In [ ]:

```
import os
import sys
from tempfile import NamedTemporaryFile
from urllib.request import urlopen
from urllib.parse import unquote, urlparse
from urllib.error import HTTPError
from zipfile import ZipFile
import tarfile
import shutil

CHUNK_SIZE = 40960
DATA_SOURCE_MAPPING = 'telecom-churn-datasets:https%3A%2F%2Fstorage.googleapis

KAGGLE_INPUT_PATH='/kaggle/input'
KAGGLE_WORKING_PATH='/kaggle/working'
KAGGLE_SYMLINK='kaggle'

!umount /kaggle/input/ 2> /dev/null
shutil.rmtree('/kaggle/input', ignore_errors=True)
os.makedirs(KAGGLE_INPUT_PATH, 0o777, exist_ok=True)
os.makedirs(KAGGLE_WORKING_PATH, 0o777, exist_ok=True)

try:
  os.symlink(KAGGLE_INPUT_PATH, os.path.join("..", 'input'), target_is_directo
except FileExistsError:
  pass
try:
  os.symlink(KAGGLE_WORKING_PATH, os.path.join("..", 'working'), target_is_dir
except FileExistsError:
  pass

for data_source_mapping in DATA_SOURCE_MAPPING.split(','):
    directory, download_url_encoded = data_source_mapping.split(':')
    download_url = unquote(download_url_encoded)
    filename = urlparse(download_url).path
    destination_path = os.path.join(KAGGLE_INPUT_PATH, directory)
    try:
        with urlopen(download_url) as fileres, NamedTemporaryFile() as tfile:
            total_length = fileres.headers['content-length']
            print(f'Downloading {directory}, {total_length} bytes compressed')
            dl = 0
            data = fileres.read(CHUNK_SIZE)
            while len(data) > 0:
                dl += len(data)
                tfile.write(data)
                done = int(50 * dl / int(total_length))
                sys.stdout.write(f"\r[{'=' * done}{' ' * (50-done)}] {dl} byte
                sys.stdout.flush()
                data = fileres.read(CHUNK_SIZE)
            if filename.endswith('.zip'):
              with ZipFile(tfile) as zfile:
                zfile.extractall(destination_path)
            else:
```

```
                with tarfile.open(tfile.name) as tarfile:
                    tarfile.extractall(destination_path)
                print(f'\nDownloaded and uncompressed: {directory}')
        except HTTPError as e:
            print(f'Failed to load (likely expired) {download_url} to path {destir
            continue
        except OSError as e:
            print(f'Failed to load {download_url} to path {destination_path}')
            continue

print('Data source import complete.')
```

```
Failed to load (likely expired) https://storage.googleapis.com/kaggle-data-set
s/255093/535845/bundle/archive.zip?X-Goog-Algorithm=GOOG4-RSA-SHA256&X-Goog-Cre
dential=gcp-kaggle-com%40kaggle-161607.iam.gserviceaccount.com%2F20241010%2Faut
o%2Fstorage%2Fgoog4_request&X-Goog-Date=20241010T051751Z&X-Goog-Expires=25920
0&X-Goog-SignedHeaders=host&X-Goog-Signature=06c803ef95f7e8b0a294fa862426ffc5b9
13eff6b872597530c7a3e5d647887bb8572f29e13a03ddc6fa5f99f041134c2742b611cc99228d9
e51819a09c4d4355d511c3cee9e2d59959fd69c958cfb17bf7614887e76d2c4f1b588eedc4a844f
3db3dcc8a44c3c59cb7a282dc66371ea3395feb45168008c9d29322b195c8193bb29cdf46eaa3c2
57bfad7db08605c49764b21a0a46e57ccb4d9e0ba40d7febcf256d76fa6b7a0e66a8d17d95acd6c
d8b45e2f5988a02e4ff94d6632b059919ebe429e5ff59852ae55048668795e67f898fa62fddb695
e7830ad308b600423e5af7cfa41a165e1a05bd61b9b145a8c5a130bde163f103d2a7d52d2b40d09
08f2 to path /kaggle/input/telecom-churn-datasets
Data source import complete.
```

In [ ]:
```
import numpy as np
import pandas as pd


import os
for dirname, _, filenames in os.walk('/kaggle/input'):
    for filename in filenames:
        print(os.path.join(dirname, filename))
```

In [ ]:
```
data = pd.read_csv('/kaggle/input/telecom-churn-datasets/churn-bigml-80.csv')
data.sample(5)
```

```
---------------------------------------------------------------------------
FileNotFoundError                         Traceback (most recent call last)
<ipython-input-24-6ca4a4ae7695> in <cell line: 1>()
----> 1 data = pd.read_csv('/kaggle/input/telecom-churn-datasets/churn-bigml-80.csv')
      2 data.sample(5)

/usr/local/lib/python3.10/dist-packages/pandas/io/parsers/readers.py in read_csv(filepath_or_buffer, sep, delimiter, header, names, index_col, usecols, dtype, engine, converters, true_values, false_values, skipinitialspace, skiprows, skipfooter, nrows, na_values, keep_default_na, na_filter, verbose, skip_blank_lines, parse_dates, infer_datetime_format, keep_date_col, date_parser, date_format, dayfirst, cache_dates, iterator, chunksize, compression, thousands, decimal, lineterminator, quotechar, quoting, doublequote, escapechar, comment, encoding, encoding_errors, dialect, on_bad_lines, delim_whitespace, low_memory, memory_map, float_precision, storage_options, dtype_backend)
   1024     kwds.update(kwds_defaults)
   1025
-> 1026     return _read(filepath_or_buffer, kwds)
   1027
   1028

/usr/local/lib/python3.10/dist-packages/pandas/io/parsers/readers.py in _read(filepath_or_buffer, kwds)
    618
    619     # Create the parser.
--> 620     parser = TextFileReader(filepath_or_buffer, **kwds)
    621
    622     if chunksize or iterator:

/usr/local/lib/python3.10/dist-packages/pandas/io/parsers/readers.py in __init__(self, f, engine, **kwds)
   1618
   1619         self.handles: IOHandles | None = None
-> 1620         self._engine = self._make_engine(f, self.engine)
   1621
   1622     def close(self) -> None:

/usr/local/lib/python3.10/dist-packages/pandas/io/parsers/readers.py in _make_engine(self, f, engine)
   1878                 if "b" not in mode:
   1879                     mode += "b"
-> 1880             self.handles = get_handle(
   1881                 f,
   1882                 mode,

/usr/local/lib/python3.10/dist-packages/pandas/io/common.py in get_handle(path_or_buf, mode, encoding, compression, memory_map, is_text, errors, storage_options)
    871         if ioargs.encoding and "b" not in ioargs.mode:
    872             # Encoding
--> 873             handle = open(
    874                 handle,
    875                 ioargs.mode,
```

```
FileNotFoundError: [Errno 2] No such file or directory: '/kaggle/input/telecom-churn-datasets/churn-bigml-80.csv'
```

