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May 3, 2023

#ML Lab Assignment - 8 (SVM Multi class classification)

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0.1 Importing required libraries and loading 'Loan Application' dataset from Kaggle

[1]:
```
import pandas as pd
import numpy as np
import seaborn as sns
from sklearn.model_selection import train_test_split
import matplotlib.pyplot as plt
from sklearn.preprocessing import StandardScaler,LabelEncoder
from sklearn.svm import SVC
from sklearn.metrics import accuracy_score, precision_score, recall_score,␣
↪f1_score, confusion_matrix,mean_squared_error,mean_absolute_error,␣
↪roc_curve, auc
```

[3]:
```
data =pd.read_csv('Loan_data.csv')
```

[4]:
```
data.head()
```

[4]:

	Unnamed: 0	Loan_ID	Gender	Married	Dependents	Education	Self_Employed	ApplicantIncome	CoapplicantIncome	LoanAmount	Loan_Amount_Term	Credit_History	Property_Area	Loan_Status	Total_Income
0	0	LP001002	Male	No	0	Graduate	No	5849	0.0	NaN	360.0	1.0	Urban	Y	$5849.0
1	1	LP001003	Male	Yes	1	Graduate	No	4583	1508.0	128.0	360.0				
2	2	LP001005	Male	Yes	0	Graduate	Yes	3000	0.0	66.0	360.0				
3	3	LP001006	Male	Yes	0	Not Graduate	No	2583	2358.0	120.0	360.0				
4	4	LP001008	Male	No	0	Graduate	No	6000	0.0	141.0	360.0				

```
1            1.0         Rural           N      $6091.0
2            1.0         Urban           Y      $3000.0
3            1.0         Urban           Y      $4941.0
4            1.0         Urban           Y      $6000.0
```

0.2 Data Preprocessing

[5]:
```
# Drop unnecessary features

data.drop(['Loan_ID', 'Gender','Unnamed: 0'], axis=1, inplace=True)
```

[6]:
```
# checking for null values

data.isnull().count()
```

[6]:
```
Married              500
Dependents           500
Education            500
Self_Employed        500
ApplicantIncome      500
CoapplicantIncome    500
LoanAmount           500
Loan_Amount_Term     500
Credit_History       500
Property_Area        500
Loan_Status          500
Total_Income         500
dtype: int64
```

[7]:
```
# dropping null values

df = data.dropna()
```

[8]:
```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 398 entries, 1 to 499
Data columns (total 12 columns):
 #   Column             Non-Null Count  Dtype
---  ------             --------------  -----
 0   Married            398 non-null    object
 1   Dependents         398 non-null    object
 2   Education          398 non-null    object
 3   Self_Employed      398 non-null    object
 4   ApplicantIncome    398 non-null    int64
 5   CoapplicantIncome  398 non-null    float64
 6   LoanAmount         398 non-null    float64
```

```
 7   Loan_Amount_Term   398 non-null    float64
 8   Credit_History     398 non-null    float64
 9   Property_Area      398 non-null    object
 10  Loan_Status        398 non-null    object
 11  Total_Income       398 non-null    object
dtypes: float64(4), int64(1), object(7)
memory usage: 40.4+ KB
```

0.2.1 Since the dataset being used does not have risk category (low-risk, medium-risk, or high-risk borrower), I am creating it by taking into consideration attributes such as 'loan_status' and 'income'.

[11]:
```
# Categorize the borrowers into high, medium, and low-risk
def risk_catagory(row):
    if row['Loan_Status'] == 'Y':
        if row['Credit_History'] == 0:
            return 'high-risk'
        else:
            if row['ApplicantIncome'] > 5000:
                return 'low-risk'
            else:
                return 'medium-risk'
    else:
        return 'high-risk'

df['risk_category'] = df.apply(risk_catagory, axis=1)
```

```
C:\Users\chakr\AppData\Local\Temp\ipykernel_13392\3726966835.py:14:
SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  df['risk_category'] = df.apply(risk_catagory, axis=1)
```

