MEX #7 - Geyzson Kristoffer

SN:2023-21036

https://uvle.upd.edu.ph/mod/assign/view.php?id=547271

Problem #1

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

diabetes = pd.read_csv('diabetes_data_upload.csv')
diabetes.head()
```

Out[ ]:

	Age	Gender	Polyuria	Polydipsia	sudden weight loss	weakness	Polyphagia	Genital thrush	visual blurring	Itching	Irritability	delayed healing	partial paresis	s
0	40	Male	No	Yes	No	Yes	No	No	No	Yes	No	Yes	No	
1	58	Male	No	No	No	Yes	No	No	Yes	No	No	No	Yes	
2	41	Male	Yes	No	No	Yes	Yes	No	No	Yes	No	Yes	No	
3	45	Male	No	No	Yes	Yes	Yes	Yes	No	Yes	No	Yes	No	
4	60	Male	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	

In [ ]:
```
diabetes.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 520 entries, 0 to 519
Data columns (total 17 columns):
 #   Column              Non-Null Count  Dtype 
---  ------              --------------  ----- 
 0   Age                 520 non-null    int64 
 1   Gender              520 non-null    object
 2   Polyuria            520 non-null    object
 3   Polydipsia          520 non-null    object
 4   sudden weight loss  520 non-null    object
 5   weakness            520 non-null    object
 6   Polyphagia          520 non-null    object
 7   Genital thrush      520 non-null    object
 8   visual blurring     520 non-null    object
 9   Itching             520 non-null    object
 10  Irritability        520 non-null    object
 11  delayed healing     520 non-null    object
 12  partial paresis     520 non-null    object
 13  muscle stiffness    520 non-null    object
 14  Alopecia            520 non-null    object
 15  Obesity             520 non-null    object
 16  class               520 non-null    object
dtypes: int64(1), object(16)
memory usage: 69.2+ KB
```

In [ ]:
```
import optuna
import pandas as pd
from sklearn.model_selection import cross_val_score, train_test_split
from sklearn.neural_network import MLPClassifier
from sklearn.ensemble import RandomForestClassifier
from sklearn.linear_model import LogisticRegression
from sklearn.naive_bayes import GaussianNB
from sklearn.svm import SVC
from sklearn.neighbors import KNeighborsClassifier
from sklearn.metrics import accuracy_score, f1_score
```

```
import xgboost as xgb
from sklearn.preprocessing import LabelEncoder, StandardScaler
from sklearn.metrics import make_scorer, f1_score, precision_score, recall_score
from ast import literal_eval

df = diabetes.copy()

df['class'] = df['class'].map({'Positive': 1, 'Negative': 0})
X = df.drop('class', axis=1)
y = df['class']

# 1a.
# encoding the labels and splitting the data into train and test sets
le = LabelEncoder()
X = X.apply(lambda col: le.fit_transform(col.astype(str)), axis=0, result_type='expand')

X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2, random_state=42)

scaler = StandardScaler()
X_train = scaler.fit_transform(X_train)
X_test = scaler.transform(X_test)


# running optuna
def objective(trial):
    classifier_name = trial.suggest_categorical('classifier', ['MLPClassifier', 'RandomForest', 'XGBoost', 'Logis

    if classifier_name == 'MLPClassifier':
        hidden_layer_sizes_str = trial.suggest_categorical('hidden_layer_sizes', ['(50, 50, 50)', '(50, 100, 50)
        hidden_layer_sizes = eval(hidden_layer_sizes_str)
        params = {
            'hidden_layer_sizes': hidden_layer_sizes,
            'activation': trial.suggest_categorical('activation', ['tanh', 'relu']),
            'solver': trial.suggest_categorical('solver', ['sgd', 'adam']),
            'max_iter': trial.suggest_int('max_iter', 1000, 2000),
```

```
            'batch_size': trial.suggest_int('batch_size', 1, 100),
            'learning_rate_init': trial.suggest_float('learning_rate_init', 1e-5, 1e-2),
            'alpha': trial.suggest_float('alpha', 1e-5, 1e-2),
            'shuffle': trial.suggest_categorical('shuffle', [True, False]),
            'tol': trial.suggest_float('tol', 1e-5, 1e-2),
            'momentum': trial.suggest_float('momentum', 1e-5, 1e-2),
            'early_stopping': trial.suggest_categorical('early_stopping', [True, False]),
        }
        model = MLPClassifier(**params)

    elif classifier_name == 'RandomForest':
        params = {
            'n_estimators': trial.suggest_int('n_estimators', 10, 1000),
            'max_depth': trial.suggest_int('max_depth', 1, 50),
            'criterion': trial.suggest_categorical('criterion', ['gini', 'entropy']),
            'min_samples_split': trial.suggest_int('min_samples_split', 2, 14),
            'min_samples_leaf': trial.suggest_int('min_samples_leaf', 1, 14),
            'bootstrap': trial.suggest_categorical('bootstrap', [True, False]),

        }
        model = RandomForestClassifier(**params)

    elif classifier_name == 'XGBoost':
        params = {
            'n_estimators': trial.suggest_int('n_estimators', 10, 1000),
            'max_depth': trial.suggest_int('max_depth', 1, 50),
            'learning_rate': trial.suggest_float('learning_rate', 1e-8, 1.0),
            'booster': trial.suggest_categorical('booster', ['gbtree', 'gblinear', 'dart']),
            'reg_alpha': trial.suggest_float('reg_alpha', 1e-8, 1.0),
            'reg_lambda': trial.suggest_float('reg_lambda', 1e-8, 1.0),
            'scale_pos_weight': trial.suggest_float('scale_pos_weight', 1e-6, 1e6),

        }
        model = xgb.XGBClassifier(**params)
```

```
    elif classifier_name == 'LogisticRegression':
        params = {
            'C': trial.suggest_float('C', 1e-8, 1e2),
            'max_iter': trial.suggest_int('max_iter', 1000, 2000),
        }
        model = LogisticRegression(**params)

    elif classifier_name == 'NaiveBayes':
        params = {
            'var_smoothing': trial.suggest_float('var_smoothing', 1e-8, 1e-2),
        }
        model = GaussianNB(**params)

    elif classifier_name == 'SVM':
        params = {
            'C': trial.suggest_float('C', 1e-8, 1e2),
            'kernel': trial.suggest_categorical('kernel', ['linear', 'poly', 'rbf', 'sigmoid']),
            'degree': trial.suggest_int('degree', 1, 10),
            'gamma': trial.suggest_categorical('gamma', ['scale', 'auto']),
        }
        model = SVC(**params)

    elif classifier_name == 'kNN':
        params = {
            'n_neighbors': trial.suggest_int('n_neighbors', 1, 50),
            'weights': trial.suggest_categorical('weights', ['uniform', 'distance']),
            'algorithm': trial.suggest_categorical('algorithm', ['auto', 'ball_tree', 'kd_tree', 'brute']),
            'leaf_size': trial.suggest_int('leaf_size', 1, 50),
        }
        model = KNeighborsClassifier(**params)

    f1_scorer = make_scorer(f1_score, average='weighted')
    precision_scorer = make_scorer(precision_score)
    recall_scorer = make_scorer(recall_score)
```

```
    score = cross_val_score(model, X_train, y_train, n_jobs=-1, cv=10).mean()
    return score

study = optuna.create_study(direction='maximize')
study.optimize(objective, n_trials=100)
```

```
[I 2024-01-23 04:13:03,199] A new study created in memory with name: no-name-373802b0-5de5-46d8-a3ba-862fc63116dc
[I 2024-01-23 04:13:04,083] Trial 0 finished with value: 0.9179442508710803 and parameters: {'classifier': 'RandomForest', 'n_estimators': 714, 'max_depth': 13, 'criterion': 'entropy', 'min_samples_split': 10, 'min_samples_leaf': 7, 'bootstrap': True}. Best is trial 0 with value: 0.9179442508710803.
[I 2024-01-23 04:13:04,111] Trial 1 finished with value: 0.870150987224158 and parameters: {'classifier': 'kNN', 'n_neighbors': 28, 'weights': 'uniform', 'algorithm': 'kd_tree', 'leaf_size': 8}. Best is trial 0 with value: 0.9179442508710803.
[I 2024-01-23 04:13:04,124] Trial 2 finished with value: 0.92061556329849 and parameters: {'classifier': 'LogisticRegression', 'C': 27.595157339340947, 'max_iter': 1996}. Best is trial 2 with value: 0.92061556329849.
[I 2024-01-23 04:13:09,391] Trial 3 finished with value: 0.5986062717770034 and parameters: {'classifier': 'XGBoost', 'n_estimators': 334, 'max_depth': 24, 'learning_rate': 0.0012840005839864727, 'booster': 'dart', 'reg_alpha': 0.9937318537545634, 'reg_lambda': 0.42952362274475325, 'scale_pos_weight': 462376.23478665506}. Best is trial 2 with value: 0.92061556329849.
[I 2024-01-23 04:13:09,420] Trial 4 finished with value: 0.5986062717770034 and parameters: {'classifier': 'XGBoost', 'n_estimators': 87, 'max_depth': 33, 'learning_rate': 0.012497103059991016, 'booster': 'gbtree', 'reg_alpha': 0.6783680116086803, 'reg_lambda': 0.21517235739232524, 'scale_pos_weight': 917579.8056591077}. Best is trial 2 with value: 0.92061556329849.
[I 2024-01-23 04:13:14,958] Trial 5 finished with value: 0.9591173054587688 and parameters: {'classifier': 'XGBoost', 'n_estimators': 338, 'max_depth': 23, 'learning_rate': 0.9940632260094652, 'booster': 'dart', 'reg_alpha': 0.5798397611120658, 'reg_lambda': 0.4914104804487928, 'scale_pos_weight': 633309.4550088117}. Best is trial 5 with value: 0.9591173054587688.
[I 2024-01-23 04:13:15,882] Trial 6 finished with value: 0.9179442508710803 and parameters: {'classifier': 'RandomForest', 'n_estimators': 870, 'max_depth': 30, 'criterion': 'gini', 'min_samples_split': 6, 'min_samples_leaf': 8, 'bootstrap': True}. Best is trial 5 with value: 0.9591173054587688.
[I 2024-01-23 04:13:15,905] Trial 7 finished with value: 0.8990127758420442 and parameters: {'classifier': 'kNN', 'n_neighbors': 22, 'weights': 'uniform', 'algorithm': 'brute', 'leaf_size': 45}. Best is trial 5 with value: 0.9591173054587688.
[I 2024-01-23 04:13:15,919] Trial 8 finished with value: 0.9686411149825783 and parameters: {'classifier': 'SVM', 'C': 73.51594749868863, 'kernel': 'poly', 'degree': 5, 'gamma': 'scale'}. Best is trial 8 with value: 0.968641114
```