EDA

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

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 2666 entries, 0 to 2665
Data columns (total 20 columns):
 #   Column                  Non-Null Count  Dtype  
---  ------                  --------------  -----  
 0   State                   2666 non-null   object 
 1   Account length          2666 non-null   int64  
 2   Area code               2666 non-null   int64  
 3   International plan      2666 non-null   object 
 4   Voice mail plan         2666 non-null   object 
 5   Number vmail messages   2666 non-null   int64  
 6   Total day minutes       2666 non-null   float64
 7   Total day calls         2666 non-null   int64  
 8   Total day charge        2666 non-null   float64
 9   Total eve minutes       2666 non-null   float64
 10  Total eve calls         2666 non-null   int64  
 11  Total eve charge        2666 non-null   float64
 12  Total night minutes     2666 non-null   float64
 13  Total night calls       2666 non-null   int64  
 14  Total night charge      2666 non-null   float64
 15  Total intl minutes      2666 non-null   float64
 16  Total intl calls        2666 non-null   int64  
 17  Total intl charge       2666 non-null   float64
 18  Customer service calls  2666 non-null   int64  
 19  Churn                   2666 non-null   bool   
dtypes: bool(1), float64(8), int64(8), object(3)
memory usage: 398.5+ KB
```

In [ ]:
```
df.shape
```

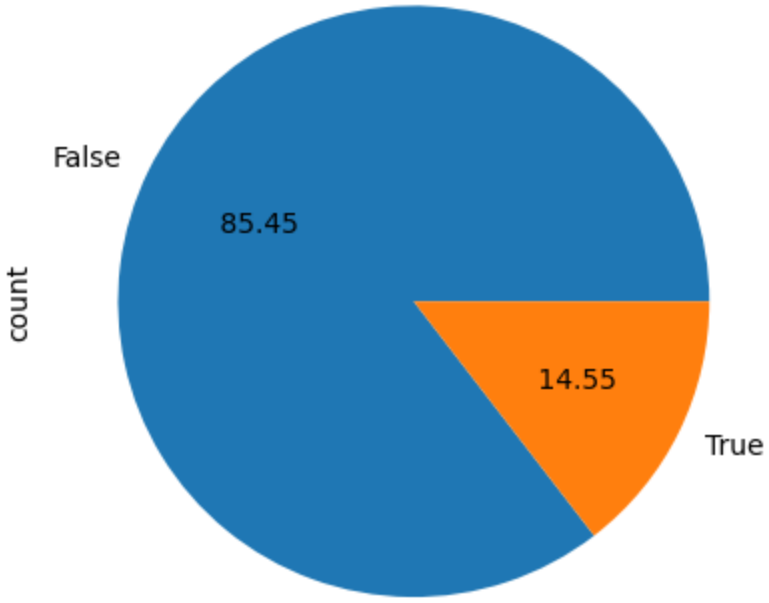
Out[ ]:
```
(2666, 20)
```

In [ ]:
```
df['State'].nunique()
```

Out[ ]:
```
51
```

In [ ]:
```
df['Churn'].value_counts().plot(kind='pie',autopct='% .2f')
```

Out[ ]:
```
<Axes: ylabel='count'>
```



**Data Preprocessing

In [ ]:
```
df1 = df.drop(columns=['State','Account length','Area code'])
df1.head()
```

Out[ ]:

	International plan	Voice mail plan	Number vmail messages	Total day minutes	Total day calls	Total day charge	Total eve minutes	Total eve calls	Tot e charg
0	No	Yes	25	265.1	110	45.07	197.4	99	16.
1	No	Yes	26	161.6	123	27.47	195.5	103	16.
2	No	No	0	243.4	114	41.38	121.2	110	10.
3	Yes	No	0	299.4	71	50.90	61.9	88	5.
4	Yes	No	0	166.7	113	28.34	148.3	122	12.

In [ ]:
```
X=df1.iloc[:,:-1]
y=df1.iloc[:,-1]
```

In [ ]:
```
X.head()
```

Out[ ]:

	International plan	Voice mail plan	Number vmail messages	Total day minutes	Total day calls	Total day charge	Total eve minutes	Total eve calls	Tot e charg
0	No	Yes	25	265.1	110	45.07	197.4	99	16.
1	No	Yes	26	161.6	123	27.47	195.5	103	16.
2	No	No	0	243.4	114	41.38	121.2	110	10.
3	Yes	No	0	299.4	71	50.90	61.9	88	5.
4	Yes	No	0	166.7	113	28.34	148.3	122	12.

In [ ]:
```
from sklearn.model_selection import train_test_split
X_train,X_test,y_train,y_test = train_test_split(X,y,test_size = 0.2, random_s
X_train.shape, X_test.shape
```

Out[ ]:
```
((2132, 16), (534, 16))
```

In [ ]:
```
from sklearn.compose import ColumnTransformer
from sklearn.preprocessing import OneHotEncoder
transformer = ColumnTransformer(transformers=[
                                ('tnf1',OneHotEncoder(sparse_output = False,dr
                                ['International plan','Voice mail plan'])],rem
```

In [ ]:
```
X_train_new = transformer.fit_transform(X_train)
X_test_new = transformer.transform(X_test)
X_train_new.shape
```

Out[ ]:
```
(2132, 16)
```

In [ ]:
```
from sklearn.preprocessing import LabelEncoder
le = LabelEncoder()
le.fit(y_train)
le.classes_
```

Out[ ]:
```
array([0, 1])
```

In [ ]:
```
y_train = le.transform(y_train)
y_test = le.transform(y_test)
```

**Model Training

In [ ]:
```
from sklearn.preprocessing import StandardScaler
scaler = StandardScaler()
scaler.fit(X_train_new)
X_train_scaled = scaler.transform(X_train_new)
X_test_scaled = scaler.transform(X_test_new)
```

```
---------------------------------------------------------------------------
NameError                                 Traceback (most recent call last)
<ipython-input-18-2fc08d7d63a2> in <cell line: 3>()
      1 from sklearn.preprocessing import StandardScaler
      2 scaler = StandardScaler()
----> 3 scaler.fit(X_train_new)
      4 X_train_scaled = scaler.transform(X_train_new)
      5 X_test_scaled = scaler.transform(X_test_new)

NameError: name 'X_train_new' is not defined
```

In [ ]:
```
from sklearn.linear_model import LogisticRegression
lr = LogisticRegression(max_iter=2000, penalty = 'l2')
lr.fit(X_train_scaled,y_train)
y_pred_lr = lr.predict(X_test_scaled)
```

```
---------------------------------------------------------------------------
NameError                                 Traceback (most recent call last)
<ipython-input-19-7a74d883a891> in <cell line: 3>()
      1 from sklearn.linear_model import LogisticRegression
      2 lr = LogisticRegression(max_iter=2000, penalty = 'l2')
----> 3 lr.fit(X_train_scaled,y_train)
      4 y_pred_lr = lr.predict(X_test_scaled)

NameError: name 'X_train_scaled' is not defined
```

In [ ]:
```
from google.colab import drive
drive.mount('/content/drive')
```

In [ ]:
```
from sklearn.metrics import accuracy_score
acc = accuracy_score(y_test,y_pred_lr)
print("Logistic Regression Accuracy: ",acc)
```

```
Logistic Regression Accuracy:  0.8595505617977528
```

Decision Tree

In [ ]:
```
from sklearn.tree import DecisionTreeClassifier
dt = DecisionTreeClassifier(max_depth = 7)
dt.fit(X_train_new,y_train)
y_pred_dt = dt.predict(X_test_new)
```

In [ ]:
```
acc_dt = accuracy_score(y_test,y_pred_dt)
print("Logistic Regression Accuracy: ",acc_dt)
```

```
Logistic Regression Accuracy:  0.9288389513108615
```

Grid Search with Random Forest

In [ ]:
```
from sklearn.ensemble import RandomForestClassifier
rf = RandomForestClassifier()
```

In [ ]:
```
n_estimators = [20,60,100,120]
max_features = [0.2,0.6,1.0]
max_depth = [2,8,None]
max_samples = [0.5,0.75,1.0]
param_grid = {'n_estimators': n_estimators,
               'max_features': max_features,
               'max_depth': max_depth,
              'max_samples':max_samples
             }
print(param_grid)
```

```
{'n_estimators': [20, 60, 100, 120], 'max_features': [0.2, 0.6, 1.0], 'max_dept
h': [2, 8, None], 'max_samples': [0.5, 0.75, 1.0]}
```

In [ ]:
```
from sklearn.model_selection import GridSearchCV

rf_grid = GridSearchCV(
                        estimator = rf,
                        param_grid = param_grid,
                        cv=5,
                        verbose = 2)