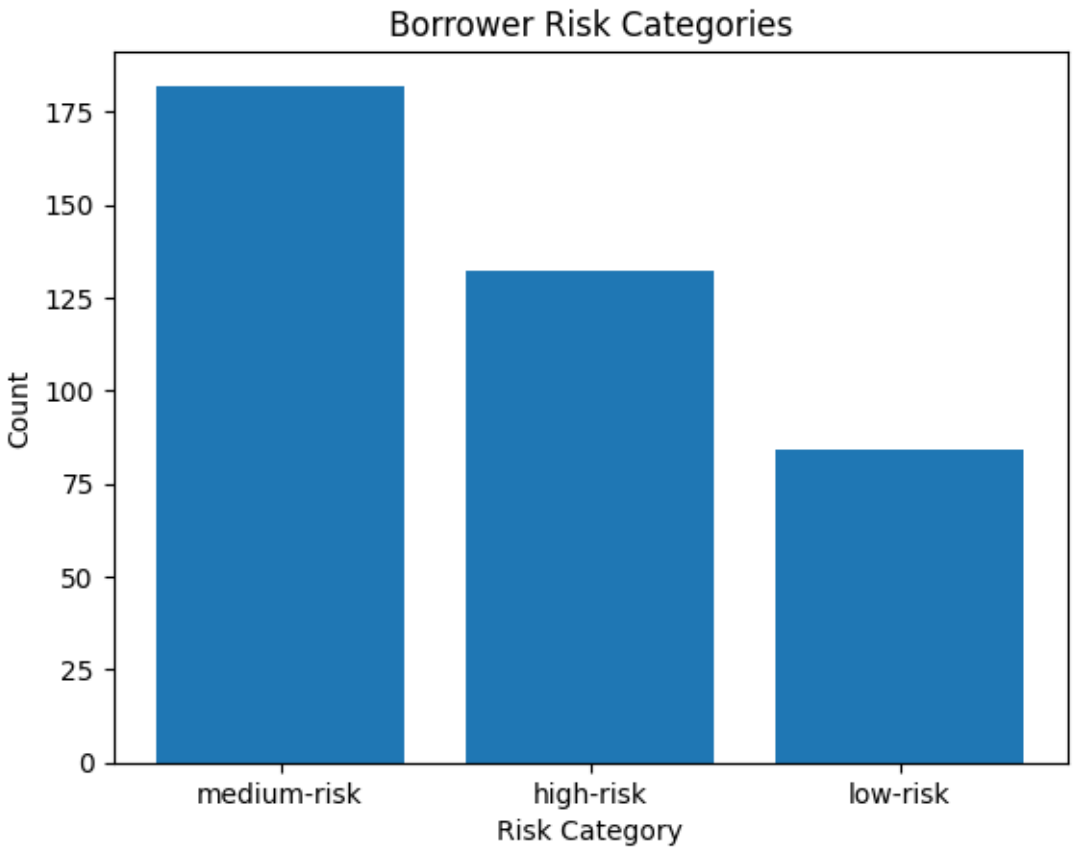
[12]:
```
# Create a new column with the risk categories
df['risk_category'] = df.apply(risk_catagory, axis=1)

# Plot the categories
categories = df['risk_category'].value_counts()
plt.bar(categories.index, categories.values)
plt.xlabel('Risk Category')
plt.ylabel('Count')
plt.title('Borrower Risk Categories')
plt.show()
```

```
C:\Users\chakr\AppData\Local\Temp\ipykernel_13392\1184034841.py:2:
```

```
SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  df['risk_category'] = df.apply(risk_catagory, axis=1)
```



[13]:
```
df.head()
```

[13]:

	Married	Dependents	Education	Self_Employed	ApplicantIncome	\
1	Yes	1	Graduate	No	4583	
2	Yes	0	Graduate	Yes	3000	
3	Yes	0	Not Graduate	No	2583	
4	No	0	Graduate	No	6000	
5	Yes	2	Graduate	Yes	5417	

	CoapplicantIncome	LoanAmount	Loan_Amount_Term	Credit_History	\
1	1508.0	128.0	360.0	1.0	
2	0.0	66.0	360.0	1.0	

```
3             2358.0       120.0             360.0             1.0
4                0.0       141.0             360.0             1.0
5             4196.0       267.0             360.0             1.0

  Property_Area Loan_Status Total_Income risk_category
1         Rural           N      $6091.0     high-risk
2         Urban           Y      $3000.0   medium-risk
3         Urban           Y      $4941.0   medium-risk
4         Urban           Y      $6000.0      low-risk
5         Urban           Y      $9613.0      low-risk
```

[14]:
```
# Replace the categorical values with numeric values
df['Married'] = df['Married'].replace({'No': 0, 'Yes': 1})
df['Education'] = df['Education'].replace({'Not Graduate': 0, 'Graduate': 1})
df['Self_Employed'] = df['Self_Employed'].replace({'No': 0, 'Yes': 1})
df['Property_Area'] = df['Property_Area'].replace({'Rural': 0,'Semiurban':1,␣
 ↪'Urban': 2})
df['Loan_Status'] = df['Loan_Status'].replace({'N': 0, 'Y': 1})
```

```
C:\Users\chakr\AppData\Local\Temp\ipykernel_13392\3089896050.py:2:
SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  df['Married'] = df['Married'].replace({'No': 0, 'Yes': 1})
C:\Users\chakr\AppData\Local\Temp\ipykernel_13392\3089896050.py:3:
SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  df['Education'] = df['Education'].replace({'Not Graduate': 0, 'Graduate': 1})
C:\Users\chakr\AppData\Local\Temp\ipykernel_13392\3089896050.py:4:
SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  df['Self_Employed'] = df['Self_Employed'].replace({'No': 0, 'Yes': 1})
C:\Users\chakr\AppData\Local\Temp\ipykernel_13392\3089896050.py:5:
SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead
```

```
See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  df['Property_Area'] = df['Property_Area'].replace({'Rural': 0,'Semiurban':1,
'Urban': 2})
C:\Users\chakr\AppData\Local\Temp\ipykernel_13392\3089896050.py:6:
SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  df['Loan_Status'] = df['Loan_Status'].replace({'N': 0, 'Y': 1})
```