```
9825783.
[I 2024-01-23 04:13:20,941] Trial 9 finished with value: 0.9639953542392566 and parameters: {'classifier': 'XGBoo
st', 'n_estimators': 313, 'max_depth': 4, 'learning_rate': 0.2876199755500976, 'booster': 'dart', 'reg_alpha': 0.
24659677246398276, 'reg_lambda': 0.17079846006509997, 'scale_pos_weight': 676690.2918784912}. Best is trial 8 wit
h value: 0.9686411149825783.
[I 2024-01-23 04:13:20,969] Trial 10 finished with value: 0.9710220673635309 and parameters: {'classifier': 'SV
M', 'C': 96.43417346035147, 'kernel': 'poly', 'degree': 5, 'gamma': 'scale'}. Best is trial 10 with value: 0.9710
220673635309.
[I 2024-01-23 04:13:20,988] Trial 11 finished with value: 0.9710220673635309 and parameters: {'classifier': 'SV
M', 'C': 90.7267218720897, 'kernel': 'poly', 'degree': 5, 'gamma': 'scale'}. Best is trial 10 with value: 0.97102
20673635309.
[I 2024-01-23 04:13:21,021] Trial 12 finished with value: 0.9685830429732871 and parameters: {'classifier': 'SV
M', 'C': 99.54200737713865, 'kernel': 'poly', 'degree': 5, 'gamma': 'scale'}. Best is trial 10 with value: 0.9710
220673635309.
[I 2024-01-23 04:13:21,037] Trial 13 finished with value: 0.8939024390243903 and parameters: {'classifier': 'Naiv
eBayes', 'var_smoothing': 0.00013479211664677287}. Best is trial 10 with value: 0.9710220673635309.
[I 2024-01-23 04:13:21,108] Trial 14 finished with value: 0.9469221835075494 and parameters: {'classifier': 'MLPC
lassifier', 'hidden_layer_sizes': '(100,)', 'activation': 'relu', 'solver': 'adam', 'max_iter': 1002, 'batch_siz
e': 76, 'learning_rate_init': 0.0024767269178855855, 'alpha': 0.007138348007408606, 'shuffle': False, 'tol': 0.00
795054654016143, 'momentum': 0.0009965656662591794, 'early_stopping': False}. Best is trial 10 with value: 0.9710
220673635309.
[I 2024-01-23 04:13:21,140] Trial 15 finished with value: 0.9519744483159116 and parameters: {'classifier': 'SV
M', 'C': 94.47920457864966, 'kernel': 'poly', 'degree': 4, 'gamma': 'auto'}. Best is trial 10 with value: 0.97102
20673635309.
[I 2024-01-23 04:13:21,160] Trial 16 finished with value: 0.966376306620209 and parameters: {'classifier': 'SVM',
'C': 61.94501298972159, 'kernel': 'rbf', 'degree': 10, 'gamma': 'scale'}. Best is trial 10 with value: 0.97102206
73635309.
[I 2024-01-23 04:13:21,177] Trial 17 finished with value: 0.8557491289198607 and parameters: {'classifier': 'SV
M', 'C': 80.9560249298696, 'kernel': 'sigmoid', 'degree': 2, 'gamma': 'scale'}. Best is trial 10 with value: 0.97
10220673635309.
[I 2024-01-23 04:13:22,733] Trial 18 finished with value: 0.925377468060395 and parameters: {'classifier': 'MLPCl
assifier', 'hidden_layer_sizes': '(50, 50, 50)', 'activation': 'tanh', 'solver': 'sgd', 'max_iter': 1470, 'batch_
size': 1, 'learning_rate_init': 0.00862995805813607, 'alpha': 1.3933523101907971e-05, 'shuffle': True, 'tol': 0.0
006177330016998673, 'momentum': 0.009562491701479419, 'early_stopping': True}. Best is trial 10 with value: 0.971
0220673635309.
```

```
[I 2024-01-23 04:13:22,749] Trial 19 finished with value: 0.8939024390243903 and parameters: {'classifier': 'Naiv
eBayes', 'var_smoothing': 0.009165371071985104}. Best is trial 10 with value: 0.9710220673635309.
[I 2024-01-23 04:13:22,766] Trial 20 finished with value: 0.92061556329849 and parameters: {'classifier': 'Logist
icRegression', 'C': 36.67117032298361, 'max_iter': 1973}. Best is trial 10 with value: 0.9710220673635309.
[I 2024-01-23 04:13:22,796] Trial 21 finished with value: 0.9471544715447155 and parameters: {'classifier': 'SV
M', 'C': 69.78571057887373, 'kernel': 'poly', 'degree': 6, 'gamma': 'scale'}. Best is trial 10 with value: 0.9710
220673635309.
[I 2024-01-23 04:13:23,075] Trial 22 finished with value: 0.9182346109175377 and parameters: {'classifier': 'SV
M', 'C': 82.8466649302196, 'kernel': 'linear', 'degree': 6, 'gamma': 'scale'}. Best is trial 10 with value: 0.971
0220673635309.
[I 2024-01-23 04:13:23,107] Trial 23 finished with value: 0.9544134727061557 and parameters: {'classifier': 'SV
M', 'C': 6.2877245128346, 'kernel': 'poly', 'degree': 4, 'gamma': 'scale'}. Best is trial 10 with value: 0.971022
0673635309.
[I 2024-01-23 04:13:23,138] Trial 24 finished with value: 0.9638211382113824 and parameters: {'classifier': 'SV
M', 'C': 82.90986332822709, 'kernel': 'poly', 'degree': 7, 'gamma': 'auto'}. Best is trial 10 with value: 0.97102
20673635309.
[I 2024-01-23 04:13:23,158] Trial 25 finished with value: 0.9663182346109178 and parameters: {'classifier': 'SV
M', 'C': 99.12994388372402, 'kernel': 'poly', 'degree': 3, 'gamma': 'scale'}. Best is trial 10 with value: 0.9710
220673635309.
[I 2024-01-23 04:13:23,190] Trial 26 finished with value: 0.9638211382113824 and parameters: {'classifier': 'SV
M', 'C': 63.55851884552162, 'kernel': 'poly', 'degree': 7, 'gamma': 'scale'}. Best is trial 10 with value: 0.9710
220673635309.
[I 2024-01-23 04:13:23,208] Trial 27 finished with value: 0.966376306620209 and parameters: {'classifier': 'SVM',
'C': 81.97649644949229, 'kernel': 'rbf', 'degree': 5, 'gamma': 'scale'}. Best is trial 10 with value: 0.971022067
3635309.
[I 2024-01-23 04:13:23,223] Trial 28 finished with value: 0.8939024390243903 and parameters: {'classifier': 'Naiv
eBayes', 'var_smoothing': 0.003329390336711483}. Best is trial 10 with value: 0.9710220673635309.
[I 2024-01-23 04:13:24,108] Trial 29 finished with value: 0.9614401858304298 and parameters: {'classifier': 'Rand
omForest', 'n_estimators': 979, 'max_depth': 46, 'criterion': 'gini', 'min_samples_split': 14, 'min_samples_lea
f': 1, 'bootstrap': False}. Best is trial 10 with value: 0.9710220673635309.
[I 2024-01-23 04:13:24,183] Trial 30 finished with value: 0.5508710801393727 and parameters: {'classifier': 'MLPC
lassifier', 'hidden_layer_sizes': '(50, 100, 50)', 'activation': 'relu', 'solver': 'sgd', 'max_iter': 1004, 'batc
h_size': 97, 'learning_rate_init': 0.00012171273176739359, 'alpha': 0.00964332514629751, 'shuffle': False, 'tol':
0.0027981558399986493, 'momentum': 0.006267733578798022, 'early_stopping': False}. Best is trial 10 with value:
0.9710220673635309.
```

```
[I 2024-01-23 04:13:24,201] Trial 31 finished with value: 0.9685830429732871 and parameters: {'classifier': 'SV
M', 'C': 97.78444586092463, 'kernel': 'poly', 'degree': 5, 'gamma': 'scale'}. Best is trial 10 with value: 0.9710
220673635309.
[I 2024-01-23 04:13:24,219] Trial 32 finished with value: 0.9278745644599304 and parameters: {'classifier': 'kN
N', 'n_neighbors': 50, 'weights': 'distance', 'algorithm': 'auto', 'leaf_size': 1}. Best is trial 10 with value:
0.9710220673635309.
[I 2024-01-23 04:13:24,238] Trial 33 finished with value: 0.9519744483159116 and parameters: {'classifier': 'SV
M', 'C': 89.92001046382018, 'kernel': 'poly', 'degree': 4, 'gamma': 'scale'}. Best is trial 10 with value: 0.9710
220673635309.
[I 2024-01-23 04:13:24,257] Trial 34 finished with value: 0.92061556329849 and parameters: {'classifier': 'Logist
icRegression', 'C': 72.49985847100943, 'max_iter': 1470}. Best is trial 10 with value: 0.9710220673635309.
[I 2024-01-23 04:13:24,286] Trial 35 finished with value: 0.9662020905923345 and parameters: {'classifier': 'SV
M', 'C': 99.64487348811114, 'kernel': 'poly', 'degree': 7, 'gamma': 'scale'}. Best is trial 10 with value: 0.9710
220673635309.
[I 2024-01-23 04:13:24,834] Trial 36 finished with value: 0.9155052264808363 and parameters: {'classifier': 'Rand
omForest', 'n_estimators': 637, 'max_depth': 45, 'criterion': 'entropy', 'min_samples_split': 2, 'min_samples_lea
f': 14, 'bootstrap': False}. Best is trial 10 with value: 0.9710220673635309.
[I 2024-01-23 04:13:24,852] Trial 37 finished with value: 0.8389082462253195 and parameters: {'classifier': 'SV
M', 'C': 87.26802061203433, 'kernel': 'sigmoid', 'degree': 5, 'gamma': 'scale'}. Best is trial 10 with value: 0.9
710220673635309.
[I 2024-01-23 04:13:24,871] Trial 38 finished with value: 0.9542973286875727 and parameters: {'classifier': 'kN
N', 'n_neighbors': 4, 'weights': 'distance', 'algorithm': 'ball_tree', 'leaf_size': 50}. Best is trial 10 with va
lue: 0.9710220673635309.
[I 2024-01-23 04:13:24,889] Trial 39 finished with value: 0.92061556329849 and parameters: {'classifier': 'Logist
icRegression', 'C': 52.37274527985346, 'max_iter': 1770}. Best is trial 10 with value: 0.9710220673635309.
/opt/homebrew/lib/python3.11/site-packages/xgboost/core.py:160: UserWarning: [04:13:24] WARNING: /Users/runner/wo
rk/xgboost/xgboost/src/learner.cc:742:
Parameters: { "max_depth" } are not used.