rf_grid.fit(X_train_new,y_train)
```

```
Fitting 5 folds for each of 108 candidates, totalling 540 fits
[CV] END max_depth=2, max_features=0.2, max_samples=0.5, n_estimators=20; total
time=   0.2s
[CV] END max_depth=2, max_features=0.2, max_samples=0.5, n_estimators=20; total
time=   0.2s
[CV] END max_depth=2, max_features=0.2, max_samples=0.5, n_estimators=20; total
time=   0.2s
[CV] END max_depth=2, max_features=0.2, max_samples=0.5, n_estimators=20; total
time=   0.2s
[CV] END max_depth=2, max_features=0.2, max_samples=0.5, n_estimators=20; total
time=   0.2s
[CV] END max_depth=2, max_features=0.2, max_samples=0.5, n_estimators=60; total
time=   0.5s
[CV] END max_depth=2, max_features=0.2, max_samples=0.5, n_estimators=60; total
time=   0.7s
[CV] END max_depth=2, max_features=0.2, max_samples=0.5, n_estimators=60; total
time=   0.5s
[CV] END max_depth=2, max_features=0.2, max_samples=0.5, n_estimators=60; total
time=   0.3s
[CV] END max_depth=2, max_features=0.2, max_samples=0.5, n_estimators=60; total
time=   0.3s
[CV] END max_depth=2, max_features=0.2, max_samples=0.5, n_estimators=100; tota
l time=   0.5s
[CV] END max_depth=2, max_features=0.2, max_samples=0.5, n_estimators=100; tota
l time=   0.3s
[CV] END max_depth=2, max_features=0.2, max_samples=0.5, n_estimators=100; tota
l time=   0.4s
[CV] END max_depth=2, max_features=0.2, max_samples=0.5, n_estimators=100; tota
l time=   0.4s
[CV] END max_depth=2, max_features=0.2, max_samples=0.5, n_estimators=100; tota
l time=   0.4s
[CV] END max_depth=2, max_features=0.2, max_samples=0.5, n_estimators=120; tota
l time=   0.4s
[CV] END max_depth=2, max_features=0.2, max_samples=0.5, n_estimators=120; tota
l time=   0.4s
[CV] END max_depth=2, max_features=0.2, max_samples=0.5, n_estimators=120; tota
l time=   0.5s
[CV] END max_depth=2, max_features=0.2, max_samples=0.5, n_estimators=120; tota
l time=   0.4s
[CV] END max_depth=2, max_features=0.2, max_samples=0.5, n_estimators=120; tota
l time=   0.5s
[CV] END max_depth=2, max_features=0.2, max_samples=0.75, n_estimators=20; tota
l time=   0.1s
[CV] END max_depth=2, max_features=0.2, max_samples=0.75, n_estimators=20; tota
l time=   0.1s
[CV] END max_depth=2, max_features=0.2, max_samples=0.75, n_estimators=20; tota
l time=   0.1s
[CV] END max_depth=2, max_features=0.2, max_samples=0.75, n_estimators=20; tota
l time=   0.1s
[CV] END max_depth=2, max_features=0.2, max_samples=0.75, n_estimators=20; tota
l time=   0.1s
[CV] END max_depth=2, max_features=0.2, max_samples=0.75, n_estimators=60; tota
l time=   0.2s
[CV] END max_depth=2, max_features=0.2, max_samples=0.75, n_estimators=60; tota
```

```
l time=   0.5s
[CV] END max_depth=2, max_features=0.2, max_samples=0.75, n_estimators=60; tota
l time=   0.4s
[CV] END max_depth=2, max_features=0.2, max_samples=0.75, n_estimators=60; tota
l time=   0.1s
[CV] END max_depth=2, max_features=0.2, max_samples=0.75, n_estimators=60; tota
l time=   0.2s
[CV] END max_depth=2, max_features=0.2, max_samples=0.75, n_estimators=100; tot
al time=   0.8s
[CV] END max_depth=2, max_features=0.2, max_samples=0.75, n_estimators=100; tot
al time=   0.6s
[CV] END max_depth=2, max_features=0.2, max_samples=0.75, n_estimators=100; tot
al time=   0.5s
[CV] END max_depth=2, max_features=0.2, max_samples=0.75, n_estimators=100; tot
al time=   0.6s
[CV] END max_depth=2, max_features=0.2, max_samples=0.75, n_estimators=100; tot
al time=   0.5s
[CV] END max_depth=2, max_features=0.2, max_samples=0.75, n_estimators=120; tot
al time=   0.7s
[CV] END max_depth=2, max_features=0.2, max_samples=0.75, n_estimators=120; tot
al time=   1.0s
[CV] END max_depth=2, max_features=0.2, max_samples=0.75, n_estimators=120; tot
al time=   1.3s
[CV] END max_depth=2, max_features=0.2, max_samples=0.75, n_estimators=120; tot
al time=   0.6s
[CV] END max_depth=2, max_features=0.2, max_samples=0.75, n_estimators=120; tot
al time=   0.4s
[CV] END max_depth=2, max_features=0.2, max_samples=1.0, n_estimators=20; total
time=   0.1s
[CV] END max_depth=2, max_features=0.2, max_samples=1.0, n_estimators=20; total
time=   0.1s
[CV] END max_depth=2, max_features=0.2, max_samples=1.0, n_estimators=20; total
time=   0.1s
[CV] END max_depth=2, max_features=0.2, max_samples=1.0, n_estimators=20; total
time=   0.1s
[CV] END max_depth=2, max_features=0.2, max_samples=1.0, n_estimators=20; total
time=   0.1s
[CV] END max_depth=2, max_features=0.2, max_samples=1.0, n_estimators=60; total
time=   0.2s
[CV] END max_depth=2, max_features=0.2, max_samples=1.0, n_estimators=60; total
time=   0.3s
[CV] END max_depth=2, max_features=0.2, max_samples=1.0, n_estimators=60; total
time=   0.3s
[CV] END max_depth=2, max_features=0.2, max_samples=1.0, n_estimators=60; total
time=   0.3s
[CV] END max_depth=2, max_features=0.2, max_samples=1.0, n_estimators=60; total
time=   0.4s
[CV] END max_depth=2, max_features=0.2, max_samples=1.0, n_estimators=100; tota
l time=   0.3s
[CV] END max_depth=2, max_features=0.2, max_samples=1.0, n_estimators=100; tota
l time=   0.4s
[CV] END max_depth=2, max_features=0.2, max_samples=1.0, n_estimators=100; tota
l time=   0.4s
[CV] END max_depth=2, max_features=0.2, max_samples=1.0, n_estimators=100; tota
```

```
l time=   0.8s
[CV] END max_depth=2, max_features=0.2, max_samples=1.0, n_estimators=100; tota
l time=   0.9s
[CV] END max_depth=2, max_features=0.2, max_samples=1.0, n_estimators=120; tota
l time=   0.8s
[CV] END max_depth=2, max_features=0.2, max_samples=1.0, n_estimators=120; tota
l time=   1.0s
[CV] END max_depth=2, max_features=0.2, max_samples=1.0, n_estimators=120; tota
l time=   1.0s
[CV] END max_depth=2, max_features=0.2, max_samples=1.0, n_estimators=120; tota
l time=   1.0s
[CV] END max_depth=2, max_features=0.2, max_samples=1.0, n_estimators=120; tota
l time=   0.9s
[CV] END max_depth=2, max_features=0.6, max_samples=0.5, n_estimators=20; total
time=   0.2s
[CV] END max_depth=2, max_features=0.6, max_samples=0.5, n_estimators=20; total
time=   0.2s
[CV] END max_depth=2, max_features=0.6, max_samples=0.5, n_estimators=20; total
time=   0.3s
[CV] END max_depth=2, max_features=0.6, max_samples=0.5, n_estimators=20; total
time=   0.1s
[CV] END max_depth=2, max_features=0.6, max_samples=0.5, n_estimators=20; total
time=   0.1s
[CV] END max_depth=2, max_features=0.6, max_samples=0.5, n_estimators=60; total
time=   1.0s
[CV] END max_depth=2, max_features=0.6, max_samples=0.5, n_estimators=60; total
time=   1.1s
[CV] END max_depth=2, max_features=0.6, max_samples=0.5, n_estimators=60; total
time=   0.9s
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time=   1.1s
[CV] END max_depth=2, max_features=0.6, max_samples=0.5, n_estimators=60; total
time=   0.7s
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l time=   1.0s
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l time=   1.1s
[CV] END max_depth=2, max_features=0.6, max_samples=0.5, n_estimators=100; tota
l time=   0.8s
[CV] END max_depth=2, max_features=0.6, max_samples=0.5, n_estimators=100; tota
l time=   0.9s
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l time=   0.6s
[CV] END max_depth=2, max_features=0.6, max_samples=0.5, n_estimators=120; tota
l time=   0.5s
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l time=   0.6s
[CV] END max_depth=2, max_features=0.6, max_samples=0.5, n_estimators=120; tota
l time=   0.5s
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l time=   0.5s
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l time=   0.5s
[CV] END max_depth=2, max_features=0.6, max_samples=0.75, n_estimators=20; tota
```

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l time=   0.1s
[CV] END max_depth=2, max_features=0.6, max_samples=0.75, n_estimators=20; tota
l time=   0.1s
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l time=   0.1s
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l time=   0.1s
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l time=   0.3s
[CV] END max_depth=2, max_features=0.6, max_samples=0.75, n_estimators=60; tota
l time=   0.3s
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l time=   0.3s
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l time=   0.3s
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al time=   0.6s
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time=   0.1s
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time=   0.2s
[CV] END max_depth=2, max_features=0.6, max_samples=1.0, n_estimators=60; total
```

```
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time=   0.2s
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l time=   0.3s
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```

```
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al time=   0.7s
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```

```
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time=   0.1s
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time=   0.1s
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time=   0.4s
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time=   0.4s
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time=   0.1s
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time=   0.3s
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```