[16]:
```
# encoding to numeric

label_encoder = LabelEncoder()
df['risk_category'] = label_encoder.fit_transform(df['risk_category'])
```

```
C:\Users\chakr\AppData\Local\Temp\ipykernel_13392\1427944643.py:4:
SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  df['risk_category'] = label_encoder.fit_transform(df['risk_category'])
```

[17]:
```
#removing non-numeric characters from income

df['Total_Income'] = pd.to_numeric(df['Total_Income'].str.replace('$', ''))
```

```
C:\Users\chakr\AppData\Local\Temp\ipykernel_13392\3168310681.py:3:
FutureWarning: The default value of regex will change from True to False in a
future version. In addition, single character regular expressions will *not* be
treated as literal strings when regex=True.
  df['Total_Income'] = pd.to_numeric(df['Total_Income'].str.replace('$', ''))
C:\Users\chakr\AppData\Local\Temp\ipykernel_13392\3168310681.py:3:
SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  df['Total_Income'] = pd.to_numeric(df['Total_Income'].str.replace('$', ''))
```

[18]:
```
# Remove non-numeric characters from dependent attribute
df['Dependents'] = df['Dependents'].str.replace('+', '')

# Convert col1 column to float type
df['Dependents'] = df['Dependents'].astype(float)
```

```
C:\Users\chakr\AppData\Local\Temp\ipykernel_13392\91495691.py:2: FutureWarning:
The default value of regex will change from True to False in a future version.
In addition, single character regular expressions will *not* be treated as
literal strings when regex=True.
  df['Dependents'] = df['Dependents'].str.replace('+', '')
C:\Users\chakr\AppData\Local\Temp\ipykernel_13392\91495691.py:2:
SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  df['Dependents'] = df['Dependents'].str.replace('+', '')
C:\Users\chakr\AppData\Local\Temp\ipykernel_13392\91495691.py:5:
SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  df['Dependents'] = df['Dependents'].astype(float)
```

[19]:
```
from sklearn.preprocessing import MinMaxScaler

# Scale numerical variables to a range of 0 to 1
scaler = MinMaxScaler(feature_range=(0, 1))
df[['ApplicantIncome','CoapplicantIncome', 'LoanAmount','Loan_Amount_Term',␣
 ↪'Total_Income']] = scaler.
 ↪fit_transform(df[['ApplicantIncome','CoapplicantIncome',␣
 ↪'LoanAmount','Loan_Amount_Term', 'Total_Income']])
```

```
C:\Users\chakr\AppData\Local\Temp\ipykernel_13392\2315699904.py:5:
SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  df[['ApplicantIncome','CoapplicantIncome', 'LoanAmount','Loan_Amount_Term',
'Total_Income']] =
scaler.fit_transform(df[['ApplicantIncome','CoapplicantIncome',
'LoanAmount','Loan_Amount_Term', 'Total_Income']])
```

[20]:
```
df.head()
```

[20]:

	Married	Dependents	Education	Self_Employed	ApplicantIncome	\
1	1	1.0	1	0	0.054830	
2	1	0.0	1	1	0.035250	
3	1	0.0	0	0	0.030093	
4	0	0.0	1	0	0.072356	
5	1	2.0	1	1	0.065145	

	CoapplicantIncome	LoanAmount	Loan_Amount_Term	Credit_History	\
1	0.0754	0.162518	0.72973	1.0	
2	0.0000	0.071742	0.72973	1.0	
3	0.1179	0.150805	0.72973	1.0	
4	0.0000	0.181552	0.72973	1.0	
5	0.2098	0.366032	0.72973	1.0	

	Property_Area	Loan_Status	Total_Income	risk_category
1	0	0	0.058435	0
2	2	1	0.019583	2
3	2	1	0.043980	2
4	2	1	0.057292	1
5	2	1	0.102705	1