  warnings.warn(smsg, UserWarning)
/opt/homebrew/lib/python3.11/site-packages/xgboost/core.py:160: UserWarning: [04:13:24] WARNING: /Users/runner/wo
rk/xgboost/xgboost/src/learner.cc:742:
Parameters: { "max_depth" } are not used.

  warnings.warn(smsg, UserWarning)
```

```
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rk/xgboost/xgboost/src/learner.cc:742:
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/opt/homebrew/lib/python3.11/site-packages/xgboost/core.py:160: UserWarning: [04:13:24] WARNING: /Users/runner/wo
rk/xgboost/xgboost/src/learner.cc:742:
Parameters: { "max_depth" } are not used.

  warnings.warn(smsg, UserWarning)
```

```
/opt/homebrew/lib/python3.11/site-packages/xgboost/core.py:160: UserWarning: [04:13:24] WARNING: /Users/runner/wo
rk/xgboost/xgboost/src/learner.cc:742:
Parameters: { "max_depth" } are not used.

  warnings.warn(smsg, UserWarning)
[I 2024-01-23 04:13:24,913] Trial 40 finished with value: 0.5986062717770034 and parameters: {'classifier': 'XGBo
ost', 'n_estimators': 39, 'max_depth': 2, 'learning_rate': 0.8146896273322293, 'booster': 'gblinear', 'reg_alph
a': 0.07872244467904588, 'reg_lambda': 0.9996731136398155, 'scale_pos_weight': 103776.46166460915}. Best is trial
10 with value: 0.9710220673635309.
[I 2024-01-23 04:13:24,931] Trial 41 finished with value: 0.9685830429732871 and parameters: {'classifier': 'SV
M', 'C': 99.2835353925193, 'kernel': 'poly', 'degree': 5, 'gamma': 'scale'}. Best is trial 10 with value: 0.97102
20673635309.
[I 2024-01-23 04:13:24,950] Trial 42 finished with value: 0.9710220673635309 and parameters: {'classifier': 'SV
M', 'C': 90.09819764223954, 'kernel': 'poly', 'degree': 5, 'gamma': 'scale'}. Best is trial 10 with value: 0.9710
220673635309.
[I 2024-01-23 04:13:24,969] Trial 43 finished with value: 0.9447154471544718 and parameters: {'classifier': 'SV
M', 'C': 89.61001982050523, 'kernel': 'poly', 'degree': 6, 'gamma': 'scale'}. Best is trial 10 with value: 0.9710
220673635309.
[I 2024-01-23 04:13:24,987] Trial 44 finished with value: 0.9567363530778163 and parameters: {'classifier': 'SV
M', 'C': 75.15985283010198, 'kernel': 'poly', 'degree': 4, 'gamma': 'auto'}. Best is trial 10 with value: 0.97102
20673635309.
[I 2024-01-23 04:13:25,214] Trial 45 finished with value: 0.9182346109175377 and parameters: {'classifier': 'SV
M', 'C': 88.9331350739514, 'kernel': 'linear', 'degree': 3, 'gamma': 'scale'}. Best is trial 10 with value: 0.971
0220673635309.
[I 2024-01-23 04:13:25,285] Trial 46 finished with value: 0.9542973286875724 and parameters: {'classifier': 'XGBo
ost', 'n_estimators': 565, 'max_depth': 13, 'learning_rate': 0.5191349784387113, 'booster': 'gbtree', 'reg_alph
a': 0.9866009840324559, 'reg_lambda': 0.8649399062559022, 'scale_pos_weight': 79369.31396094809}. Best is trial 1
0 with value: 0.9710220673635309.
[I 2024-01-23 04:13:26,134] Trial 47 finished with value: 0.9468641114982578 and parameters: {'classifier': 'Rand
omForest', 'n_estimators': 759, 'max_depth': 38, 'criterion': 'gini', 'min_samples_split': 14, 'min_samples_lea
f': 1, 'bootstrap': True}. Best is trial 10 with value: 0.9710220673635309.
[I 2024-01-23 04:13:26,165] Trial 48 finished with value: 0.9470963995354239 and parameters: {'classifier': 'SV
M', 'C': 90.73597620423888, 'kernel': 'poly', 'degree': 6, 'gamma': 'scale'}. Best is trial 10 with value: 0.9710
220673635309.
[I 2024-01-23 04:13:26,323] Trial 49 finished with value: 0.9423344947735192 and parameters: {'classifier': 'MLPC
```

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lassifier', 'hidden_layer_sizes': '(50, 100, 50)', 'activation': 'tanh', 'solver': 'adam', 'max_iter': 1259, 'bat
ch_size': 22, 'learning_rate_init': 0.009520102316764527, 'alpha': 0.0017542108464353896, 'shuffle': True, 'tol':
0.009979338714018437, 'momentum': 0.0003880290079186369, 'early_stopping': True}. Best is trial 10 with value: 0.
9710220673635309.
[I 2024-01-23 04:13:26,339] Trial 50 finished with value: 0.8939024390243903 and parameters: {'classifier': 'Naiv
eBayes', 'var_smoothing': 0.009414374010277098}. Best is trial 10 with value: 0.9710220673635309.
[I 2024-01-23 04:13:26,359] Trial 51 finished with value: 0.9710220673635309 and parameters: {'classifier': 'SV
M', 'C': 94.85315003648734, 'kernel': 'poly', 'degree': 5, 'gamma': 'scale'}. Best is trial 10 with value: 0.9710
220673635309.
[I 2024-01-23 04:13:26,378] Trial 52 finished with value: 0.9710220673635309 and parameters: {'classifier': 'SV
M', 'C': 91.66677133378234, 'kernel': 'poly', 'degree': 5, 'gamma': 'scale'}. Best is trial 10 with value: 0.9710
220673635309.
[I 2024-01-23 04:13:26,397] Trial 53 finished with value: 0.9686411149825783 and parameters: {'classifier': 'SV
M', 'C': 77.78517424792732, 'kernel': 'poly', 'degree': 5, 'gamma': 'scale'}. Best is trial 10 with value: 0.9710
220673635309.
[I 2024-01-23 04:13:26,416] Trial 54 finished with value: 0.9519744483159116 and parameters: {'classifier': 'SV
M', 'C': 91.68475246719163, 'kernel': 'poly', 'degree': 4, 'gamma': 'scale'}. Best is trial 10 with value: 0.9710
220673635309.
[I 2024-01-23 04:13:26,443] Trial 55 finished with value: 0.9447154471544718 and parameters: {'classifier': 'SV
M', 'C': 85.09781706637078, 'kernel': 'poly', 'degree': 6, 'gamma': 'scale'}. Best is trial 10 with value: 0.9710
220673635309.
[I 2024-01-23 04:13:26,471] Trial 56 finished with value: 0.9710220673635309 and parameters: {'classifier': 'SV
M', 'C': 93.04124133422152, 'kernel': 'poly', 'degree': 5, 'gamma': 'scale'}. Best is trial 10 with value: 0.9710
220673635309.
[I 2024-01-23 04:13:26,490] Trial 57 finished with value: 0.935075493612079 and parameters: {'classifier': 'kNN',
'n_neighbors': 49, 'weights': 'distance', 'algorithm': 'ball_tree', 'leaf_size': 30}. Best is trial 10 with valu
e: 0.9710220673635309.
[I 2024-01-23 04:13:26,509] Trial 58 finished with value: 0.966376306620209 and parameters: {'classifier': 'SVM',
'C': 91.59310943856241, 'kernel': 'rbf', 'degree': 3, 'gamma': 'scale'}. Best is trial 10 with value: 0.971022067
3635309.
[I 2024-01-23 04:13:26,782] Trial 59 finished with value: 0.9182346109175377 and parameters: {'classifier': 'SV
M', 'C': 93.93296419487285, 'kernel': 'linear', 'degree': 4, 'gamma': 'auto'}. Best is trial 10 with value: 0.971
0220673635309.
[I 2024-01-23 04:13:26,810] Trial 60 finished with value: 0.96869918699187 and parameters: {'classifier': 'SVM',
'C': 19.630739502460585, 'kernel': 'poly', 'degree': 5, 'gamma': 'scale'}. Best is trial 10 with value: 0.9710220
```

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673635309.
[I 2024-01-23 04:13:26,829] Trial 61 finished with value: 0.96869918699187 and parameters: {'classifier': 'SVM',
'C': 10.083410339182677, 'kernel': 'poly', 'degree': 5, 'gamma': 'scale'}. Best is trial 10 with value: 0.9710220
673635309.
[I 2024-01-23 04:13:26,848] Trial 62 finished with value: 0.96869918699187 and parameters: {'classifier': 'SVM',
'C': 30.854412838358915, 'kernel': 'poly', 'degree': 5, 'gamma': 'scale'}. Best is trial 10 with value: 0.9710220
673635309.
[I 2024-01-23 04:13:26,878] Trial 63 finished with value: 0.9519744483159119 and parameters: {'classifier': 'SV
M', 'C': 20.133069442534865, 'kernel': 'poly', 'degree': 6, 'gamma': 'scale'}. Best is trial 10 with value: 0.971
0220673635309.
[I 2024-01-23 04:13:26,896] Trial 64 finished with value: 0.96869918699187 and parameters: {'classifier': 'SVM',
'C': 46.013667848859654, 'kernel': 'poly', 'degree': 5, 'gamma': 'scale'}. Best is trial 10 with value: 0.9710220
673635309.
[I 2024-01-23 04:13:26,912] Trial 65 finished with value: 0.92061556329849 and parameters: {'classifier': 'Logist
icRegression', 'C': 95.23655424463293, 'max_iter': 1735}. Best is trial 10 with value: 0.9710220673635309.
[I 2024-01-23 04:13:26,926] Trial 66 finished with value: 0.8939024390243903 and parameters: {'classifier': 'Naiv
eBayes', 'var_smoothing': 0.005142837300311034}. Best is trial 10 with value: 0.9710220673635309.
[I 2024-01-23 04:13:26,945] Trial 67 finished with value: 0.8556910569105691 and parameters: {'classifier': 'SV
M', 'C': 19.683965379358327, 'kernel': 'sigmoid', 'degree': 4, 'gamma': 'scale'}. Best is trial 10 with value: 0.
9710220673635309.
[I 2024-01-23 04:13:27,105] Trial 68 finished with value: 0.8842044134727061 and parameters: {'classifier': 'MLPC
lassifier', 'hidden_layer_sizes': '(50, 50, 50)', 'activation': 'tanh', 'solver': 'sgd', 'max_iter': 1211, 'batch
_size': 47, 'learning_rate_init': 0.005641571114883129, 'alpha': 0.004217576740048508, 'shuffle': True, 'tol': 0.
005155703170113382, 'momentum': 0.004441792517852435, 'early_stopping': True}. Best is trial 10 with value: 0.971
0220673635309.
/opt/homebrew/lib/python3.11/site-packages/xgboost/core.py:160: UserWarning: [04:13:27] WARNING: /Users/runner/wo
rk/xgboost/xgboost/src/learner.cc:742:
Parameters: { "max_depth" } are not used.

