Tuned_DT_Model_Results.print_cv_summary()
print()
print('results for Tuned LR(previous best model):')
Tuned_LR_Model_Results.print_cv_summary()
```

```
{'max_depth': 2, 'min_samples_split': 0.05, 'criterion': 'gini', 'min_sample
s_leaf': 0.1425, 'max_features': 4}
SMOTEing and Randomly Undersampling
```



Average Train Confusion Matrix for Tuned_DT_Model
8056.90
108.80
1516.50
6649.20
True label
Predicted label
0
1
8000
7000
6000
5000
4000
3000
2000
1000



Average Confusion Matrix for Tuned_DT_Model
895.30
12.00
61.40
256.20
True label
Predicted label
0
1
800
700
600
500
400
300
200
100

```
results for Tuned DT:
###TRAIN###
CV results for Tuned_DT_Model model:Average specificity: 0.98668
Average precision: 0.98390
Average recall: 0.81428
###VAL###
CV results for Tuned_DT_Model model:Average specificity: 0.98677
Average precision: 0.95563
Average recall: 0.80668

results for Tuned LR(previous best model):
###TRAIN###
CV results for Tuned_LR_Model model:Average specificity: 0.98004
Average precision: 0.93440
Average recall: 0.81224
###VAL###
CV results for Tuned_LR_Model model:Average specificity: 0.97983
Average precision: 0.93396
Average recall: 0.81172
```

```
Out[31]: (0.9798307583212313,
 0.9339614675372335,
 0.8117195405035416,
 {'C': 10, 'solver': 'liblinear', 'fit_intercept': True, 'penalty': 'l2'},
 False,
 False)
```

We can see that this new tuned Decision Tree model is performing better than the previous most effective model (Tuned Logistic Regression). Not only did this tuned model get rid of most of the baseline Decision Tree's overfitting, but its validation specificity improved by almost 1% over the previous best model, and its precision improved over 2% over the previous best model. The only downside is that recal took about an 0.05% hit compared to the previous best model, but given the manufacturer's context for efficiency (maximize specificity and precision), this is an acceptable loss.

This is now considered the most effective model given the context.

Now lets run this new best model on the X_test data hold out we saved from the original train test split, and evaluate the results.

Run this final tuned Decision Tree Model on the X_test data holdout and evaluate the results

I created a new model evaluating class by modifying the above ModelWithCv class so that it runs any inputted model on the final X_test data, instead of using Stratified K-fold Cross Validation on the training data, while keeping most other class features and functionality constant. This class will also be able to produce an accuracy score, which is not 100% relevant to the manufacturer's requested success metrics, but could still be interesting to know. I also removed the scaler input because the model we will be plugging into this will not be using scaling data preprocessing.

In [26]:
```
class Model_with_final():
    #initialize the instance of the class
    def __init__(self, model_instantiator, model_name, X_tr, y_tr, X_te, y_t
                 smote_and_rand_und= False, model_kwargs = {}):
        self.model_instatiator = model_instantiator
        self.model = None
        self.name = model_name
        self.model_kwargs = model_kwargs
        self.X_train = X_tr
        self.y_train = y_tr
        self.X_test = X_te
        self.y_test = y_te
        self.smote_and_rand_und= smote_and_rand_und
        self.model_kwargs = model_kwargs
        self.final_results = None
        self.final_accuracy = None
        self.final_specificity = None
        self.final_precision = None
        self.final_recall = None
        self.final_conf_matrix = None
        self.train_and_evaluate()

    #train the model and evaluate it on the test data
    def train_and_evaluate(self):

        #instantiate the model, make sure random_state is set to 24 for repr
        self.model = self.model_instatiator(random_state= 24, **self.model_k

        #SMOTE and Randomly Undersample the date
        if self.smote_and_rand_und:
            print('SMOTEing and Randomly Undersampling')
            smote = SMOTE(sampling_strategy='auto', random_state=24)
            undersample = RandomUnderSampler(sampling_strategy='auto', rando
            pipeline = Pipeline(steps=[('smote', smote), ('undersample', unc

            X_train, y_train = pipeline.fit_resample(self.X_train, self.y_tr

        self.model.fit(X_train, y_train)

        #make test set predictions
        y_pred = self.model.predict(self.X_test)

        #make test accuracy score
        self.final_accuracy = accuracy_score(self.y_test, y_pred)

        #make test confusion matrix
        self.final_conf_matrix = confusion_matrix(self.y_test, y_pred)

        #make test performance scores
        TN, FP, FN, TP = self.final_conf_matrix.ravel()
        self.final_specificity = TN / (TN + FP)
        self.final_precision = precision_score(self.y_test, y_pred)
```

```
        self.final_recall = recall_score(self.y_test, y_pred)
        self.final_results = {'Accuracy': self.final_accuracy,
            'Specificity': self.final_specificity,
            'Precision': self.final_precision,
            'Recall': self.final_recall}

    #print the performance scores of the test set
    def print_final_summary(self):
        print(f"Final results for {self.name} model on X_test:")
        print(f"Accuracy: {self.final_accuracy:.5f}")
        print(f"Specificity: {self.final_specificity:.5f}")
        print(f"Precision: {self.final_precision:.5f}")
        print(f"Recall: {self.final_recall:.5f}")