[21]:
```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 398 entries, 1 to 499
Data columns (total 13 columns):
 #   Column             Non-Null Count  Dtype
---  ------             --------------  -----
 0   Married            398 non-null    int64
 1   Dependents         398 non-null    float64
 2   Education          398 non-null    int64
 3   Self_Employed      398 non-null    int64
 4   ApplicantIncome    398 non-null    float64
 5   CoapplicantIncome  398 non-null    float64
 6   LoanAmount         398 non-null    float64
 7   Loan_Amount_Term   398 non-null    float64
 8   Credit_History     398 non-null    float64
 9   Property_Area      398 non-null    int64
 10  Loan_Status        398 non-null    int64
 11  Total_Income       398 non-null    float64
 12  risk_category      398 non-null    int64
dtypes: float64(7), int64(6)
memory usage: 43.5 KB
```

0.3 Implementing SVM Model & HyperParameter Tuning

[22]:
```
# Split the data into training and testing sets
X_train, X_test, y_train, y_test = train_test_split(df.drop('risk_category',␣
 ↪axis=1), df['risk_category'],test_size=0.3, random_state=42)
```

[23]:
```
from sklearn.model_selection import GridSearchCV
param_grid = {'C': [0.1,0.2,0.3,0.4,0.5,1,5,10,15,20], 'kernel': ['linear',␣
 ↪'Polynomial kernel',"Sigmoid kernel","Gaussian kernel"], 'gamma': ['scale',␣
 ↪'auto']}
```

[24]:
```
svm1 = SVC()
grid_search = GridSearchCV(svm1, param_grid, cv=5, scoring='accuracy',␣
 ↪n_jobs=-1)
```