  warnings.warn(smsg, UserWarning)
/opt/homebrew/lib/python3.11/site-packages/xgboost/core.py:160: UserWarning: [04:13:27] WARNING: /Users/runner/wo
rk/xgboost/xgboost/src/learner.cc:742:
Parameters: { "max_depth" } are not used.

  warnings.warn(smsg, UserWarning)
```

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/opt/homebrew/lib/python3.11/site-packages/xgboost/core.py:160: UserWarning: [04:13:27] WARNING: /Users/runner/wo
rk/xgboost/xgboost/src/learner.cc:742:
Parameters: { "max_depth" } are not used.

  warnings.warn(smsg, UserWarning)
/opt/homebrew/lib/python3.11/site-packages/xgboost/core.py:160: UserWarning: [04:13:27] WARNING: /Users/runner/wo
rk/xgboost/xgboost/src/learner.cc:742:
Parameters: { "max_depth" } are not used.

  warnings.warn(smsg, UserWarning)
/opt/homebrew/lib/python3.11/site-packages/xgboost/core.py:160: UserWarning: [04:13:27] WARNING: /Users/runner/wo
rk/xgboost/xgboost/src/learner.cc:742:
Parameters: { "max_depth" } are not used.

  warnings.warn(smsg, UserWarning)
/opt/homebrew/lib/python3.11/site-packages/xgboost/core.py:160: UserWarning: [04:13:27] WARNING: /Users/runner/wo
rk/xgboost/xgboost/src/learner.cc:742:
Parameters: { "max_depth" } are not used.

  warnings.warn(smsg, UserWarning)
/opt/homebrew/lib/python3.11/site-packages/xgboost/core.py:160: UserWarning: [04:13:27] WARNING: /Users/runner/wo
rk/xgboost/xgboost/src/learner.cc:742:
Parameters: { "max_depth" } are not used.

  warnings.warn(smsg, UserWarning)
/opt/homebrew/lib/python3.11/site-packages/xgboost/core.py:160: UserWarning: [04:13:27] WARNING: /Users/runner/wo
rk/xgboost/xgboost/src/learner.cc:742:
Parameters: { "max_depth" } are not used.

  warnings.warn(smsg, UserWarning)
/opt/homebrew/lib/python3.11/site-packages/xgboost/core.py:160: UserWarning: [04:13:27] WARNING: /Users/runner/wo
rk/xgboost/xgboost/src/learner.cc:742:
Parameters: { "max_depth" } are not used.

  warnings.warn(smsg, UserWarning)
```

```
/opt/homebrew/lib/python3.11/site-packages/xgboost/core.py:160: UserWarning: [04:13:27] WARNING: /Users/runner/wo
rk/xgboost/xgboost/src/learner.cc:742:
Parameters: { "max_depth" } are not used.

  warnings.warn(smsg, UserWarning)
[I 2024-01-23 04:13:27,164] Trial 69 finished with value: 0.5986062717770034 and parameters: {'classifier': 'XGBo
ost', 'n_estimators': 473, 'max_depth': 50, 'learning_rate': 0.5894205332208391, 'booster': 'gblinear', 'reg_alph
a': 0.3469830395472857, 'reg_lambda': 0.0014920764641753737, 'scale_pos_weight': 335004.61313439487}. Best is tri
al 10 with value: 0.9710220673635309.
[I 2024-01-23 04:13:27,194] Trial 70 finished with value: 0.9447154471544718 and parameters: {'classifier': 'SV
M', 'C': 85.90800760912944, 'kernel': 'poly', 'degree': 6, 'gamma': 'scale'}. Best is trial 10 with value: 0.9710
220673635309.
[I 2024-01-23 04:13:27,213] Trial 71 finished with value: 0.96869918699187 and parameters: {'classifier': 'SVM',
'C': 13.80223481981487, 'kernel': 'poly', 'degree': 5, 'gamma': 'scale'}. Best is trial 10 with value: 0.97102206
73635309.
[I 2024-01-23 04:13:27,232] Trial 72 finished with value: 0.9734610917537747 and parameters: {'classifier': 'SV
M', 'C': 2.9090105588450754, 'kernel': 'poly', 'degree': 5, 'gamma': 'scale'}. Best is trial 72 with value: 0.973
4610917537747.
[I 2024-01-23 04:13:27,263] Trial 73 finished with value: 0.9544134727061557 and parameters: {'classifier': 'SV
M', 'C': 42.37996596667249, 'kernel': 'poly', 'degree': 4, 'gamma': 'scale'}. Best is trial 72 with value: 0.9734
610917537747.
[I 2024-01-23 04:13:27,306] Trial 74 finished with value: 0.9637630662020907 and parameters: {'classifier': 'SV
M', 'C': 1.7371851438114965, 'kernel': 'poly', 'degree': 5, 'gamma': 'scale'}. Best is trial 72 with value: 0.973
4610917537747.
[I 2024-01-23 04:13:27,486] Trial 75 finished with value: 0.913124274099884 and parameters: {'classifier': 'Rando
mForest', 'n_estimators': 182, 'max_depth': 11, 'criterion': 'entropy', 'min_samples_split': 2, 'min_samples_lea
f': 14, 'bootstrap': False}. Best is trial 72 with value: 0.9734610917537747.
[I 2024-01-23 04:13:27,505] Trial 76 finished with value: 0.9470963995354239 and parameters: {'classifier': 'SV
M', 'C': 95.43481809713786, 'kernel': 'poly', 'degree': 6, 'gamma': 'scale'}. Best is trial 72 with value: 0.9734
610917537747.
[I 2024-01-23 04:13:27,525] Trial 77 finished with value: 0.9637630662020907 and parameters: {'classifier': 'SV
M', 'C': 1.87812231655775, 'kernel': 'poly', 'degree': 5, 'gamma': 'auto'}. Best is trial 72 with value: 0.973461
0917537747.
[I 2024-01-23 04:13:27,543] Trial 78 finished with value: 0.9639372822299652 and parameters: {'classifier': 'kN
N', 'n_neighbors': 1, 'weights': 'uniform', 'algorithm': 'auto', 'leaf_size': 20}. Best is trial 72 with value:
```

```
0.9734610917537747.
[I 2024-01-23 04:13:27,562] Trial 79 finished with value: 0.9567363530778163 and parameters: {'classifier': 'SV
M', 'C': 80.45068247790337, 'kernel': 'poly', 'degree': 4, 'gamma': 'scale'}. Best is trial 72 with value: 0.9734
610917537747.
[I 2024-01-23 04:13:27,581] Trial 80 finished with value: 0.966376306620209 and parameters: {'classifier': 'SVM',
'C': 56.89355418540991, 'kernel': 'rbf', 'degree': 10, 'gamma': 'scale'}. Best is trial 72 with value: 0.97346109
17537747.
[I 2024-01-23 04:13:27,599] Trial 81 finished with value: 0.96869918699187 and parameters: {'classifier': 'SVM',
'C': 10.199602932227643, 'kernel': 'poly', 'degree': 5, 'gamma': 'scale'}. Best is trial 72 with value: 0.9734610
917537747.
[I 2024-01-23 04:13:27,618] Trial 82 finished with value: 0.96869918699187 and parameters: {'classifier': 'SVM',
'C': 9.852989377604333, 'kernel': 'poly', 'degree': 5, 'gamma': 'scale'}. Best is trial 72 with value: 0.97346109
17537747.
[I 2024-01-23 04:13:27,636] Trial 83 finished with value: 0.9519744483159119 and parameters: {'classifier': 'SV
M', 'C': 18.48318881855576, 'kernel': 'poly', 'degree': 6, 'gamma': 'scale'}. Best is trial 72 with value: 0.9734
610917537747.
[I 2024-01-23 04:13:27,656] Trial 84 finished with value: 0.96869918699187 and parameters: {'classifier': 'SVM',
'C': 5.449534916151092, 'kernel': 'poly', 'degree': 5, 'gamma': 'scale'}. Best is trial 72 with value: 0.97346109
17537747.
[I 2024-01-23 04:13:27,674] Trial 85 finished with value: 0.92061556329849 and parameters: {'classifier': 'Logist
icRegression', 'C': 94.73600722461042, 'max_iter': 1668}. Best is trial 72 with value: 0.9734610917537747.
[I 2024-01-23 04:13:27,693] Trial 86 finished with value: 0.8531939605110338 and parameters: {'classifier': 'SV
M', 'C': 67.17937770043625, 'kernel': 'sigmoid', 'degree': 5, 'gamma': 'scale'}. Best is trial 72 with value: 0.9
734610917537747.
[I 2024-01-23 04:13:27,713] Trial 87 finished with value: 0.9544134727061557 and parameters: {'classifier': 'SV
M', 'C': 14.741488370300395, 'kernel': 'poly', 'degree': 4, 'gamma': 'scale'}. Best is trial 72 with value: 0.973
4610917537747.
[I 2024-01-23 04:13:27,729] Trial 88 finished with value: 0.8939024390243903 and parameters: {'classifier': 'Naiv
eBayes', 'var_smoothing': 0.0065635942890983805}. Best is trial 72 with value: 0.9734610917537747.
[I 2024-01-23 04:13:27,804] Trial 89 finished with value: 0.9639953542392569 and parameters: {'classifier': 'MLPC
lassifier', 'hidden_layer_sizes': '(100,)', 'activation': 'relu', 'solver': 'adam', 'max_iter': 1273, 'batch_siz
e': 53, 'learning_rate_init': 0.005700622685068756, 'alpha': 0.00505394857349118, 'shuffle': False, 'tol': 0.0056
091758437743205, 'momentum': 0.00968148848388958, 'early_stopping': False}. Best is trial 72 with value: 0.973461
0917537747.
[I 2024-01-23 04:13:27,834] Trial 90 finished with value: 0.9638211382113824 and parameters: {'classifier': 'SV
```

```
M', 'C': 27.704642683069313, 'kernel': 'poly', 'degree': 7, 'gamma': 'scale'}. Best is trial 72 with value: 0.973
4610917537747.
[I 2024-01-23 04:13:27,853] Trial 91 finished with value: 0.96869918699187 and parameters: {'classifier': 'SVM',
'C': 29.41524851447025, 'kernel': 'poly', 'degree': 5, 'gamma': 'scale'}. Best is trial 72 with value: 0.97346109
17537747.
[I 2024-01-23 04:13:27,871] Trial 92 finished with value: 0.96869918699187 and parameters: {'classifier': 'SVM',
'C': 32.428161703792775, 'kernel': 'poly', 'degree': 5, 'gamma': 'scale'}. Best is trial 72 with value: 0.9734610
917537747.
[I 2024-01-23 04:13:27,891] Trial 93 finished with value: 0.96869918699187 and parameters: {'classifier': 'SVM',
'C': 24.70164581031176, 'kernel': 'poly', 'degree': 5, 'gamma': 'scale'}. Best is trial 72 with value: 0.97346109
17537747.
[I 2024-01-23 04:13:27,975] Trial 94 finished with value: 0.9639372822299652 and parameters: {'classifier': 'XGBo
ost', 'n_estimators': 459, 'max_depth': 20, 'learning_rate': 0.21262116901970451, 'booster': 'gbtree', 'reg_alph
a': 0.004478368589993398, 'reg_lambda': 0.7087295921203218, 'scale_pos_weight': 995491.8979060121}. Best is trial
72 with value: 0.9734610917537747.
[I 2024-01-23 04:13:28,104] Trial 95 finished with value: 0.9182346109175377 and parameters: {'classifier': 'SV
M', 'C': 38.30714314119352, 'kernel': 'linear', 'degree': 6, 'gamma': 'scale'}. Best is trial 72 with value: 0.97
34610917537747.
[I 2024-01-23 04:13:29,151] Trial 96 finished with value: 0.9253193960511034 and parameters: {'classifier': 'Rand
omForest', 'n_estimators': 959, 'max_depth': 36, 'criterion': 'gini', 'min_samples_split': 8, 'min_samples_leaf':
8, 'bootstrap': True}. Best is trial 72 with value: 0.9734610917537747.
[I 2024-01-23 04:13:29,168] Trial 97 finished with value: 0.96869918699187 and parameters: {'classifier': 'SVM',
'C': 6.736812205057969, 'kernel': 'poly', 'degree': 5, 'gamma': 'scale'}. Best is trial 72 with value: 0.97346109
17537747.
[I 2024-01-23 04:13:29,188] Trial 98 finished with value: 0.9567363530778163 and parameters: {'classifier': 'SV
M', 'C': 86.71665705653152, 'kernel': 'poly', 'degree': 4, 'gamma': 'auto'}. Best is trial 72 with value: 0.97346
10917537747.
[I 2024-01-23 04:13:29,207] Trial 99 finished with value: 0.9400696864111499 and parameters: {'classifier': 'kN
N', 'n_neighbors': 33, 'weights': 'distance', 'algorithm': 'brute', 'leaf_size': 32}. Best is trial 72 with valu
e: 0.9734610917537747.
```