```
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al time=   0.6s
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```

```
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time=   0.1s
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time=   0.6s
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l time=   0.7s
[CV] END max_depth=8, max_features=0.2, max_samples=1.0, n_estimators=120; tota
l time=   0.6s
[CV] END max_depth=8, max_features=0.6, max_samples=0.5, n_estimators=20; total
time=   0.2s
[CV] END max_depth=8, max_features=0.6, max_samples=0.5, n_estimators=20; total
time=   0.2s
[CV] END max_depth=8, max_features=0.6, max_samples=0.5, n_estimators=20; total
```

```
time=   0.2s
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time=   0.2s
[CV] END max_depth=8, max_features=0.6, max_samples=0.5, n_estimators=20; total
time=   0.2s
[CV] END max_depth=8, max_features=0.6, max_samples=0.5, n_estimators=60; total
time=   0.5s
[CV] END max_depth=8, max_features=0.6, max_samples=0.5, n_estimators=60; total
time=   0.5s
[CV] END max_depth=8, max_features=0.6, max_samples=0.5, n_estimators=60; total
time=   0.5s
[CV] END max_depth=8, max_features=0.6, max_samples=0.5, n_estimators=60; total
time=   0.5s
[CV] END max_depth=8, max_features=0.6, max_samples=0.5, n_estimators=60; total
time=   0.6s
[CV] END max_depth=8, max_features=0.6, max_samples=0.5, n_estimators=100; tota
l time=   2.2s
[CV] END max_depth=8, max_features=0.6, max_samples=0.5, n_estimators=100; tota
l time=   2.6s
[CV] END max_depth=8, max_features=0.6, max_samples=0.5, n_estimators=100; tota
l time=   1.4s
[CV] END max_depth=8, max_features=0.6, max_samples=0.5, n_estimators=100; tota
l time=   0.9s
[CV] END max_depth=8, max_features=0.6, max_samples=0.5, n_estimators=100; tota
l time=   1.0s
[CV] END max_depth=8, max_features=0.6, max_samples=0.5, n_estimators=120; tota
l time=   1.3s
[CV] END max_depth=8, max_features=0.6, max_samples=0.5, n_estimators=120; tota
l time=   1.4s
[CV] END max_depth=8, max_features=0.6, max_samples=0.5, n_estimators=120; tota
l time=   0.7s
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l time=   0.7s
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l time=   0.7s
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l time=   0.1s
[CV] END max_depth=8, max_features=0.6, max_samples=0.75, n_estimators=20; tota
l time=   0.1s
[CV] END max_depth=8, max_features=0.6, max_samples=0.75, n_estimators=20; tota
l time=   0.2s
[CV] END max_depth=8, max_features=0.6, max_samples=0.75, n_estimators=20; tota
l time=   0.1s
[CV] END max_depth=8, max_features=0.6, max_samples=0.75, n_estimators=20; tota
l time=   0.1s
[CV] END max_depth=8, max_features=0.6, max_samples=0.75, n_estimators=60; tota
l time=   0.4s
[CV] END max_depth=8, max_features=0.6, max_samples=0.75, n_estimators=60; tota
l time=   0.4s
[CV] END max_depth=8, max_features=0.6, max_samples=0.75, n_estimators=60; tota
l time=   0.5s
[CV] END max_depth=8, max_features=0.6, max_samples=0.75, n_estimators=60; tota
l time=   0.6s
[CV] END max_depth=8, max_features=0.6, max_samples=0.75, n_estimators=60; tota
```

```
l time=   0.6s
[CV] END max_depth=8, max_features=0.6, max_samples=0.75, n_estimators=100; tot
al time=   1.0s
[CV] END max_depth=8, max_features=0.6, max_samples=0.75, n_estimators=100; tot
al time=   1.0s
[CV] END max_depth=8, max_features=0.6, max_samples=0.75, n_estimators=100; tot
al time=   0.7s
[CV] END max_depth=8, max_features=0.6, max_samples=0.75, n_estimators=100; tot
al time=   0.7s
[CV] END max_depth=8, max_features=0.6, max_samples=0.75, n_estimators=100; tot
al time=   0.9s
[CV] END max_depth=8, max_features=0.6, max_samples=0.75, n_estimators=120; tot
al time=   1.2s
[CV] END max_depth=8, max_features=0.6, max_samples=0.75, n_estimators=120; tot
al time=   1.2s
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al time=   1.2s
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al time=   1.2s
[CV] END max_depth=8, max_features=0.6, max_samples=0.75, n_estimators=120; tot
al time=   1.0s
[CV] END max_depth=8, max_features=0.6, max_samples=1.0, n_estimators=20; total
time=   0.2s
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time=   0.2s
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time=   0.2s
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time=   0.2s
[CV] END max_depth=8, max_features=0.6, max_samples=1.0, n_estimators=60; total
time=   0.7s
[CV] END max_depth=8, max_features=0.6, max_samples=1.0, n_estimators=60; total
time=   0.9s
[CV] END max_depth=8, max_features=0.6, max_samples=1.0, n_estimators=60; total
time=   1.1s
[CV] END max_depth=8, max_features=0.6, max_samples=1.0, n_estimators=60; total
time=   1.1s
[CV] END max_depth=8, max_features=0.6, max_samples=1.0, n_estimators=60; total
time=   1.3s
[CV] END max_depth=8, max_features=0.6, max_samples=1.0, n_estimators=100; tota
l time=   1.1s
[CV] END max_depth=8, max_features=0.6, max_samples=1.0, n_estimators=100; tota
l time=   1.1s
[CV] END max_depth=8, max_features=0.6, max_samples=1.0, n_estimators=100; tota
l time=   1.0s
[CV] END max_depth=8, max_features=0.6, max_samples=1.0, n_estimators=100; tota
l time=   1.0s
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l time=   1.0s
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l time=   1.4s
[CV] END max_depth=8, max_features=0.6, max_samples=1.0, n_estimators=120; tota
```

```
l time=   1.4s
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l time=   1.4s
[CV] END max_depth=8, max_features=0.6, max_samples=1.0, n_estimators=120; tota
l time=   1.9s
[CV] END max_depth=8, max_features=0.6, max_samples=1.0, n_estimators=120; tota
l time=   2.1s
[CV] END max_depth=8, max_features=1.0, max_samples=0.5, n_estimators=20; total
time=   0.5s
[CV] END max_depth=8, max_features=1.0, max_samples=0.5, n_estimators=20; total
time=   0.4s
[CV] END max_depth=8, max_features=1.0, max_samples=0.5, n_estimators=20; total
time=   0.9s
[CV] END max_depth=8, max_features=1.0, max_samples=0.5, n_estimators=20; total
time=   0.8s
[CV] END max_depth=8, max_features=1.0, max_samples=0.5, n_estimators=20; total
time=   0.7s
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time=   2.1s
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time=   1.4s
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time=   1.4s
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time=   1.1s
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time=   2.5s
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l time=   3.3s
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l time=   1.6s
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l time=   0.9s
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l time=   1.0s
[CV] END max_depth=8, max_features=1.0, max_samples=0.5, n_estimators=120; tota
l time=   1.0s
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l time=   1.1s
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l time=   1.5s
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l time=   0.3s
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l time=   0.2s
[CV] END max_depth=8, max_features=1.0, max_samples=0.75, n_estimators=20; tota
l time=   0.2s
[CV] END max_depth=8, max_features=1.0, max_samples=0.75, n_estimators=20; tota
```

```
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l time=   0.2s
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l time=   0.6s
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l time=   0.6s
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al time=   1.5s
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al time=   1.2s
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time=   0.2s
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time=   0.2s
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time=   0.2s
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time=   0.2s
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time=   0.3s
[CV] END max_depth=8, max_features=1.0, max_samples=1.0, n_estimators=60; total
time=   0.7s
[CV] END max_depth=8, max_features=1.0, max_samples=1.0, n_estimators=60; total
time=   0.7s
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time=   0.7s
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time=   0.7s
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```

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l time=   1.7s
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l time=   1.5s
[CV] END max_depth=8, max_features=1.0, max_samples=1.0, n_estimators=100; tota
l time=   1.2s
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l time=   1.5s
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l time=   1.4s
[CV] END max_depth=8, max_features=1.0, max_samples=1.0, n_estimators=120; tota
l time=   1.5s
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tal time=   0.1s
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tal time=   0.2s
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tal time=   0.3s
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tal time=   0.3s
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otal time=   0.5s
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otal time=   0.5s
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otal time=   0.5s
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otal time=   0.3s
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otal time=   0.4s
[CV] END max_depth=None, max_features=0.2, max_samples=0.5, n_estimators=120; t
otal time=   0.4s
[CV] END max_depth=None, max_features=0.2, max_samples=0.5, n_estimators=120; t
```

```
otal time=   0.4s
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otal time=   0.1s
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otal time=   0.3s
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total time=   0.4s
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total time=   0.4s
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total time=   0.4s
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total time=   0.5s
[CV] END max_depth=None, max_features=0.2, max_samples=0.75, n_estimators=120;
total time=   0.5s
[CV] END max_depth=None, max_features=0.2, max_samples=0.75, n_estimators=120;
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total time=   0.5s
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total time=   0.5s
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tal time=   0.1s
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tal time=   0.1s
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tal time=   0.1s
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tal time=   0.1s
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```