[25]:
```
grid_search.fit(X_train, y_train)
```

```
c:\Users\chakr\AppData\Local\Programs\Python\Python310\lib\site-
packages\sklearn\model_selection\_validation.py:378: FitFailedWarning:
300 fits failed out of a total of 400.
The score on these train-test partitions for these parameters will be set to
nan.
If these failures are not expected, you can try to debug them by setting
error_score='raise'.

Below are more details about the failures:
--------------------------------------------------------------------------------
5 fits failed with the following error:
Traceback (most recent call last):
  File "c:\Users\chakr\AppData\Local\Programs\Python\Python310\lib\site-
packages\sklearn\model_selection\_validation.py", line 686, in _fit_and_score
    estimator.fit(X_train, y_train, **fit_params)
  File "c:\Users\chakr\AppData\Local\Programs\Python\Python310\lib\site-
packages\sklearn\svm\_base.py", line 180, in fit
    self._validate_params()
  File "c:\Users\chakr\AppData\Local\Programs\Python\Python310\lib\site-
packages\sklearn\base.py", line 570, in _validate_params
    validate_parameter_constraints(
  File "c:\Users\chakr\AppData\Local\Programs\Python\Python310\lib\site-
packages\sklearn\utils\_param_validation.py", line 97, in
validate_parameter_constraints
    raise InvalidParameterError(
sklearn.utils._param_validation.InvalidParameterError: The 'kernel' parameter of
SVC must be a str among {'precomputed', 'sigmoid', 'poly', 'linear', 'rbf'} or a
callable. Got 'Polynomial kernel' instead.

--------------------------------------------------------------------------------
13 fits failed with the following error:
```

```
Traceback (most recent call last):
  File "c:\Users\chakr\AppData\Local\Programs\Python\Python310\lib\site-
packages\sklearn\model_selection\_validation.py", line 686, in _fit_and_score
    estimator.fit(X_train, y_train, **fit_params)
  File "c:\Users\chakr\AppData\Local\Programs\Python\Python310\lib\site-
packages\sklearn\svm\_base.py", line 180, in fit
    self._validate_params()
  File "c:\Users\chakr\AppData\Local\Programs\Python\Python310\lib\site-
packages\sklearn\base.py", line 570, in _validate_params
    validate_parameter_constraints(
  File "c:\Users\chakr\AppData\Local\Programs\Python\Python310\lib\site-
packages\sklearn\utils\_param_validation.py", line 97, in
validate_parameter_constraints
    raise InvalidParameterError(
sklearn.utils._param_validation.InvalidParameterError: The 'kernel' parameter of
SVC must be a str among {'linear', 'sigmoid', 'poly', 'rbf', 'precomputed'} or a
callable. Got 'Polynomial kernel' instead.

--------------------------------------------------------------------------------
2 fits failed with the following error:
Traceback (most recent call last):
  File "c:\Users\chakr\AppData\Local\Programs\Python\Python310\lib\site-
packages\sklearn\model_selection\_validation.py", line 686, in _fit_and_score
    estimator.fit(X_train, y_train, **fit_params)
  File "c:\Users\chakr\AppData\Local\Programs\Python\Python310\lib\site-
packages\sklearn\svm\_base.py", line 180, in fit
    self._validate_params()
  File "c:\Users\chakr\AppData\Local\Programs\Python\Python310\lib\site-
packages\sklearn\base.py", line 570, in _validate_params
    validate_parameter_constraints(
  File "c:\Users\chakr\AppData\Local\Programs\Python\Python310\lib\site-
packages\sklearn\utils\_param_validation.py", line 97, in
validate_parameter_constraints
    raise InvalidParameterError(
sklearn.utils._param_validation.InvalidParameterError: The 'kernel' parameter of
SVC must be a str among {'precomputed', 'poly', 'linear', 'rbf', 'sigmoid'} or a
callable. Got 'Polynomial kernel' instead.

--------------------------------------------------------------------------------
12 fits failed with the following error:
Traceback (most recent call last):
  File "c:\Users\chakr\AppData\Local\Programs\Python\Python310\lib\site-
packages\sklearn\model_selection\_validation.py", line 686, in _fit_and_score
    estimator.fit(X_train, y_train, **fit_params)
  File "c:\Users\chakr\AppData\Local\Programs\Python\Python310\lib\site-
packages\sklearn\svm\_base.py", line 180, in fit
    self._validate_params()
  File "c:\Users\chakr\AppData\Local\Programs\Python\Python310\lib\site-
```

```
packages\sklearn\base.py", line 570, in _validate_params
    validate_parameter_constraints(
  File "c:\Users\chakr\AppData\Local\Programs\Python\Python310\lib\site-
packages\sklearn\utils\_param_validation.py", line 97, in
validate_parameter_constraints
    raise InvalidParameterError(
sklearn.utils._param_validation.InvalidParameterError: The 'kernel' parameter of
SVC must be a str among {'sigmoid', 'precomputed', 'rbf', 'linear', 'poly'} or a
callable. Got 'Polynomial kernel' instead.

--------------------------------------------------------------------------------
13 fits failed with the following error:
Traceback (most recent call last):
  File "c:\Users\chakr\AppData\Local\Programs\Python\Python310\lib\site-
packages\sklearn\model_selection\_validation.py", line 686, in _fit_and_score
    estimator.fit(X_train, y_train, **fit_params)
  File "c:\Users\chakr\AppData\Local\Programs\Python\Python310\lib\site-
packages\sklearn\svm\_base.py", line 180, in fit
    self._validate_params()
  File "c:\Users\chakr\AppData\Local\Programs\Python\Python310\lib\site-
packages\sklearn\base.py", line 570, in _validate_params
    validate_parameter_constraints(
  File "c:\Users\chakr\AppData\Local\Programs\Python\Python310\lib\site-
packages\sklearn\utils\_param_validation.py", line 97, in
validate_parameter_constraints
    raise InvalidParameterError(
sklearn.utils._param_validation.InvalidParameterError: The 'kernel' parameter of
SVC must be a str among {'linear', 'rbf', 'poly', 'sigmoid', 'precomputed'} or a
callable. Got 'Polynomial kernel' instead.

--------------------------------------------------------------------------------
9 fits failed with the following error:
Traceback (most recent call last):
  File "c:\Users\chakr\AppData\Local\Programs\Python\Python310\lib\site-
packages\sklearn\model_selection\_validation.py", line 686, in _fit_and_score
    estimator.fit(X_train, y_train, **fit_params)
  File "c:\Users\chakr\AppData\Local\Programs\Python\Python310\lib\site-
packages\sklearn\svm\_base.py", line 180, in fit
    self._validate_params()
  File "c:\Users\chakr\AppData\Local\Programs\Python\Python310\lib\site-
packages\sklearn\base.py", line 570, in _validate_params
    validate_parameter_constraints(
  File "c:\Users\chakr\AppData\Local\Programs\Python\Python310\lib\site-
packages\sklearn\utils\_param_validation.py", line 97, in
validate_parameter_constraints
    raise InvalidParameterError(
sklearn.utils._param_validation.InvalidParameterError: The 'kernel' parameter of
SVC must be a str among {'sigmoid', 'precomputed', 'poly', 'rbf', 'linear'} or a
```

```
callable. Got 'Sigmoid kernel' instead.

--------------------------------------------------------------------------------
9 fits failed with the following error:
Traceback (most recent call last):
  File "c:\Users\chakr\AppData\Local\Programs\Python\Python310\lib\site-
packages\sklearn\model_selection\_validation.py", line 686, in _fit_and_score
    estimator.fit(X_train, y_train, **fit_params)
  File "c:\Users\chakr\AppData\Local\Programs\Python\Python310\lib\site-
packages\sklearn\svm\_base.py", line 180, in fit
    self._validate_params()
  File "c:\Users\chakr\AppData\Local\Programs\Python\Python310\lib\site-
packages\sklearn\base.py", line 570, in _validate_params
    validate_parameter_constraints(
  File "c:\Users\chakr\AppData\Local\Programs\Python\Python310\lib\site-
packages\sklearn\utils\_param_validation.py", line 97, in
validate_parameter_constraints
    raise InvalidParameterError(
sklearn.utils._param_validation.InvalidParameterError: The 'kernel' parameter of
SVC must be a str among {'sigmoid', 'precomputed', 'poly', 'linear', 'rbf'} or a
callable. Got 'Sigmoid kernel' instead.