In [ ]:
```python
best_trial = study.best_trial
print(f"Best trial final score: {best_trial.value}")
for key, value in best_trial.params.items():
    print(f"{key}: {value}")
```

```
best_classifier = best_trial.params['classifier']
```

```
Best trial final score: 0.9734610917537747
classifier: SVM
C: 2.9090105588450754
kernel: poly
degree: 5
gamma: scale
```

In [ ]:
```
best_params = study.best_trial.params
best_params
```

Out[ ]:
```
{'classifier': 'SVM',
 'C': 2.9090105588450754,
 'kernel': 'poly',
 'degree': 5,
 'gamma': 'scale'}
```

In [ ]:
```
if best_params['classifier'] == 'MLPClassifier':
    model = MLPClassifier(**{k: v for k, v in best_params.items() if k != 'classifier'})
elif best_params['classifier'] == 'RandomForest':
    model = RandomForestClassifier(**{k: v for k, v in best_params.items() if k != 'classifier'})
elif best_params['classifier'] == 'XGBoost':
    model = xgb.XGBClassifier(**{k: v for k, v in best_params.items() if k != 'classifier'})
elif best_params['classifier'] == 'LogisticRegression':
    model = LogisticRegression(**{k: v for k, v in best_params.items() if k != 'classifier'})
elif best_params['classifier'] == 'NaiveBayes':
    model = GaussianNB()
elif best_params['classifier'] == 'SVM':
    model = SVC(**{k: v for k, v in best_params.items() if k != 'classifier'})
elif best_params['classifier'] == 'kNN':
    model = KNeighborsClassifier(**{k: v for k, v in best_params.items() if k != 'classifier'})

model.fit(X_train, y_train)
```

```
y_pred = model.predict(X_test)
accuracy = accuracy_score(y_test, y_pred)
f1 = f1_score(y_test, y_pred, average='weighted')
precision = precision_score(y_test, y_pred, average='weighted')
recall = recall_score(y_test, y_pred, average='weighted')

print('The accuracy of the and F1-score of the best model in the test data ')
print(f"Test Set Evaluation Metrics:\nAccuracy: {accuracy}\nF1 Score: {f1}\nPrecision: {precision}\nRecall: {reca
```

```
The accuracy of the and F1-score of the best model in the test data
Test Set Evaluation Metrics:
Accuracy: 0.9807692307692307
F1 Score: 0.980602297008547
Precision: 0.9812961011591148
Recall: 0.9807692307692307
```

In [ ]:

```
def objective2(trial):

    params = {
        'n_estimators': trial.suggest_int('n_estimators', 10, 1000),
        'max_depth': trial.suggest_int('max_depth', 1, 50),
        'criterion': trial.suggest_categorical('criterion', ['gini', 'entropy']),
        'min_samples_split': trial.suggest_int('min_samples_split', 2, 14),
        'min_samples_leaf': trial.suggest_int('min_samples_leaf', 1, 14),
        'bootstrap': trial.suggest_categorical('bootstrap', [True, False]),

    }
    model = RandomForestClassifier(**params)

    f1_scorer = make_scorer(f1_score, average='weighted')
    precision_scorer = make_scorer(precision_score)
    recall_scorer = make_scorer(recall_score)

    score = cross_val_score(model, X_train, y_train, n_jobs=-1, cv=10, scoring=f1_scorer).mean()
    return score
```

```
study2 = optuna.create_study(direction='maximize')
study2.optimize(objective2, n_trials=100)

best_trial2 = study2.best_trial
print(f"Best trial final score: {best_trial2.value}")
for key, value in best_trial2.params.items():
    print(f"{key}: {value}")
```

```
[I 2024-01-23 04:17:31,795] A new study created in memory with name: no-name-041dc1fb-a486-4389-b543-b6fe4a02ac25
[I 2024-01-23 04:17:31,914] Trial 0 finished with value: 0.9468575229369947 and parameters: {'n_estimators': 69,
'max_depth': 16, 'criterion': 'entropy', 'min_samples_split': 13, 'min_samples_leaf': 5, 'bootstrap': False}. Bes
t is trial 0 with value: 0.9468575229369947.
[I 2024-01-23 04:17:32,922] Trial 1 finished with value: 0.8937037041242073 and parameters: {'n_estimators': 969,
'max_depth': 1, 'criterion': 'gini', 'min_samples_split': 7, 'min_samples_leaf': 13, 'bootstrap': True}. Best is
trial 0 with value: 0.9468575229369947.
[I 2024-01-23 04:17:33,295] Trial 2 finished with value: 0.915081379664103 and parameters: {'n_estimators': 400,
'max_depth': 21, 'criterion': 'entropy', 'min_samples_split': 2, 'min_samples_leaf': 14, 'bootstrap': False}. Bes
t is trial 0 with value: 0.9468575229369947.
[I 2024-01-23 04:17:33,429] Trial 3 finished with value: 0.9420767735497775 and parameters: {'n_estimators': 90,
'max_depth': 49, 'criterion': 'gini', 'min_samples_split': 3, 'min_samples_leaf': 5, 'bootstrap': True}. Best is
trial 0 with value: 0.9468575229369947.
[I 2024-01-23 04:17:34,023] Trial 4 finished with value: 0.9444386624438087 and parameters: {'n_estimators': 660,
'max_depth': 50, 'criterion': 'gini', 'min_samples_split': 4, 'min_samples_leaf': 5, 'bootstrap': False}. Best is
trial 0 with value: 0.9468575229369947.
[I 2024-01-23 04:17:34,087] Trial 5 finished with value: 0.9153006353294927 and parameters: {'n_estimators': 52,
'max_depth': 29, 'criterion': 'entropy', 'min_samples_split': 7, 'min_samples_leaf': 14, 'bootstrap': False}. Bes
t is trial 0 with value: 0.9468575229369947.
[I 2024-01-23 04:17:34,870] Trial 6 finished with value: 0.9156571237145148 and parameters: {'n_estimators': 693,
'max_depth': 24, 'criterion': 'gini', 'min_samples_split': 8, 'min_samples_leaf': 9, 'bootstrap': True}. Best is
trial 0 with value: 0.9468575229369947.
[I 2024-01-23 04:17:35,308] Trial 7 finished with value: 0.9250992205872816 and parameters: {'n_estimators': 481,
'max_depth': 35, 'criterion': 'entropy', 'min_samples_split': 4, 'min_samples_leaf': 11, 'bootstrap': False}. Bes
t is trial 0 with value: 0.9468575229369947.
[I 2024-01-23 04:17:35,973] Trial 8 finished with value: 0.9395264252291453 and parameters: {'n_estimators': 697,
'max_depth': 12, 'criterion': 'entropy', 'min_samples_split': 7, 'min_samples_leaf': 8, 'bootstrap': False}. Best
```