```
tal time=   0.1s
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tal time=   0.3s
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tal time=   0.4s
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tal time=   0.4s
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tal time=   0.4s
[CV] END max_depth=None, max_features=0.2, max_samples=1.0, n_estimators=100; t
otal time=   0.7s
[CV] END max_depth=None, max_features=0.2, max_samples=1.0, n_estimators=100; t
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[CV] END max_depth=None, max_features=0.2, max_samples=1.0, n_estimators=100; t
otal time=   0.7s
[CV] END max_depth=None, max_features=0.2, max_samples=1.0, n_estimators=100; t
otal time=   0.5s
[CV] END max_depth=None, max_features=0.2, max_samples=1.0, n_estimators=100; t
otal time=   0.5s
[CV] END max_depth=None, max_features=0.2, max_samples=1.0, n_estimators=120; t
otal time=   0.5s
[CV] END max_depth=None, max_features=0.2, max_samples=1.0, n_estimators=120; t
otal time=   0.6s
[CV] END max_depth=None, max_features=0.2, max_samples=1.0, n_estimators=120; t
otal time=   0.6s
[CV] END max_depth=None, max_features=0.2, max_samples=1.0, n_estimators=120; t
otal time=   0.6s
[CV] END max_depth=None, max_features=0.2, max_samples=1.0, n_estimators=120; t
otal time=   0.6s
[CV] END max_depth=None, max_features=0.6, max_samples=0.5, n_estimators=20; to
tal time=   0.1s
[CV] END max_depth=None, max_features=0.6, max_samples=0.5, n_estimators=20; to
tal time=   0.1s
[CV] END max_depth=None, max_features=0.6, max_samples=0.5, n_estimators=20; to
tal time=   0.1s
[CV] END max_depth=None, max_features=0.6, max_samples=0.5, n_estimators=20; to
tal time=   0.1s
[CV] END max_depth=None, max_features=0.6, max_samples=0.5, n_estimators=20; to
tal time=   0.1s
[CV] END max_depth=None, max_features=0.6, max_samples=0.5, n_estimators=60; to
tal time=   0.4s
[CV] END max_depth=None, max_features=0.6, max_samples=0.5, n_estimators=60; to
tal time=   0.4s
[CV] END max_depth=None, max_features=0.6, max_samples=0.5, n_estimators=60; to
tal time=   0.4s
[CV] END max_depth=None, max_features=0.6, max_samples=0.5, n_estimators=60; to
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[CV] END max_depth=None, max_features=0.6, max_samples=0.5, n_estimators=60; to
tal time=   0.4s
[CV] END max_depth=None, max_features=0.6, max_samples=0.5, n_estimators=100; t
otal time=   0.6s
[CV] END max_depth=None, max_features=0.6, max_samples=0.5, n_estimators=100; t
```

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otal time=   0.6s
[CV] END max_depth=None, max_features=0.6, max_samples=0.5, n_estimators=100; t
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[CV] END max_depth=None, max_features=0.6, max_samples=0.5, n_estimators=100; t
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[CV] END max_depth=None, max_features=0.6, max_samples=0.5, n_estimators=100; t
otal time=   0.6s
[CV] END max_depth=None, max_features=0.6, max_samples=0.5, n_estimators=120; t
otal time=   0.8s
[CV] END max_depth=None, max_features=0.6, max_samples=0.5, n_estimators=120; t
otal time=   1.1s
[CV] END max_depth=None, max_features=0.6, max_samples=0.5, n_estimators=120; t
otal time=   1.1s
[CV] END max_depth=None, max_features=0.6, max_samples=0.5, n_estimators=120; t
otal time=   1.0s
[CV] END max_depth=None, max_features=0.6, max_samples=0.5, n_estimators=120; t
otal time=   0.7s
[CV] END max_depth=None, max_features=0.6, max_samples=0.75, n_estimators=20; t
otal time=   0.2s
[CV] END max_depth=None, max_features=0.6, max_samples=0.75, n_estimators=20; t
otal time=   0.2s
[CV] END max_depth=None, max_features=0.6, max_samples=0.75, n_estimators=20; t
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[CV] END max_depth=None, max_features=0.6, max_samples=0.75, n_estimators=20; t
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[CV] END max_depth=None, max_features=0.6, max_samples=0.75, n_estimators=20; t
otal time=   0.2s
[CV] END max_depth=None, max_features=0.6, max_samples=0.75, n_estimators=60; t
otal time=   0.5s
[CV] END max_depth=None, max_features=0.6, max_samples=0.75, n_estimators=60; t
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[CV] END max_depth=None, max_features=0.6, max_samples=0.75, n_estimators=60; t
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[CV] END max_depth=None, max_features=0.6, max_samples=0.75, n_estimators=60; t
otal time=   0.5s
[CV] END max_depth=None, max_features=0.6, max_samples=0.75, n_estimators=100;
total time=   0.8s
[CV] END max_depth=None, max_features=0.6, max_samples=0.75, n_estimators=100;
total time=   0.8s
[CV] END max_depth=None, max_features=0.6, max_samples=0.75, n_estimators=100;
total time=   0.8s
[CV] END max_depth=None, max_features=0.6, max_samples=0.75, n_estimators=100;
total time=   0.8s
[CV] END max_depth=None, max_features=0.6, max_samples=0.75, n_estimators=100;
total time=   0.8s
[CV] END max_depth=None, max_features=0.6, max_samples=0.75, n_estimators=120;
total time=   1.0s
[CV] END max_depth=None, max_features=0.6, max_samples=0.75, n_estimators=120;
total time=   1.0s
[CV] END max_depth=None, max_features=0.6, max_samples=0.75, n_estimators=120;
total time=   1.4s
[CV] END max_depth=None, max_features=0.6, max_samples=0.75, n_estimators=120;
```

```
total time=   1.4s
[CV] END max_depth=None, max_features=0.6, max_samples=0.75, n_estimators=120;
total time=   1.0s
[CV] END max_depth=None, max_features=0.6, max_samples=1.0, n_estimators=20; to
tal time=   0.2s
[CV] END max_depth=None, max_features=0.6, max_samples=1.0, n_estimators=20; to
tal time=   0.2s
[CV] END max_depth=None, max_features=0.6, max_samples=1.0, n_estimators=20; to
tal time=   0.2s
[CV] END max_depth=None, max_features=0.6, max_samples=1.0, n_estimators=20; to
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[CV] END max_depth=None, max_features=0.6, max_samples=1.0, n_estimators=20; to
tal time=   0.2s
[CV] END max_depth=None, max_features=0.6, max_samples=1.0, n_estimators=60; to
tal time=   0.6s
[CV] END max_depth=None, max_features=0.6, max_samples=1.0, n_estimators=60; to
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[CV] END max_depth=None, max_features=0.6, max_samples=1.0, n_estimators=60; to
tal time=   0.6s