--------------------------------------------------------------------------------
14 fits failed with the following error:
Traceback (most recent call last):
  File "c:\Users\chakr\AppData\Local\Programs\Python\Python310\lib\site-
packages\sklearn\model_selection\_validation.py", line 686, in _fit_and_score
    estimator.fit(X_train, y_train, **fit_params)
  File "c:\Users\chakr\AppData\Local\Programs\Python\Python310\lib\site-
packages\sklearn\svm\_base.py", line 180, in fit
    self._validate_params()
  File "c:\Users\chakr\AppData\Local\Programs\Python\Python310\lib\site-
packages\sklearn\base.py", line 570, in _validate_params
    validate_parameter_constraints(
  File "c:\Users\chakr\AppData\Local\Programs\Python\Python310\lib\site-
packages\sklearn\utils\_param_validation.py", line 97, in
validate_parameter_constraints
    raise InvalidParameterError(
sklearn.utils._param_validation.InvalidParameterError: The 'kernel' parameter of
SVC must be a str among {'linear', 'precomputed', 'poly', 'rbf', 'sigmoid'} or a
callable. Got 'Sigmoid kernel' instead.

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17 fits failed with the following error:
Traceback (most recent call last):
  File "c:\Users\chakr\AppData\Local\Programs\Python\Python310\lib\site-
packages\sklearn\model_selection\_validation.py", line 686, in _fit_and_score
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  File "c:\Users\chakr\AppData\Local\Programs\Python\Python310\lib\site-
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  File "c:\Users\chakr\AppData\Local\Programs\Python\Python310\lib\site-
packages\sklearn\utils\_param_validation.py", line 97, in
validate_parameter_constraints
    raise InvalidParameterError(
sklearn.utils._param_validation.InvalidParameterError: The 'kernel' parameter of
SVC must be a str among {'rbf', 'sigmoid', 'poly', 'precomputed', 'linear'} or a
callable. Got 'Sigmoid kernel' instead.

--------------------------------------------------------------------------------
6 fits failed with the following error:
Traceback (most recent call last):
  File "c:\Users\chakr\AppData\Local\Programs\Python\Python310\lib\site-
packages\sklearn\model_selection\_validation.py", line 686, in _fit_and_score
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SVC must be a str among {'linear', 'precomputed', 'poly', 'sigmoid', 'rbf'} or a
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SVC must be a str among {'linear', 'precomputed', 'poly', 'sigmoid', 'rbf'} or a
callable. Got 'Gaussian kernel' instead.

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11 fits failed with the following error:
Traceback (most recent call last):
  File "c:\Users\chakr\AppData\Local\Programs\Python\Python310\lib\site-
packages\sklearn\model_selection\_validation.py", line 686, in _fit_and_score
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16 fits failed with the following error:
Traceback (most recent call last):
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Traceback (most recent call last):
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Traceback (most recent call last):
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SVC must be a str among {'rbf', 'sigmoid', 'precomputed', 'linear', 'poly'} or a
callable. Got 'Sigmoid kernel' instead.

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Traceback (most recent call last):
  File "c:\Users\chakr\AppData\Local\Programs\Python\Python310\lib\site-
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SVC must be a str among {'rbf', 'sigmoid', 'precomputed', 'linear', 'poly'} or a
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```
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Traceback (most recent call last):
  File "c:\Users\chakr\AppData\Local\Programs\Python\Python310\lib\site-
packages\sklearn\model_selection\_validation.py", line 686, in _fit_and_score
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sklearn.utils._param_validation.InvalidParameterError: The 'kernel' parameter of
SVC must be a str among {'rbf', 'sigmoid', 'poly', 'precomputed', 'linear'} or a
callable. Got 'Polynomial kernel' instead.

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10 fits failed with the following error:
Traceback (most recent call last):
  File "c:\Users\chakr\AppData\Local\Programs\Python\Python310\lib\site-
packages\sklearn\model_selection\_validation.py", line 686, in _fit_and_score
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SVC must be a str among {'precomputed', 'poly', 'rbf', 'linear', 'sigmoid'} or a
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  File "c:\Users\chakr\AppData\Local\Programs\Python\Python310\lib\site-
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sklearn.utils._param_validation.InvalidParameterError: The 'kernel' parameter of
SVC must be a str among {'precomputed', 'poly', 'rbf', 'linear', 'sigmoid'} or a
callable. Got 'Sigmoid kernel' instead.

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Traceback (most recent call last):
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sklearn.utils._param_validation.InvalidParameterError: The 'kernel' parameter of
SVC must be a str among {'precomputed', 'poly', 'rbf', 'linear', 'sigmoid'} or a
callable. Got 'Gaussian kernel' instead.

--------------------------------------------------------------------------------
13 fits failed with the following error:
Traceback (most recent call last):
  File "c:\Users\chakr\AppData\Local\Programs\Python\Python310\lib\site-
packages\sklearn\model_selection\_validation.py", line 686, in _fit_and_score
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8 fits failed with the following error:
Traceback (most recent call last):
  File "c:\Users\chakr\AppData\Local\Programs\Python\Python310\lib\site-
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SVC must be a str among {'linear', 'sigmoid', 'poly', 'rbf', 'precomputed'} or a
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Traceback (most recent call last):
  File "c:\Users\chakr\AppData\Local\Programs\Python\Python310\lib\site-
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Traceback (most recent call last):
  File "c:\Users\chakr\AppData\Local\Programs\Python\Python310\lib\site-
packages\sklearn\model_selection\_validation.py", line 686, in _fit_and_score
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5 fits failed with the following error:
Traceback (most recent call last):
  File "c:\Users\chakr\AppData\Local\Programs\Python\Python310\lib\site-
packages\sklearn\model_selection\_validation.py", line 686, in _fit_and_score
    estimator.fit(X_train, y_train, **fit_params)
  File "c:\Users\chakr\AppData\Local\Programs\Python\Python310\lib\site-
packages\sklearn\svm\_base.py", line 180, in fit
    self._validate_params()
  File "c:\Users\chakr\AppData\Local\Programs\Python\Python310\lib\site-
packages\sklearn\base.py", line 570, in _validate_params
    validate_parameter_constraints(
  File "c:\Users\chakr\AppData\Local\Programs\Python\Python310\lib\site-
packages\sklearn\utils\_param_validation.py", line 97, in
validate_parameter_constraints
    raise InvalidParameterError(
sklearn.utils._param_validation.InvalidParameterError: The 'kernel' parameter of
SVC must be a str among {'sigmoid', 'precomputed', 'poly', 'rbf', 'linear'} or a
callable. Got 'Gaussian kernel' instead.

--------------------------------------------------------------------------------
7 fits failed with the following error:
Traceback (most recent call last):
  File "c:\Users\chakr\AppData\Local\Programs\Python\Python310\lib\site-
packages\sklearn\model_selection\_validation.py", line 686, in _fit_and_score
    estimator.fit(X_train, y_train, **fit_params)
  File "c:\Users\chakr\AppData\Local\Programs\Python\Python310\lib\site-
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--------------------------------------------------------------------------------
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```