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is trial 0 with value: 0.9468575229369947.
[I 2024-01-23 04:17:36,398] Trial 9 finished with value: 0.8988255920865594 and parameters: {'n_estimators': 389,
'max_depth': 44, 'criterion': 'gini', 'min_samples_split': 7, 'min_samples_leaf': 14, 'bootstrap': True}. Best is
trial 0 with value: 0.9468575229369947.
[I 2024-01-23 04:17:36,658] Trial 10 finished with value: 0.958714130200892 and parameters: {'n_estimators': 279,
'max_depth': 13, 'criterion': 'entropy', 'min_samples_split': 14, 'min_samples_leaf': 1, 'bootstrap': False}. Bes
t is trial 10 with value: 0.958714130200892.
[I 2024-01-23 04:17:36,866] Trial 11 finished with value: 0.958714130200892 and parameters: {'n_estimators': 230,
'max_depth': 12, 'criterion': 'entropy', 'min_samples_split': 14, 'min_samples_leaf': 1, 'bootstrap': False}. Bes
t is trial 10 with value: 0.958714130200892.
[I 2024-01-23 04:17:37,116] Trial 12 finished with value: 0.9492360968322066 and parameters: {'n_estimators': 25
9, 'max_depth': 7, 'criterion': 'entropy', 'min_samples_split': 14, 'min_samples_leaf': 1, 'bootstrap': False}. B
est is trial 10 with value: 0.958714130200892.
[I 2024-01-23 04:17:37,350] Trial 13 finished with value: 0.9636269781288869 and parameters: {'n_estimators': 23
0, 'max_depth': 10, 'criterion': 'entropy', 'min_samples_split': 11, 'min_samples_leaf': 1, 'bootstrap': False}.
Best is trial 13 with value: 0.9636269781288869.
[I 2024-01-23 04:17:37,541] Trial 14 finished with value: 0.884250831957256 and parameters: {'n_estimators': 253,
'max_depth': 2, 'criterion': 'entropy', 'min_samples_split': 11, 'min_samples_leaf': 3, 'bootstrap': False}. Best
is trial 13 with value: 0.9636269781288869.
[I 2024-01-23 04:17:37,730] Trial 15 finished with value: 0.9541216798859977 and parameters: {'n_estimators': 19
5, 'max_depth': 18, 'criterion': 'entropy', 'min_samples_split': 11, 'min_samples_leaf': 3, 'bootstrap': False}.
Best is trial 13 with value: 0.9636269781288869.
[I 2024-01-23 04:17:38,103] Trial 16 finished with value: 0.9492360968322066 and parameters: {'n_estimators': 38
4, 'max_depth': 8, 'criterion': 'entropy', 'min_samples_split': 11, 'min_samples_leaf': 3, 'bootstrap': False}. B
est is trial 13 with value: 0.9636269781288869.
[I 2024-01-23 04:17:38,621] Trial 17 finished with value: 0.958714130200892 and parameters: {'n_estimators': 570,
'max_depth': 29, 'criterion': 'entropy', 'min_samples_split': 12, 'min_samples_leaf': 1, 'bootstrap': False}. Bes
t is trial 13 with value: 0.9636269781288869.
[I 2024-01-23 04:17:39,705] Trial 18 finished with value: 0.934611649161283 and parameters: {'n_estimators': 895,
'max_depth': 8, 'criterion': 'entropy', 'min_samples_split': 9, 'min_samples_leaf': 6, 'bootstrap': True}. Best i
s trial 13 with value: 0.9636269781288869.
[I 2024-01-23 04:17:39,828] Trial 19 finished with value: 0.9636075417829199 and parameters: {'n_estimators': 13
7, 'max_depth': 15, 'criterion': 'entropy', 'min_samples_split': 10, 'min_samples_leaf': 2, 'bootstrap': False}.
Best is trial 13 with value: 0.9636269781288869.
[I 2024-01-23 04:17:40,004] Trial 20 finished with value: 0.9541353123230996 and parameters: {'n_estimators': 16
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0, 'max_depth': 38, 'criterion': 'entropy', 'min_samples_split': 9, 'min_samples_leaf': 3, 'bootstrap': False}. B
est is trial 13 with value: 0.9636269781288869.
[I 2024-01-23 04:17:40,296] Trial 21 finished with value: 0.961255743920918 and parameters: {'n_estimators': 298,
'max_depth': 15, 'criterion': 'entropy', 'min_samples_split': 10, 'min_samples_leaf': 2, 'bootstrap': False}. Bes
t is trial 13 with value: 0.9636269781288869.
[I 2024-01-23 04:17:40,343] Trial 22 finished with value: 0.9466775001482374 and parameters: {'n_estimators': 11,
'max_depth': 19, 'criterion': 'entropy', 'min_samples_split': 10, 'min_samples_leaf': 2, 'bootstrap': False}. Bes
t is trial 13 with value: 0.9636269781288869.
[I 2024-01-23 04:17:40,653] Trial 23 finished with value: 0.9468575229369947 and parameters: {'n_estimators': 32
6, 'max_depth': 24, 'criterion': 'entropy', 'min_samples_split': 9, 'min_samples_leaf': 4, 'bootstrap': False}. B
est is trial 13 with value: 0.9636269781288869.
[I 2024-01-23 04:17:40,797] Trial 24 finished with value: 0.9303786529157223 and parameters: {'n_estimators': 14
5, 'max_depth': 5, 'criterion': 'entropy', 'min_samples_split': 12, 'min_samples_leaf': 2, 'bootstrap': False}. B
est is trial 13 with value: 0.9636269781288869.
[I 2024-01-23 04:17:41,289] Trial 25 finished with value: 0.9420946931100435 and parameters: {'n_estimators': 50
6, 'max_depth': 15, 'criterion': 'entropy', 'min_samples_split': 10, 'min_samples_leaf': 6, 'bootstrap': False}.
Best is trial 13 with value: 0.9636269781288869.
[I 2024-01-23 04:17:41,458] Trial 26 finished with value: 0.9367438176061066 and parameters: {'n_estimators': 14
3, 'max_depth': 10, 'criterion': 'gini', 'min_samples_split': 12, 'min_samples_leaf': 2, 'bootstrap': True}. Best
is trial 13 with value: 0.9636269781288869.
[I 2024-01-23 04:17:41,706] Trial 27 finished with value: 0.9468575229369947 and parameters: {'n_estimators': 29
1, 'max_depth': 21, 'criterion': 'entropy', 'min_samples_split': 10, 'min_samples_leaf': 4, 'bootstrap': False}.
Best is trial 13 with value: 0.9636269781288869.
[I 2024-01-23 04:17:42,038] Trial 28 finished with value: 0.9395264252291453 and parameters: {'n_estimators': 36
4, 'max_depth': 29, 'criterion': 'entropy', 'min_samples_split': 8, 'min_samples_leaf': 7, 'bootstrap': False}. B
est is trial 13 with value: 0.9636269781288869.
[I 2024-01-23 04:17:42,149] Trial 29 finished with value: 0.9517431059907857 and parameters: {'n_estimators': 94,
'max_depth': 16, 'criterion': 'entropy', 'min_samples_split': 6, 'min_samples_leaf': 4, 'bootstrap': False}. Best
is trial 13 with value: 0.9636269781288869.
[I 2024-01-23 04:17:42,533] Trial 30 finished with value: 0.9254040688470617 and parameters: {'n_estimators': 44
9, 'max_depth': 4, 'criterion': 'entropy', 'min_samples_split': 13, 'min_samples_leaf': 9, 'bootstrap': False}. B
est is trial 13 with value: 0.9636269781288869.
[I 2024-01-23 04:17:42,731] Trial 31 finished with value: 0.961065928062894 and parameters: {'n_estimators': 209,
'max_depth': 14, 'criterion': 'entropy', 'min_samples_split': 13, 'min_samples_leaf': 1, 'bootstrap': False}. Bes
t is trial 13 with value: 0.9636269781288869.
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[I 2024-01-23 04:17:42,909] Trial 32 finished with value: 0.9563565284300249 and parameters: {'n_estimators': 18
6, 'max_depth': 15, 'criterion': 'entropy', 'min_samples_split': 13, 'min_samples_leaf': 2, 'bootstrap': False}.
Best is trial 13 with value: 0.9636269781288869.
[I 2024-01-23 04:17:43,198] Trial 33 finished with value: 0.958714130200892 and parameters: {'n_estimators': 318,
'max_depth': 18, 'criterion': 'entropy', 'min_samples_split': 12, 'min_samples_leaf': 1, 'bootstrap': False}. Bes
t is trial 13 with value: 0.9636269781288869.
[I 2024-01-23 04:17:43,319] Trial 34 finished with value: 0.9539058384859601 and parameters: {'n_estimators': 97,
'max_depth': 10, 'criterion': 'gini', 'min_samples_split': 11, 'min_samples_leaf': 2, 'bootstrap': True}. Best is
trial 13 with value: 0.9636269781288869.
[I 2024-01-23 04:17:43,495] Trial 35 finished with value: 0.9517567384278875 and parameters: {'n_estimators': 18
7, 'max_depth': 22, 'criterion': 'entropy', 'min_samples_split': 10, 'min_samples_leaf': 4, 'bootstrap': False}.
Best is trial 13 with value: 0.9636269781288869.
[I 2024-01-23 04:17:43,556] Trial 36 finished with value: 0.900844576507612 and parameters: {'n_estimators': 56,
'max_depth': 1, 'criterion': 'entropy', 'min_samples_split': 13, 'min_samples_leaf': 12, 'bootstrap': False}. Bes
t is trial 13 with value: 0.9636269781288869.
[I 2024-01-23 04:17:43,769] Trial 37 finished with value: 0.9515590940416269 and parameters: {'n_estimators': 22
5, 'max_depth': 13, 'criterion': 'gini', 'min_samples_split': 11, 'min_samples_leaf': 3, 'bootstrap': False}. Bes
t is trial 13 with value: 0.9636269781288869.
[I 2024-01-23 04:17:43,915] Trial 38 finished with value: 0.9322219816821681 and parameters: {'n_estimators': 10
9, 'max_depth': 26, 'criterion': 'entropy', 'min_samples_split': 12, 'min_samples_leaf': 5, 'bootstrap': True}. B
est is trial 13 with value: 0.9636269781288869.
[I 2024-01-23 04:17:44,285] Trial 39 finished with value: 0.9400720433705455 and parameters: {'n_estimators': 43
3, 'max_depth': 5, 'criterion': 'gini', 'min_samples_split': 9, 'min_samples_leaf': 2, 'bootstrap': False}. Best
is trial 13 with value: 0.9636269781288869.
[I 2024-01-23 04:17:44,602] Trial 40 finished with value: 0.9783538944195402 and parameters: {'n_estimators': 32
8, 'max_depth': 10, 'criterion': 'entropy', 'min_samples_split': 6, 'min_samples_leaf': 1, 'bootstrap': False}. B
est is trial 40 with value: 0.9783538944195402.
[I 2024-01-23 04:17:44,908] Trial 41 finished with value: 0.9783538944195402 and parameters: {'n_estimators': 34
3, 'max_depth': 10, 'criterion': 'entropy', 'min_samples_split': 6, 'min_samples_leaf': 1, 'bootstrap': False}. B
est is trial 40 with value: 0.9783538944195402.
[I 2024-01-23 04:17:45,248] Trial 42 finished with value: 0.980707195313251 and parameters: {'n_estimators': 340,
'max_depth': 10, 'criterion': 'entropy', 'min_samples_split': 5, 'min_samples_leaf': 1, 'bootstrap': False}. Best
is trial 42 with value: 0.980707195313251.
[I 2024-01-23 04:17:45,750] Trial 43 finished with value: 0.9783553974512491 and parameters: {'n_estimators': 55
5, 'max_depth': 10, 'criterion': 'entropy', 'min_samples_split': 5, 'min_samples_leaf': 1, 'bootstrap': False}. B
```

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est is trial 42 with value: 0.980707195313251.
[I 2024-01-23 04:17:46,274] Trial 44 finished with value: 0.9783538944195402 and parameters: {'n_estimators': 58
0, 'max_depth': 10, 'criterion': 'entropy', 'min_samples_split': 5, 'min_samples_leaf': 1, 'bootstrap': False}. B
est is trial 42 with value: 0.980707195313251.
[I 2024-01-23 04:17:46,801] Trial 45 finished with value: 0.9592601997332914 and parameters: {'n_estimators': 59
9, 'max_depth': 6, 'criterion': 'entropy', 'min_samples_split': 5, 'min_samples_leaf': 1, 'bootstrap': False}. Be
st is trial 42 with value: 0.980707195313251.
[I 2024-01-23 04:17:47,673] Trial 46 finished with value: 0.9711154336250228 and parameters: {'n_estimators': 74
8, 'max_depth': 11, 'criterion': 'entropy', 'min_samples_split': 3, 'min_samples_leaf': 1, 'bootstrap': True}. Be
st is trial 42 with value: 0.980707195313251.
[I 2024-01-23 04:17:48,167] Trial 47 finished with value: 0.9517567384278875 and parameters: {'n_estimators': 53
3, 'max_depth': 8, 'criterion': 'entropy', 'min_samples_split': 6, 'min_samples_leaf': 3, 'bootstrap': False}. Be
st is trial 42 with value: 0.980707195313251.
[I 2024-01-23 04:17:48,638] Trial 48 finished with value: 0.8795741692508814 and parameters: {'n_estimators': 62
8, 'max_depth': 2, 'criterion': 'gini', 'min_samples_split': 5, 'min_samples_leaf': 1, 'bootstrap': False}. Best
is trial 42 with value: 0.980707195313251.
[I 2024-01-23 04:17:48,981] Trial 49 finished with value: 0.9008125435715375 and parameters: {'n_estimators': 44
3, 'max_depth': 3, 'criterion': 'entropy', 'min_samples_split': 4, 'min_samples_leaf': 10, 'bootstrap': False}. B
est is trial 42 with value: 0.980707195313251.
[I 2024-01-23 04:17:49,651] Trial 50 finished with value: 0.9517567384278875 and parameters: {'n_estimators': 78
8, 'max_depth': 9, 'criterion': 'entropy', 'min_samples_split': 6, 'min_samples_leaf': 3, 'bootstrap': False}. Be
st is trial 42 with value: 0.980707195313251.
[I 2024-01-23 04:17:50,464] Trial 51 finished with value: 0.9734773486707613 and parameters: {'n_estimators': 72
2, 'max_depth': 11, 'criterion': 'entropy', 'min_samples_split': 2, 'min_samples_leaf': 1, 'bootstrap': True}. Be
st is trial 42 with value: 0.980707195313251.
[I 2024-01-23 04:17:51,252] Trial 52 finished with value: 0.9711154336250228 and parameters: {'n_estimators': 68
7, 'max_depth': 11, 'criterion': 'entropy', 'min_samples_split': 2, 'min_samples_leaf': 1, 'bootstrap': True}. Be
st is trial 42 with value: 0.980707195313251.
[I 2024-01-23 04:17:52,003] Trial 53 finished with value: 0.9543106764216172 and parameters: {'n_estimators': 54
6, 'max_depth': 7, 'criterion': 'entropy', 'min_samples_split': 3, 'min_samples_leaf': 2, 'bootstrap': True}. Bes
t is trial 42 with value: 0.980707195313251.
[I 2024-01-23 04:17:52,927] Trial 54 finished with value: 0.9686609821355363 and parameters: {'n_estimators': 81