[CV] END max_depth=None, max_features=0.6, max_samples=1.0, n_estimators=60; to
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tal time=   0.6s
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[CV] END max_depth=None, max_features=0.6, max_samples=1.0, n_estimators=100; t
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[CV] END max_depth=None, max_features=0.6, max_samples=1.0, n_estimators=120; t
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[CV] END max_depth=None, max_features=0.6, max_samples=1.0, n_estimators=120; t
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[CV] END max_depth=None, max_features=0.6, max_samples=1.0, n_estimators=120; t
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[CV] END max_depth=None, max_features=0.6, max_samples=1.0, n_estimators=120; t
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[CV] END max_depth=None, max_features=1.0, max_samples=0.5, n_estimators=20; to
tal time=   0.2s
[CV] END max_depth=None, max_features=1.0, max_samples=0.5, n_estimators=20; to
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[CV] END max_depth=None, max_features=1.0, max_samples=0.5, n_estimators=20; to
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[CV] END max_depth=None, max_features=1.0, max_samples=0.5, n_estimators=20; to
tal time=   0.2s
[CV] END max_depth=None, max_features=1.0, max_samples=0.5, n_estimators=60; to
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tal time=   0.6s
[CV] END max_depth=None, max_features=1.0, max_samples=0.5, n_estimators=60; to
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[CV] END max_depth=None, max_features=1.0, max_samples=0.5, n_estimators=100; t
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[CV] END max_depth=None, max_features=1.0, max_samples=0.5, n_estimators=120; t
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[CV] END max_depth=None, max_features=1.0, max_samples=0.5, n_estimators=120; t
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[CV] END max_depth=None, max_features=1.0, max_samples=0.5, n_estimators=120; t
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[CV] END max_depth=None, max_features=1.0, max_samples=0.5, n_estimators=120; t
otal time=   1.1s
[CV] END max_depth=None, max_features=1.0, max_samples=0.75, n_estimators=20; t
otal time=   0.3s
[CV] END max_depth=None, max_features=1.0, max_samples=0.75, n_estimators=20; t
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[CV] END max_depth=None, max_features=1.0, max_samples=0.75, n_estimators=20; t
otal time=   0.3s
[CV] END max_depth=None, max_features=1.0, max_samples=0.75, n_estimators=20; t
otal time=   0.3s
[CV] END max_depth=None, max_features=1.0, max_samples=0.75, n_estimators=20; t
otal time=   0.3s
[CV] END max_depth=None, max_features=1.0, max_samples=0.75, n_estimators=60; t
otal time=   0.7s
[CV] END max_depth=None, max_features=1.0, max_samples=0.75, n_estimators=60; t
otal time=   0.8s
[CV] END max_depth=None, max_features=1.0, max_samples=0.75, n_estimators=60; t
otal time=   0.8s
[CV] END max_depth=None, max_features=1.0, max_samples=0.75, n_estimators=60; t
otal time=   0.8s
[CV] END max_depth=None, max_features=1.0, max_samples=0.75, n_estimators=60; t
otal time=   0.8s
[CV] END max_depth=None, max_features=1.0, max_samples=0.75, n_estimators=100;
total time=   1.5s
[CV] END max_depth=None, max_features=1.0, max_samples=0.75, n_estimators=100;
total time=   1.8s
[CV] END max_depth=None, max_features=1.0, max_samples=0.75, n_estimators=100;
```

```
total time=   1.4s
[CV] END max_depth=None, max_features=1.0, max_samples=0.75, n_estimators=100;
total time=   1.2s
[CV] END max_depth=None, max_features=1.0, max_samples=0.75, n_estimators=100;
total time=   1.2s
[CV] END max_depth=None, max_features=1.0, max_samples=0.75, n_estimators=120;
total time=   1.5s
[CV] END max_depth=None, max_features=1.0, max_samples=0.75, n_estimators=120;
total time=   1.5s
[CV] END max_depth=None, max_features=1.0, max_samples=0.75, n_estimators=120;
total time=   1.6s
[CV] END max_depth=None, max_features=1.0, max_samples=0.75, n_estimators=120;
total time=   1.5s
[CV] END max_depth=None, max_features=1.0, max_samples=0.75, n_estimators=120;
total time=   1.9s
[CV] END max_depth=None, max_features=1.0, max_samples=1.0, n_estimators=20; to
tal time=   0.4s
[CV] END max_depth=None, max_features=1.0, max_samples=1.0, n_estimators=20; to
tal time=   0.4s
[CV] END max_depth=None, max_features=1.0, max_samples=1.0, n_estimators=20; to
tal time=   0.4s
[CV] END max_depth=None, max_features=1.0, max_samples=1.0, n_estimators=20; to
tal time=   0.4s
[CV] END max_depth=None, max_features=1.0, max_samples=1.0, n_estimators=20; to
tal time=   0.3s
[CV] END max_depth=None, max_features=1.0, max_samples=1.0, n_estimators=60; to
tal time=   0.9s
[CV] END max_depth=None, max_features=1.0, max_samples=1.0, n_estimators=60; to
tal time=   0.9s
[CV] END max_depth=None, max_features=1.0, max_samples=1.0, n_estimators=60; to
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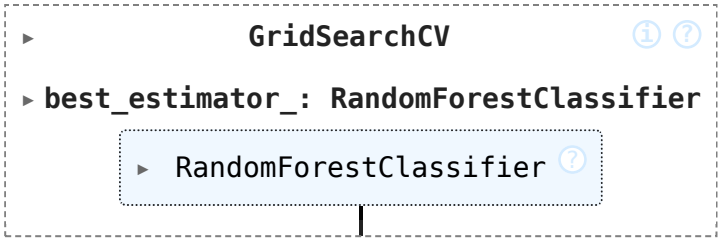
[CV] END max_depth=None, max_features=1.0, max_samples=1.0, n_estimators=60; to
tal time=   0.9s
[CV] END max_depth=None, max_features=1.0, max_samples=1.0, n_estimators=60; to
tal time=   0.9s
[CV] END max_depth=None, max_features=1.0, max_samples=1.0, n_estimators=100; t
otal time=   1.5s
[CV] END max_depth=None, max_features=1.0, max_samples=1.0, n_estimators=100; t
otal time=   1.5s
[CV] END max_depth=None, max_features=1.0, max_samples=1.0, n_estimators=100; t
otal time=   1.5s
[CV] END max_depth=None, max_features=1.0, max_samples=1.0, n_estimators=100; t
otal time=   1.8s
[CV] END max_depth=None, max_features=1.0, max_samples=1.0, n_estimators=100; t
otal time=   2.1s
[CV] END max_depth=None, max_features=1.0, max_samples=1.0, n_estimators=120; t
otal time=   1.8s
[CV] END max_depth=None, max_features=1.0, max_samples=1.0, n_estimators=120; t
otal time=   1.8s
[CV] END max_depth=None, max_features=1.0, max_samples=1.0, n_estimators=120; t
otal time=   1.9s
[CV] END max_depth=None, max_features=1.0, max_samples=1.0, n_estimators=120; t
otal time=   1.8s
[CV] END max_depth=None, max_features=1.0, max_samples=1.0, n_estimators=120; t
```

```
otal time=   1.9s
```