```
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validate_parameter_constraints
    raise InvalidParameterError(
sklearn.utils._param_validation.InvalidParameterError: The 'kernel' parameter of
SVC must be a str among {'linear', 'rbf', 'poly', 'sigmoid', 'precomputed'} or a
callable. Got 'Sigmoid kernel' instead.

--------------------------------------------------------------------------------
3 fits failed with the following error:
Traceback (most recent call last):
  File "c:\Users\chakr\AppData\Local\Programs\Python\Python310\lib\site-
packages\sklearn\model_selection\_validation.py", line 686, in _fit_and_score
    estimator.fit(X_train, y_train, **fit_params)
  File "c:\Users\chakr\AppData\Local\Programs\Python\Python310\lib\site-
packages\sklearn\svm\_base.py", line 180, in fit
    self._validate_params()
  File "c:\Users\chakr\AppData\Local\Programs\Python\Python310\lib\site-
packages\sklearn\base.py", line 570, in _validate_params
    validate_parameter_constraints(
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SVC must be a str among {'linear', 'sigmoid', 'poly', 'rbf', 'precomputed'} or a
callable. Got 'Gaussian kernel' instead.

--------------------------------------------------------------------------------
3 fits failed with the following error:
Traceback (most recent call last):
  File "c:\Users\chakr\AppData\Local\Programs\Python\Python310\lib\site-
packages\sklearn\model_selection\_validation.py", line 686, in _fit_and_score
    estimator.fit(X_train, y_train, **fit_params)
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packages\sklearn\base.py", line 570, in _validate_params
    validate_parameter_constraints(
  File "c:\Users\chakr\AppData\Local\Programs\Python\Python310\lib\site-
packages\sklearn\utils\_param_validation.py", line 97, in
```

```
validate_parameter_constraints
    raise InvalidParameterError(
sklearn.utils._param_validation.InvalidParameterError: The 'kernel' parameter of
SVC must be a str among {'linear', 'rbf', 'poly', 'sigmoid', 'precomputed'} or a
callable. Got 'Gaussian kernel' instead.