    #print the confusion matrix of the test set
    def plot_conf_matrix(self):
        if self.final_conf_matrix is not None:
            disp = ConfusionMatrixDisplay(confusion_matrix=self.final_conf_m
            disp.plot(cmap=plt.cm.Blues, values_format='.2f')
            plt.title(f"Confusion Matrix for {self.name} on X_test")
            plt.show()
```

Input the final model details into the new X_test model evaluator:

model_instantiator= DecisionTreeClassifier

Data Preprocessing:

1. Scaler: None
2. Data distribution normalization through Box-Cox and Log transformation: False
3. Class imbalance redistribution through SMOTE and Random Undersampling: True

Model Hyperparameter Tuning:

1. max_depth= 2
2. min_samples_split= 0.05
3. criterion= gini
4. min_samples_leaf= 0.1425
5. max_features= 4

In [27]:
```
model_kwargs= {'max_depth': 2, 'min_samples_split': 0.05,
               'criterion': 'gini', 'min_samples_leaf': 0.1425,
               'max_features': 4}

Final_Model_Results= Model_with_final(model_instantiator= DecisionTreeClassi
                                    model_name= 'Final_Model: Smoted/Randoml
                                    X_tr = X_train,
                                    y_tr = y_train,
                                     X_te = X_test,
```

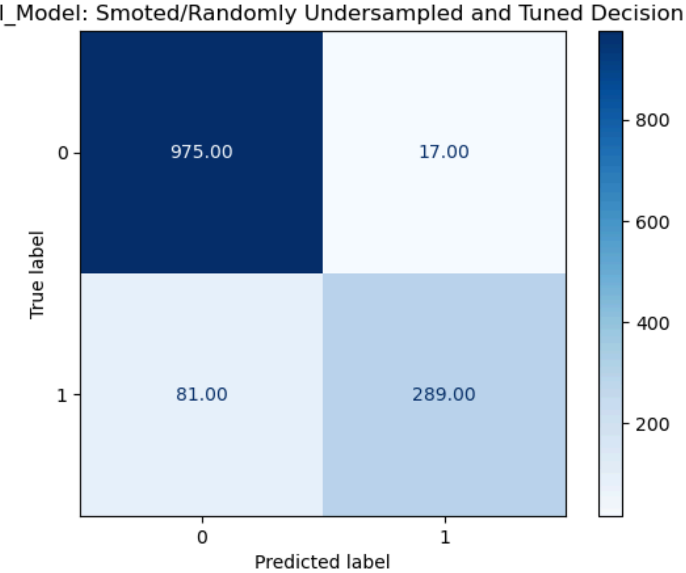
```
                                              y_te = y_test,
                                              smote_and_rand_und= True,
                                              model_kwargs= model_kwargs)

Final_Model_Results.plot_conf_matrix()

Final_Model_Results.print_final_summary()
```

```
SMOTEing and Randomly Undersampling
```

Confusion Matrix for Final_Model: Smoted/Randomly Undersampled and Tuned Decision Tree model on X_test




```
Final results for Final_Model: Smoted/Randomly Undersampled and Tuned Decisi
on Tree model model on X_test:
Accuracy: 0.92805
Specificity: 0.98286
Precision: 0.94444
Recall: 0.78108
```

Conclusions

My conclusion from the meta-analysis is that this food manufacturer could use binary classification via supervised machine learning in their production line to start to implement process automation that would cut down on manual labor time and potentially improve their manufacturing efficiency.

In this specific test case area of concern, the Tuned Decision Tree Binary classification model can be used to separate Dermason beans from the mixture of other 6 other beans as the batch heads down the conveyor belt. If the classifier determines the bean is indeed a Dermason bean, an actuated pusher could be utilized to push the bean off of the belt and over to the Dermason processing area.

Since Speceficity and Precision were the requested optimized metrics for success, and recal being the metric with the highest allowable error rate, we can say the following:

1. Given this model's Specificity rating of 98.286% on the testing data we can say that this model is extremely good at determining what is not a Dermason bean. This means that less than 2% of the time, a non-Dermason bean is incorrectly classified as a Dermason bean.

2. Given this model's precision rating of 94.444% on the testing data, we can say that when the model predicts a bean to be a Dermason bean, there is a high likelihood that it actually is a Dermason bean. This means that out of all the beans the model predicts as Dermason, less than 6% are actually non-Dermason beans.

3. Given this model's Recal rating of 78.108% on the testing data we can say that the model is decent at being able to identify all of the dermason beans going down the conveyor belt. This means that out of all the beans going down the conveyor that are actually Dermason beans, the model will correctly classify slightly over 78% of those beans as Dermason beans. Even though this score is not bad, it is still lower than the model's extremely high Specificity and Precision scores, but in this context that is okay because we would rather minimize the errors for beans that are classified as Dermason beans, and all beans not distinctly identified as a specific classification will be sent to the mixed batch process location where they can still be sold for a profit.

To deal with the small percentage of beans that are incorrectly classified as Dermason beans after going through the Decision Tree classification process, the manufacturer could put these beans through a second manual double-checking filter to remove the small number of incorrect classifications, thus significantly cutting down the time and effort put into manual sorting on the production line.

Next Steps

Here are three potential next steps that the manufacturer can take to further improve their system via automation:

1. Add additional types of sensors to the bean conveyor belt. Currently, this model is only run using dimensional multivariate data from computer vision processing. Beans have many more easily quantifiable attributes like weight and color that could be taken into account when trying to classify the type of bean. Equipping the conveyor with sensors that can extract this currently unquantified data could improve the effectiveness of this model.

2. We can run deeper parameter and data pre-processing grid searches on more classification models, like K Nearest Kneighbors or Random Forest, to

see if there is an even more effective machine learning classifier that can be utilized.

3. Given more metrics and context other than product dimensions, a classification model could be created to separate the products by grade and quality. This could enable the manufacturer to seperate one product into different tears such as: Medicinal Grade, Human Consumption, Animal Consumption, and Throw Away.