Out[ ]:



In [ ]:
```
rf_grid.best_params_
```

Out[ ]:
```
{'max_depth': None,
 'max_features': 0.6,
 'max_samples': 1.0,
 'n_estimators': 120}
```

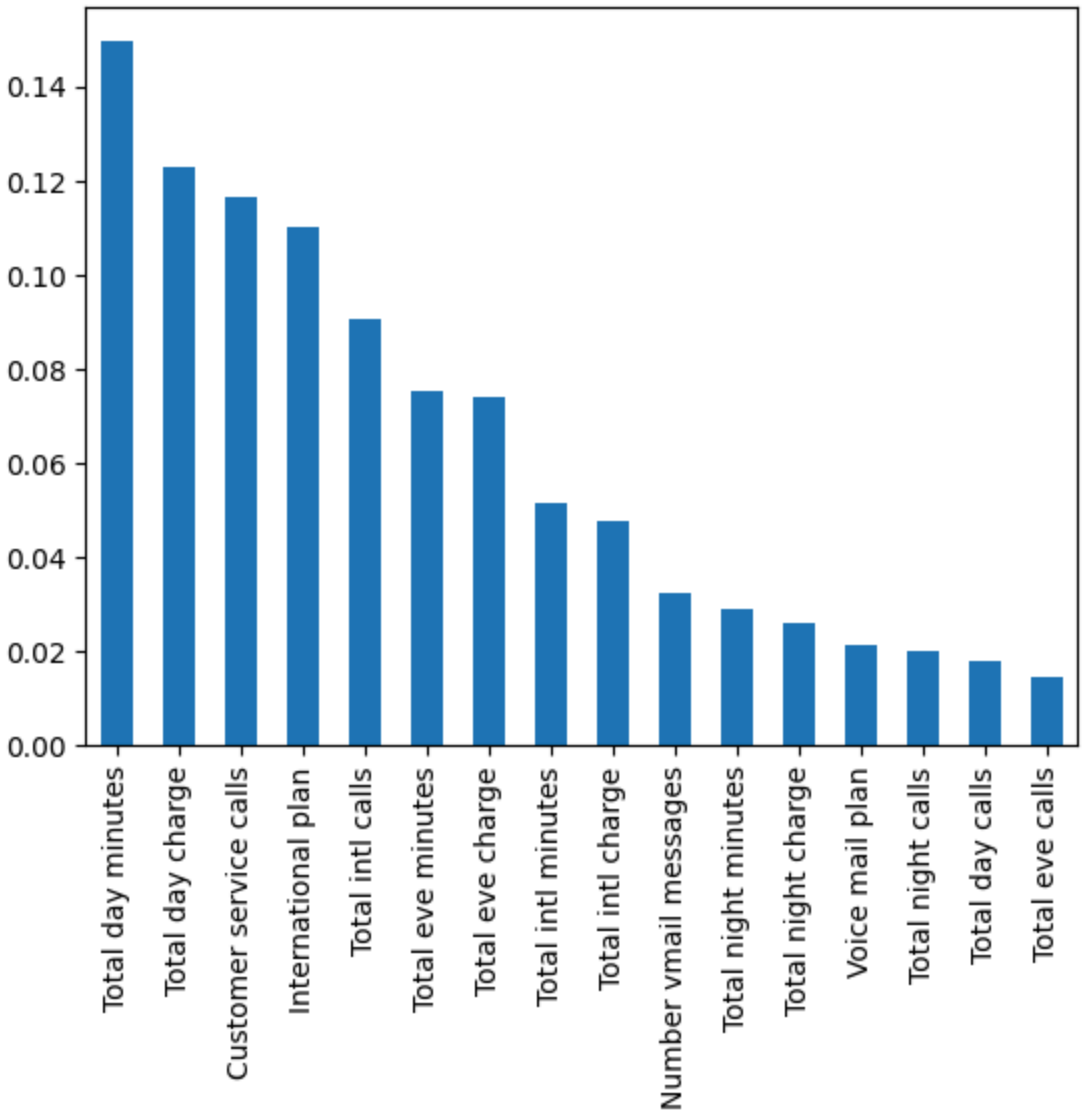
In [ ]:
```
rf1 = RandomForestClassifier(max_depth=8, max_features=0.6, max_samples=0.75,
rf1.fit(X_train_new,y_train)
y_pred_rf = rf1.predict(X_test_new)
acc_rf = accuracy_score(y_test,y_pred_rf)
print("Random Forest Accuracy: ",acc_rf)
```

```
Random Forest Accuracy:  0.9531835205992509
```

Feature Importance

In [ ]:
```
cols = X_train.columns
r=pd.Series(np.abs(rf1.feature_importances_),index = cols)
r.sort_values(ascending=False).plot(kind='bar')
```

Out[ ]:
```
<Axes: >
```



Validation with Random Forest

In [ ]:
```
val = pd.read_csv("/kaggle/input/telecom-churn-datasets/churn-bigml-20.csv")
val1 = val.drop(columns=['State','Account length','Area code'])
X_val= val1.iloc[:,:-1]
y_val= val1.iloc[:,-1]
X_val_new = transformer.transform(X_val)
```

In [ ]:
```
y_pred_val = rf1.predict(X_val_new)

acc_val = accuracy_score(y_val,y_pred_val)

print("Validation Accuracy: ", acc_val)
```

```
Validation Accuracy:  0.9580209895052474
```

In [ ]:
```
from sklearn.metrics import accuracy_score, confusion_matrix, classification_r
```

```
print("Accuracy:", accuracy_score(y_val,y_pred_val))
print("Confusion Matrix:\n", confusion_matrix(y_val,y_pred_val))
print("Classification Report:\n", classification_report(y_val,y_pred_val))
```

```
Accuracy: 0.9580209895052474
Confusion Matrix:
 [[568   4]
 [ 24  71]]
Classification Report:
              precision    recall  f1-score   support

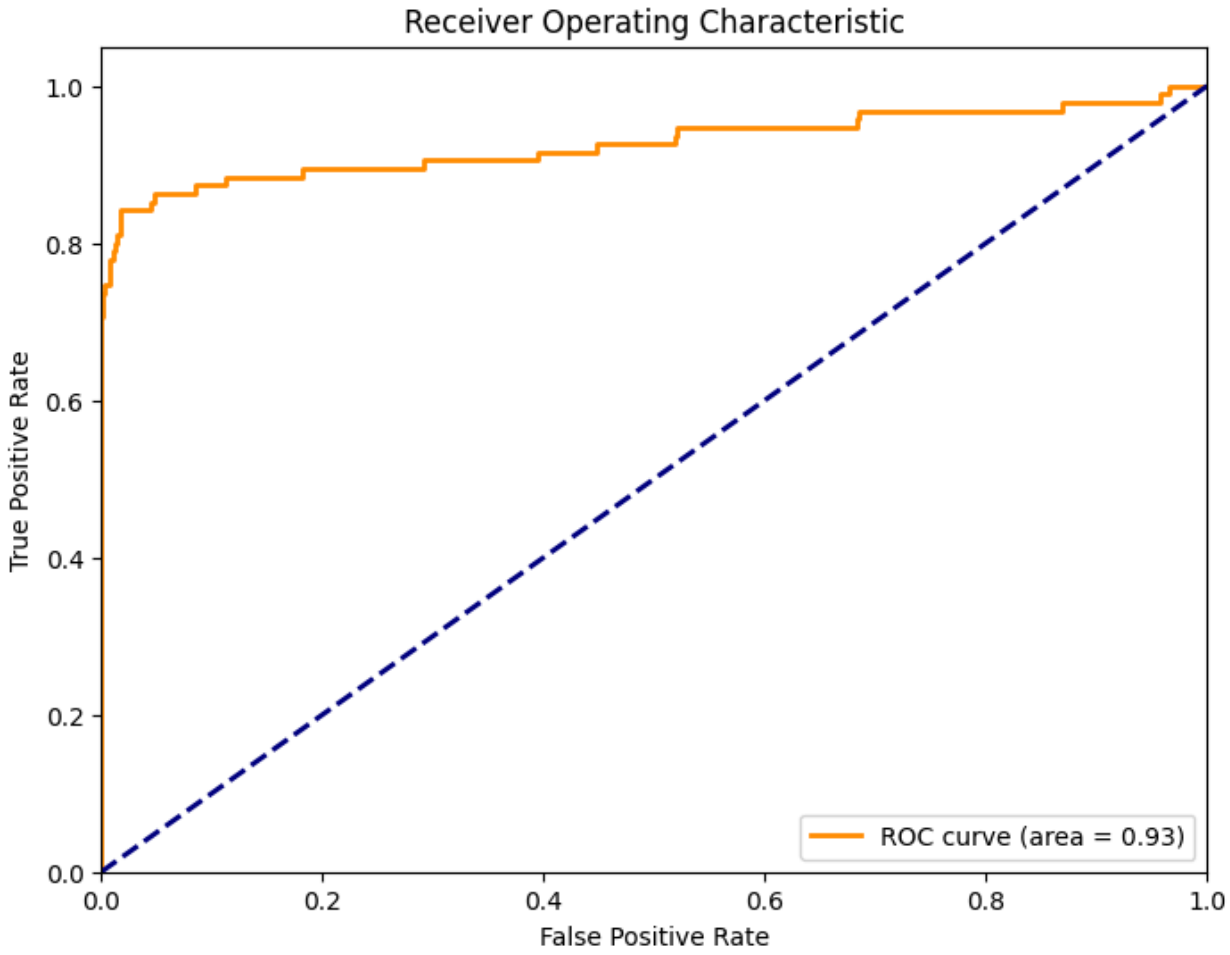
       False       0.96      0.99      0.98       572
        True       0.95      0.75      0.84        95

    accuracy                           0.96       667
   macro avg       0.95      0.87      0.91       667
weighted avg       0.96      0.96      0.96       667
```

ROC-AUC

In [ ]:
```
from sklearn.metrics import roc_curve, roc_auc_score, auc
import matplotlib.pyplot as plt
y_prob = rf1.predict_proba(X_val_new)[:,1]
fpr, tpr, thresholds = roc_curve(y_val,y_prob)
roc_auc = auc(fpr,tpr)
```

In [ ]:
```
plt.figure(figsize=(8, 6))
plt.plot(fpr, tpr, color='darkorange', lw=2, label='ROC curve (area = %0.2f)'
plt.plot([0, 1], [0, 1], color='navy', lw=2, linestyle='--')
plt.xlim([0.0, 1.0])
plt.ylim([0.0, 1.05])
plt.xlabel('False Positive Rate')
plt.ylabel('True Positive Rate')
plt.title('Receiver Operating Characteristic')
plt.legend(loc='lower right')
plt.show()
print("AUC Score:", roc_auc_score(y_val,y_prob))
```




```
AUC Score: 0.9270887007729114
```