0, 'max_depth': 17, 'criterion': 'entropy', 'min_samples_split': 5, 'min_samples_leaf': 1, 'bootstrap': True}. Be
st is trial 42 with value: 0.980707195313251.
[I 2024-01-23 04:17:53,319] Trial 55 finished with value: 0.9588505158648337 and parameters: {'n_estimators': 34
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9, 'max_depth': 13, 'criterion': 'entropy', 'min_samples_split': 4, 'min_samples_leaf': 2, 'bootstrap': True}. Be
st is trial 42 with value: 0.980707195313251.
[I 2024-01-23 04:17:53,853] Trial 56 finished with value: 0.9636075417829199 and parameters: {'n_estimators': 48
0, 'max_depth': 12, 'criterion': 'entropy', 'min_samples_split': 7, 'min_samples_leaf': 1, 'bootstrap': True}. Be
st is trial 42 with value: 0.980707195313251.
[I 2024-01-23 04:17:54,744] Trial 57 finished with value: 0.9471018412278696 and parameters: {'n_estimators': 97
6, 'max_depth': 6, 'criterion': 'entropy', 'min_samples_split': 5, 'min_samples_leaf': 3, 'bootstrap': False}. Be
st is trial 42 with value: 0.980707195313251.
[I 2024-01-23 04:17:55,121] Trial 58 finished with value: 0.9735312229147748 and parameters: {'n_estimators': 41
5, 'max_depth': 9, 'criterion': 'entropy', 'min_samples_split': 3, 'min_samples_leaf': 2, 'bootstrap': False}. Be
st is trial 42 with value: 0.980707195313251.
[I 2024-01-23 04:17:55,498] Trial 59 finished with value: 0.9685385178934836 and parameters: {'n_estimators': 41
4, 'max_depth': 38, 'criterion': 'entropy', 'min_samples_split': 6, 'min_samples_leaf': 2, 'bootstrap': False}. B
est is trial 42 with value: 0.980707195313251.
[I 2024-01-23 04:17:55,916] Trial 60 finished with value: 0.9541353123230996 and parameters: {'n_estimators': 47
5, 'max_depth': 9, 'criterion': 'entropy', 'min_samples_split': 3, 'min_samples_leaf': 3, 'bootstrap': False}. Be
st is trial 42 with value: 0.980707195313251.
[I 2024-01-23 04:17:56,504] Trial 61 finished with value: 0.9664028668689124 and parameters: {'n_estimators': 63
2, 'max_depth': 7, 'criterion': 'entropy', 'min_samples_split': 2, 'min_samples_leaf': 1, 'bootstrap': False}. Be
st is trial 42 with value: 0.980707195313251.
[I 2024-01-23 04:17:56,863] Trial 62 finished with value: 0.9759284399720268 and parameters: {'n_estimators': 37
9, 'max_depth': 11, 'criterion': 'entropy', 'min_samples_split': 4, 'min_samples_leaf': 1, 'bootstrap': False}. B
est is trial 42 with value: 0.980707195313251.
[I 2024-01-23 04:17:57,186] Trial 63 finished with value: 0.9328948128021789 and parameters: {'n_estimators': 37
7, 'max_depth': 4, 'criterion': 'entropy', 'min_samples_split': 4, 'min_samples_leaf': 2, 'bootstrap': False}. Be
st is trial 42 with value: 0.980707195313251.
[I 2024-01-23 04:17:57,503] Trial 64 finished with value: 0.9783538944195402 and parameters: {'n_estimators': 33
9, 'max_depth': 9, 'criterion': 'entropy', 'min_samples_split': 4, 'min_samples_leaf': 1, 'bootstrap': False}. Be
st is trial 42 with value: 0.980707195313251.
[I 2024-01-23 04:17:57,792] Trial 65 finished with value: 0.9783553974512491 and parameters: {'n_estimators': 33
9, 'max_depth': 12, 'criterion': 'entropy', 'min_samples_split': 5, 'min_samples_leaf': 1, 'bootstrap': False}. B
est is trial 42 with value: 0.980707195313251.
[I 2024-01-23 04:17:58,047] Trial 66 finished with value: 0.9735665249262884 and parameters: {'n_estimators': 25
8, 'max_depth': 19, 'criterion': 'entropy', 'min_samples_split': 7, 'min_samples_leaf': 1, 'bootstrap': False}. B
est is trial 42 with value: 0.980707195313251.
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[I 2024-01-23 04:17:58,371] Trial 67 finished with value: 0.970989609194749 and parameters: {'n_estimators': 343,
'max_depth': 13, 'criterion': 'gini', 'min_samples_split': 5, 'min_samples_leaf': 2, 'bootstrap': False}. Best is
trial 42 with value: 0.980707195313251.
[I 2024-01-23 04:17:58,631] Trial 68 finished with value: 0.9807808518987624 and parameters: {'n_estimators': 29
0, 'max_depth': 32, 'criterion': 'entropy', 'min_samples_split': 6, 'min_samples_leaf': 1, 'bootstrap': False}. B
est is trial 68 with value: 0.9807808518987624.
[I 2024-01-23 04:17:58,903] Trial 69 finished with value: 0.9373782482029196 and parameters: {'n_estimators': 29
4, 'max_depth': 21, 'criterion': 'entropy', 'min_samples_split': 6, 'min_samples_leaf': 8, 'bootstrap': False}. B
est is trial 68 with value: 0.9807808518987624.
[I 2024-01-23 04:17:59,375] Trial 70 finished with value: 0.9468575229369947 and parameters: {'n_estimators': 51
2, 'max_depth': 34, 'criterion': 'entropy', 'min_samples_split': 6, 'min_samples_leaf': 4, 'bootstrap': False}. B
est is trial 68 with value: 0.9807808518987624.
[I 2024-01-23 04:17:59,615] Trial 71 finished with value: 0.9783553974512491 and parameters: {'n_estimators': 25
3, 'max_depth': 36, 'criterion': 'entropy', 'min_samples_split': 5, 'min_samples_leaf': 1, 'bootstrap': False}. B
est is trial 68 with value: 0.9807808518987624.
[I 2024-01-23 04:17:59,877] Trial 72 finished with value: 0.9685385178934836 and parameters: {'n_estimators': 27
4, 'max_depth': 35, 'criterion': 'entropy', 'min_samples_split': 5, 'min_samples_leaf': 2, 'bootstrap': False}. B
est is trial 68 with value: 0.9807808518987624.
[I 2024-01-23 04:18:00,393] Trial 73 finished with value: 0.9225340347072656 and parameters: {'n_estimators': 58
2, 'max_depth': 42, 'criterion': 'entropy', 'min_samples_split': 7, 'min_samples_leaf': 13, 'bootstrap': False}.
Best is trial 68 with value: 0.9807808518987624.
[I 2024-01-23 04:18:00,621] Trial 74 finished with value: 0.970791782337893 and parameters: {'n_estimators': 233,
'max_depth': 32, 'criterion': 'entropy', 'min_samples_split': 8, 'min_samples_leaf': 1, 'bootstrap': False}. Best
is trial 68 with value: 0.9807808518987624.
[I 2024-01-23 04:18:00,922] Trial 75 finished with value: 0.9783553974512491 and parameters: {'n_estimators': 31
0, 'max_depth': 39, 'criterion': 'entropy', 'min_samples_split': 5, 'min_samples_leaf': 1, 'bootstrap': False}. B
est is trial 68 with value: 0.9807808518987624.
[I 2024-01-23 04:18:01,221] Trial 76 finished with value: 0.970989609194749 and parameters: {'n_estimators': 315,
'max_depth': 41, 'criterion': 'entropy', 'min_samples_split': 6, 'min_samples_leaf': 2, 'bootstrap': False}. Best
is trial 68 with value: 0.9807808518987624.
[I 2024-01-23 04:18:01,447] Trial 77 finished with value: 0.9420946931100435 and parameters: {'n_estimators': 25
9, 'max_depth': 47, 'criterion': 'entropy', 'min_samples_split': 7, 'min_samples_leaf': 6, 'bootstrap': False}. B
est is trial 68 with value: 0.9807808518987624.
[I 2024-01-23 04:18:01,733] Trial 78 finished with value: 0.970989609194749 and parameters: {'n_estimators': 305,
'max_depth': 36, 'criterion': 'entropy', 'min_samples_split': 5, 'min_samples_leaf': 2, 'bootstrap': False}. Best
```

```
is trial 68 with value: 0.9807808518987624.
[I 2024-01-23 04:18:02,098] Trial 79 finished with value: 0.9517567384278875 and parameters: {'n_estimators': 39
5, 'max_depth': 31, 'criterion': 'gini', 'min_samples_split': 6, 'min_samples_leaf': 3, 'bootstrap': False}. Best
is trial 68 with value: 0.9807808518987624.
[I 2024-01-23 04:18:02,282] Trial 80 finished with value: 0.9734739884825405 and parameters: {'n_estimators': 17
0, 'max_depth': 38, 'criterion': 'entropy', 'min_samples_split': 5, 'min_samples_leaf': 1, 'bootstrap': False}. B
est is trial 68 with value: 0.9807808518987624.
[I 2024-01-23 04:18:02,569] Trial 81 finished with value: 0.9759284399720268 and parameters: {'n_estimators': 28
1, 'max_depth': 40, 'criterion': 'entropy', 'min_samples_split': 5, 'min_samples_leaf': 1, 'bootstrap': False}. B
est is trial 68 with value: 0.9807808518987624.
[I 2024-01-23 04:18:02,776] Trial 82 finished with value: 0.9831326497607644 and parameters: {'n_estimators': 20
9, 'max_depth': 27, 'criterion': 'entropy', 'min_samples_split': 6, 'min_samples_leaf': 1, 'bootstrap': False}. B
est is trial 82 with value: 0.9831326497607644.
[I 2024-01-23 04:18:02,994] Trial 83 finished with value: 0.9734739884825405 and parameters: {'n_estimators': 22
2, 'max_depth': 28, 'criterion': 'entropy', 'min_samples_split': 7, 'min_samples_leaf': 1, 'bootstrap': False}. B
est is trial 82 with value: 0.9831326497607644.
[I 2024-01-23 04:18:03,320] Trial 84 finished with value: 0.9685385178934836 and parameters: {'n_estimators': 35
2, 'max_depth': 26, 'criterion': 'entropy', 'min_samples_split': 6, 'min_samples_leaf': 2, 'bootstrap': False}. B
est is trial 82 with value: 0.9831326497607644.
[I 2024-01-23 04:18:03,515] Trial 85 finished with value: 0.9759284399720268 and parameters: {'n_estimators': 20
1, 'max_depth': 32, 'criterion': 'entropy', 'min_samples_split': 4, 'min_samples_leaf': 1, 'bootstrap': False}. B
est is trial 82 with value: 0.9831326497607644.
[I 2024-01-23 04:18:03,828] Trial 86 finished with value: 0.9685385178934836 and parameters: {'n_estimators': 33
1, 'max_depth': 36, 'criterion': 'entropy', 'min_samples_split': 6, 'min_samples_leaf': 2, 'bootstrap': False}. B
est is trial 82 with value: 0.9831326497607644.
[I 2024-01-23 04:18:04,081] Trial 87 finished with value: 0.9541216798859977 and parameters: {'n_estimators': 27
8, 'max_depth': 28, 'criterion': 'entropy', 'min_samples_split': 4, 'min_samples_leaf': 3, 'bootstrap': False}. B
est is trial 82 with value: 0.9831326497607644.
[I 2024-01-23 04:18:04,320] Trial 88 finished with value: 0.9759284399720268 and parameters: {'n_estimators': 24
4, 'max_depth': 24, 'criterion': 'entropy', 'min_samples_split': 5, 'min_samples_leaf': 1, 'bootstrap': False}. B
est is trial 82 with value: 0.9831326497607644.
[I 2024-01-23 04:18:04,664] Trial 89 finished with value: 0.968570459716776 and parameters: {'n_estimators': 368,
'max_depth': 44, 'criterion': 'entropy', 'min_samples_split': 8, 'min_samples_leaf': 1, 'bootstrap': False}. Best
is trial 82 with value: 0.9831326497607644.
[I 2024-01-23 04:18:04,798] Trial 90 finished with value: 0.9637481342075416 and parameters: {'n_estimators': 11
```

```
8, 'max_depth': 31, 'criterion': 'gini', 'min_samples_split': 6, 'min_samples_leaf': 2, 'bootstrap': False}. Best
is trial 82 with value: 0.9831326497607644.
[I 2024-01-23 04:18:05,383] Trial 91 finished with value: 0.9783553974512491 and parameters: {'n_estimators': 61
5, 'max_depth': 39, 'criterion': 'entropy', 'min_samples_split': 5, 'min_samples_leaf': 1, 'bootstrap': False}. B
est is trial 82 with value: 0.9831326497607644.
[I 2024-01-23 04:18:05,977] Trial 92 finished with value: 0.9783553974512491 and parameters: {'n_estimators': 62
8, 'max_depth': 33, 'criterion': 'entropy', 'min_samples_split': 5, 'min_samples_leaf': 1, 'bootstrap': False}. B
est is trial 82 with value: 0.9831326497607644.
[I 2024-01-23 04:18:06,575] Trial 93 finished with value: 0.9759284399720268 and parameters: {'n_estimators': 61
4, 'max_depth': 34, 'criterion': 'entropy', 'min_samples_split': 5, 'min_samples_leaf': 1, 'bootstrap': False}. B
est is trial 82 with value: 0.9831326497607644.
[I 2024-01-23 04:18:07,072] Trial 94 finished with value: 0.9710801316135094 and parameters: {'n_estimators': 54
2, 'max_depth': 39, 'criterion': 'entropy', 'min_samples_split': 5, 'min_samples_leaf': 2, 'bootstrap': False}. B
est is trial 82 with value: 0.9831326497607644.
[I 2024-01-23 04:18:07,727] Trial 95 finished with value: 0.9759284399720268 and parameters: {'n_estimators': 68
8, 'max_depth': 37, 'criterion': 'entropy', 'min_samples_split': 4, 'min_samples_leaf': 1, 'bootstrap': False}. B
est is trial 82 with value: 0.9831326497607644.
[I 2024-01-23 04:18:08,298] Trial 96 finished with value: 0.9759284399720268 and parameters: {'n_estimators': 63
4, 'max_depth': 43, 'criterion': 'entropy', 'min_samples_split': 5, 'min_samples_leaf': 1, 'bootstrap': False}. B
est is trial 82 with value: 0.9831326497607644.
[I 2024-01-23 04:18:08,818] Trial 97 finished with value: 0.9759856744042613 and parameters: {'n_estimators': 56
2, 'max_depth': 33, 'criterion': 'entropy', 'min_samples_split': 4, 'min_samples_leaf': 2, 'bootstrap': False}. B
est is trial 82 with value: 0.9831326497607644.
[I 2024-01-23 04:18:09,244] Trial 98 finished with value: 0.9759284399720268 and parameters: {'n_estimators': 45
5, 'max_depth': 30, 'criterion': 'entropy', 'min_samples_split': 5, 'min_samples_leaf': 1, 'bootstrap': False}. B
est is trial 82 with value: 0.9831326497607644.
[I 2024-01-23 04:18:09,866] Trial 99 finished with value: 0.9685385178934836 and parameters: {'n_estimators': 66
8, 'max_depth': 40, 'criterion': 'entropy', 'min_samples_split': 6, 'min_samples_leaf': 2, 'bootstrap': False}. B
est is trial 82 with value: 0.9831326497607644.
```

```
Best trial final score: 0.9831326497607644
n_estimators: 209
max_depth: 27
criterion: entropy
min_samples_split: 6
min_samples_leaf: 1
bootstrap: False
```