--------------------------------------------------------------------------------
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  File "c:\Users\chakr\AppData\Local\Programs\Python\Python310\lib\site-
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    estimator.fit(X_train, y_train, **fit_params)
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    self._validate_params()
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packages\sklearn\base.py", line 570, in _validate_params
    validate_parameter_constraints(
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packages\sklearn\utils\_param_validation.py", line 97, in
validate_parameter_constraints
    raise InvalidParameterError(
sklearn.utils._param_validation.InvalidParameterError: The 'kernel' parameter of
SVC must be a str among {'precomputed', 'poly', 'linear', 'rbf', 'sigmoid'} or a
callable. Got 'Sigmoid kernel' instead.

  warnings.warn(some_fits_failed_message, FitFailedWarning)
c:\Users\chakr\AppData\Local\Programs\Python\Python310\lib\site-
packages\sklearn\model_selection\_search.py:953: UserWarning: One or more of the
test scores are non-finite: [0.79136364        nan        nan        nan
0.79136364        nan
        nan        nan 0.80571429        nan        nan        nan
 0.80571429        nan        nan        nan 0.83071429        nan
        nan        nan 0.83071429        nan        nan        nan
 0.83071429        nan        nan        nan 0.83071429        nan
        nan        nan 0.83792208        nan        nan        nan
 0.83792208        nan        nan        nan 0.85603896        nan
        nan        nan 0.85603896        nan        nan        nan
 0.92448052        nan        nan        nan 0.92448052        nan
        nan        nan 0.93162338        nan        nan        nan
 0.93162338        nan        nan        nan 0.93519481        nan
        nan        nan 0.93519481        nan        nan        nan
 0.93519481        nan        nan        nan 0.93519481        nan
        nan        nan]
  warnings.warn(
```

[25]:
```
GridSearchCV(cv=5, estimator=SVC(), n_jobs=-1,
             param_grid={'C': [0.1, 0.2, 0.3, 0.4, 0.5, 1, 5, 10, 15, 20],
                         'gamma': ['scale', 'auto'],
                         'kernel': ['linear', 'Polynomial kernel',
                                    'Sigmoid kernel', 'Gaussian kernel']},
             scoring='accuracy')
```

[26]:
```
print("Best parameters:", grid_search.best_params_)
print("Best score:", grid_search.best_score_)
```

```
Best parameters: {'C': 15, 'gamma': 'scale', 'kernel': 'linear'}
Best score: 0.9351948051948051
```

[27]:
```
best_model = grid_search.best_estimator_
y_pred = best_model.predict(X_test)
accuracy = accuracy_score(y_test, y_pred)
print("Test accuracy:", accuracy)
```

```
Test accuracy: 0.9083333333333333
```

[28]:
```
# Calculate RMSE and MAE
rmse = np.sqrt(mean_squared_error(y_test, y_pred))
mae = mean_absolute_error(y_test, y_pred)

print('RMSE :', rmse)
print('MAE :', mae)
```

```
RMSE : 0.30276503540974914
MAE : 0.09166666666666666
```

[29]:
```
# Evaluate the performance
precision = precision_score(y_test, y_pred, average='weighted')
recall = recall_score(y_test, y_pred, average='weighted')
f1 = f1_score(y_test, y_pred, average='weighted')
print(f"Accuracy: {accuracy:.2f}, Precision: {precision:.2f}, Recall: {recall:.
↪2f}, F1-score: {f1:.2f}")
```

```
Accuracy: 0.91, Precision: 0.91, Recall: 0.91, F1-score: 0.90
```

[ ]:
```
sns.heatmap(confusion_matrix, annot=True, cmap='Blues', fmt='g',␣
↪xticklabels=label_encoder.classes_, yticklabels=label_encoder.classes_)
plt.xlabel('Predicted')
plt.ylabel('Actual')
plt.title('Confusion Matrix')
plt.show()
```

[33]:
```
from sklearn.metrics import confusion_matrix
conf_matrix = confusion_matrix(y_true=y_test, y_pred=y_pred)
fig, ax = plt.subplots(figsize=(7.5, 7.5))
ax.matshow(conf_matrix, cmap=plt.cm.Blues, alpha=0.3)
for i in range(conf_matrix.shape[0]):
    for j in range(conf_matrix.shape[1]):
        ax.text(x=j, y=i,s=conf_matrix[i, j], va='center', ha='center',␣
 ↪size='xx-large')

plt.xlabel('Predictions', fontsize=18)
plt.ylabel('Actuals', fontsize=18)
plt.title('Confusion Matrix', fontsize=18)
plt.show()
```