Gradient Boosting

In [ ]:
```
from sklearn.ensemble import GradientBoostingClassifier

gbc = GradientBoostingClassifier(learning_rate=0.1, n_estimators=100, max_dept

gbc.fit(X_train_new,y_train)

y_pred_gb = gbc.predict(X_test_new)

acc_gb = accuracy_score(y_test, y_pred_gb)

print("Testing accuracy:", acc_gb)
```

```
Testing accuracy: 0.9550561797752809
```

In [ ]:
```
print("Accuracy:", accuracy_score(y_test, y_pred_gb))
print("Confusion Matrix:\n", confusion_matrix(y_test, y_pred_gb))
print("Classification Report:\n", classification_report(y_test, y_pred_gb))
```

```
Accuracy: 0.9550561797752809
Confusion Matrix:
 [[454   1]
 [ 23  56]]
Classification Report:
              precision    recall  f1-score   support

           0       0.95      1.00      0.97       455
           1       0.98      0.71      0.82        79

    accuracy                           0.96       534
   macro avg       0.97      0.85      0.90       534
weighted avg       0.96      0.96      0.95       534
```

Stacking

In [ ]:
```
from sklearn.neighbors import KNeighborsClassifier

estimators = [
    ('rfs', RandomForestClassifier(n_estimators=50, random_state=42)),
    ('knn', KNeighborsClassifier(n_neighbors=3)),
    ('gbdt',GradientBoostingClassifier())
]
```

```
---------------------------------------------------------------------------
NameError                                 Traceback (most recent call last)
<ipython-input-13-b9d594bf29dd> in <cell line: 4>()
      2
      3 estimators = [
----> 4     ('rfs', RandomForestClassifier(n_estimators=50, random_state=42)),
      5     ('knn', KNeighborsClassifier(n_neighbors=3)),
      6     ('gbdt',GradientBoostingClassifier())

NameError: name 'RandomForestClassifier' is not defined
```

In [ ]:
```
from sklearn.ensemble import StackingClassifier

clf = StackingClassifier(
    estimators=estimators,
    final_estimator=LogisticRegression(),
    cv=10
)

clf.fit(X_train_new,y_train)
```

```
---------------------------------------------------------------------------
NameError                                 Traceback (most recent call last)
<ipython-input-9-059946556de1> in <cell line: 3>()
      2
      3 clf = StackingClassifier(
----> 4     estimators=estimators,
      5     final_estimator=LogisticRegression(),
      6     cv=10

NameError: name 'estimators' is not defined
```

In [ ]:
```
y_pred_st = clf.predict(X_test_new)

acc_st = accuracy_score(y_test, y_pred_st)

print("Testing accuracy:", acc_st)
```

```
Testing accuracy: 0.9531835205992509
```

In [ ]:
```
print("Accuracy:", accuracy_score(y_test, y_pred_st))
print("Confusion Matrix:\n", confusion_matrix(y_test, y_pred_st))
print("Classification Report:\n", classification_report(y_test, y_pred_st))
```

```
Accuracy: 0.9531835205992509
Confusion Matrix:
 [[451   4]
 [ 21  58]]
Classification Report:
              precision    recall  f1-score   support

           0       0.96      0.99      0.97       455
           1       0.94      0.73      0.82        79

    accuracy                           0.95       534
   macro avg       0.95      0.86      0.90       534
weighted avg       0.95      0.95      0.95       534
```

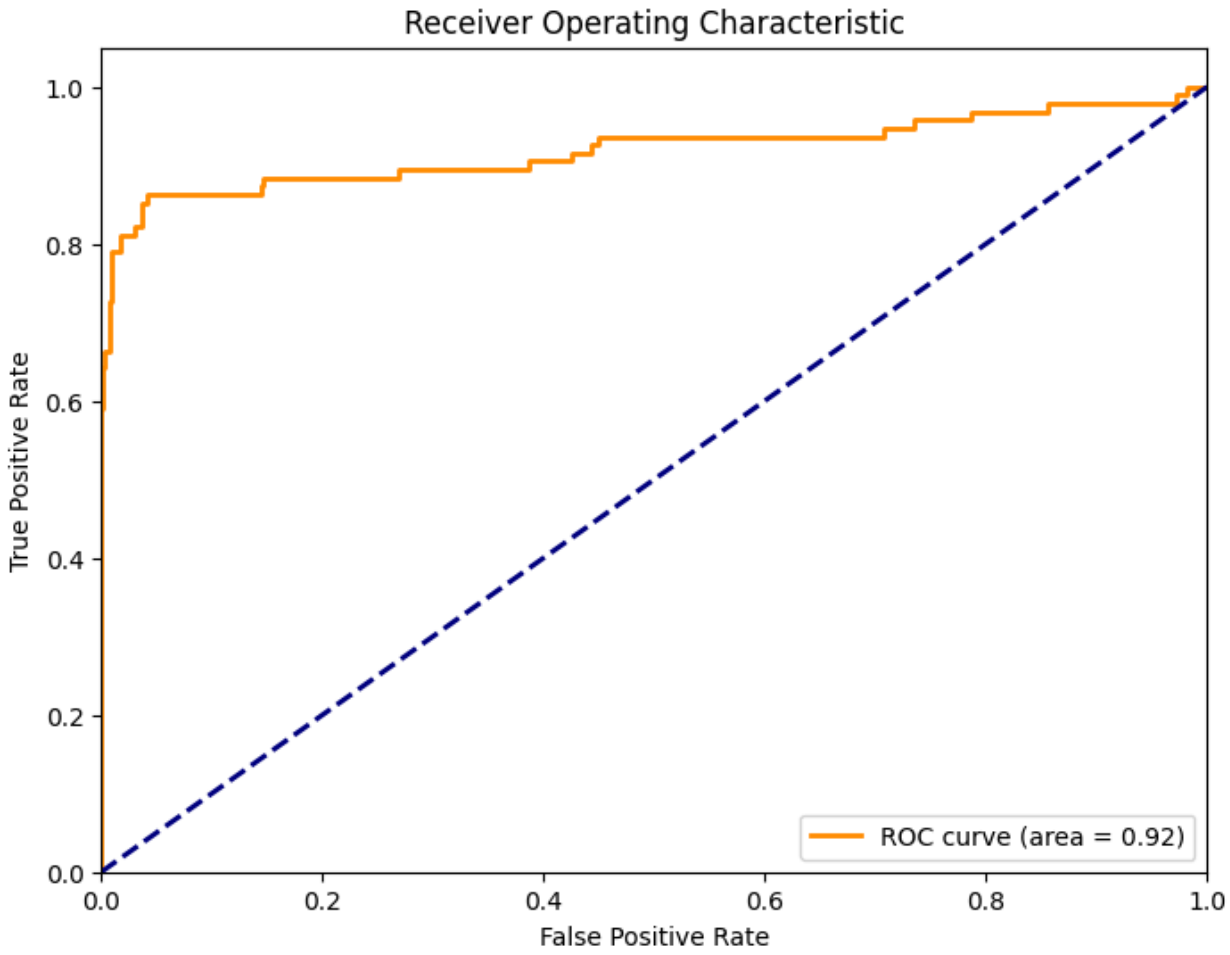
In [ ]:
```
y_prob_st = clf.predict_proba(X_val_new)[:,1]
fpr, tpr, thresholds = roc_curve(y_val,y_prob_st)
roc_auc = auc(fpr,tpr)
```

```
---------------------------------------------------------------------------
NameError                                 Traceback (most recent call last)
<ipython-input-16-5057430a3752> in <cell line: 1>()
----> 1 y_prob_st = clf.predict_proba(X_val_new)[:,1]
      2 fpr, tpr, thresholds = roc_curve(y_val,y_prob_st)
      3 roc_auc = auc(fpr,tpr)

NameError: name 'clf' is not defined
```

In [ ]:
```
plt.figure(figsize=(8, 6))
plt.plot(fpr, tpr, color='darkorange', lw=2, label='ROC curve (area = %0.2f)'
plt.plot([0, 1], [0, 1], color='navy', lw=2, linestyle='--')
```

```
plt.xlim([0.0, 1.0])
plt.ylim([0.0, 1.05])
plt.xlabel('False Positive Rate')
plt.ylabel('True Positive Rate')
plt.title('Receiver Operating Characteristic')
plt.legend(loc='lower right')
plt.show()
print("AUC Score:", roc_auc_score(y_val,y_prob_st))
```




```
AUC Score: 0.9196724328303276
```