In [ ]:
```
best_classifier2 = best_trial2.params
best_classifier2
```

Out[ ]:
```
{'n_estimators': 209,
 'max_depth': 27,
 'criterion': 'entropy',
 'min_samples_split': 6,
 'min_samples_leaf': 1,
 'bootstrap': False}
```

In [ ]:
```
model2 = RandomForestClassifier(**best_classifier2)
model2
```

Out[ ]:
```
RandomForestClassifier(bootstrap=False, criterion='entropy', max_depth=27,
                       min_samples_split=6, n_estimators=209)
```

In [ ]:
```
model2.fit(X_train, y_train)

y_pred2 = model2.predict(X_test)
accuracy2 = accuracy_score(y_test, y_pred2)
f1_2 = f1_score(y_test, y_pred2, average='weighted')
precision2 = precision_score(y_test, y_pred2, average='weighted')
recall2 = recall_score(y_test, y_pred2, average='weighted')
```

```
print('The F1-Score of a better RF model in the test data is \n', f1_2)
print()
print(f"Test Set Evaluation Metrics:\nAccuracy: {accuracy2}\nF1 Score: {f1_2}\nPrecision: {precision2}\nRecall: 
```

```
The F1-Score of a better RF model in the test data is
 0.9904222748776574

Test Set Evaluation Metrics:
Accuracy: 0.9903846153846154
F1 Score: 0.9904222748776574
Precision: 0.9906674208144797
Recall: 0.9903846153846154
```