Project: 'Nayyer' Prediction Model for SDAIA

Describtion: ML model to predict if the candidate is suitable for the sensitive ML and Data Science career or not. **Model Type:** Classification model.

Career Types:
- AI Engineer.
- ML Engineer.
- Data Engineer.
- Data Scientist.

```python
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sn
from sklearn.model_selection import train_test_split
from sklearn.preprocessing import StandardScaler, OrdinalEncoder,
OneHotEncoder
```

(1) Import the dataset:

```python
df = pd.read_csv('Placement_Data_Full_Class.csv')
df.head()
```

```
   sl_no gender  ssc_p    ssc_b  ...  specialisation  mba_p
status    salary
0      1      M  67.00   Others  ...          Mkt&HR  58.80
Placed  270000.0
1      2      M  79.33  Central  ...          Mkt&Fin  66.28
Placed  200000.0
2      3      M  65.00  Central  ...          Mkt&Fin  57.80
Placed  250000.0
3      4      M  56.00  Central  ...          Mkt&HR  59.43  Not
Placed       NaN
4      5      M  85.80  Central  ...          Mkt&Fin  55.50
Placed  425000.0

[5 rows x 15 columns]
```

```python
print(f"Bachelor's: {df['degree_t'].unique()}\n
{df['specialisation'].unique()}\n MBA MAX: {df['mba_p'].max()}\n MBA
MIN: {df['mba_p'].min()}")
```

```
Bachelor's: ['Sci&Tech' 'Comm&Mgmt' 'Others']
 ['Mkt&HR' 'Mkt&Fin']
 MBA MAX: 77.89
 MBA MIN: 51.21
```

(2) Clean and prepare the data:

```python
np.random.seed(42)

# (1) delete the index, secondary school related, workex, salary
columns:
#df.drop(columns=['sl_no', 'ssc_p', 'ssc_b', 'hsc_p', 'hsc_b','hsc_s',
'degree_p', 'workex', 'salary'], inplace=True)

# (2) Rename columns:
#df.rename(columns= {'degree_t' : 'bachelors', 'specialisation' :
'master', 'mba_p' : 'degree'}, inplace=True)

# (3.0) change major, MBA, and specialisation values:
df['degree'] = np.random.randint(55.0, 99.0, len(df['degree']))
df['degree'].astype(np.float64)
df['bachelors'] = df['bachelors'].replace({'Others' : 'Sci&Tech'})

# (3.1) write random majors for master:
master_majores = ['AI', 'Data Engineer', 'MBA', 'None']

for i, row in df.iterrows():
    if row['bachelors'] == 'Comm&Mgmt':
        df.loc[i, 'master'] = master_majores[ np.random.randint(2,4)]
    else:
        df.loc[i, 'master'] =
master_majores[ np.random.randint(len(master_majores))]

for i, row in df.iterrows():
    if row['master'] == 'None':
        df.loc[i, 'degree'] = 0.

# display the dataframe:
df.head()
```

```
  gender  bachelors  etest_p master  degree status  year_exp  age
0      M    Sci&Tech     55.0     AI      85      0         4   29
1      M    Sci&Tech     86.5   None       0      0         3   42
2      M   Comm&Mgmt     75.0   None       0      0         1   37
3      M    Sci&Tech     66.0   None       0      0         5   33
4      M   Comm&Mgmt     96.8    MBA      88      1         6   30
```

```python
# (4) create new columns: 'year_experince' at technology career and
'age':
df['year_exp'] = 0
df['age'] = np.random.randint(23, 47, len(df['year_exp']))
for i, row in df.iterrows():
    if row['master'] == 'None':
        df.loc[i, 'year_exp'] = np.random.randint(0,2)
    elif row['master'] == 'AI':
        df.loc[i, 'year_exp'] = np.random.randint(1,5)
```

```python
    else:
        df.loc[i, 'year_exp'] = np.random.randint(0,7)

# display the dataframe:
df.head()
```

```
  gender  bachelors  etest_p master  degree  status  year_exp  age
0      M   Sci&Tech     55.0     AI      85       0         4   37
1      M   Sci&Tech     86.5   None       0       0         1   40
2      M  Comm&Mgmt     75.0   None       0       0         0   40
3      M   Sci&Tech     66.0   None       0       0         1   34
4      M  Comm&Mgmt     96.8    MBA      88       1         0   40
```

```python
# (5) change status values to be suitable to new data (1 : placed, 0 :
not placed):
df ['status'] = df['status'].astype(np.int32)

for i, row in df.iterrows():
    if int(int(row['master'] != 'None') & row['degree'] > 75):
        df.loc[i, 'status'] = 1 # placed
    elif (int(row['master'] == 'None') & int(row['year_exp'] > 2) &
int(row['etest_p'] > 74)):
        df.loc[i, 'status'] = 1 # placed
    elif(row['etest_p'] > 90):
        df.loc[i, 'status'] = 1 # placed
    else:
        df.loc[i, 'status'] = 0 # not placed

# display the dataframe:
df.head()
```

```
  gender  bachelors  etest_p master  degree  status  year_exp  age
0      M   Sci&Tech     55.0     AI      85       0         4   23
1      M   Sci&Tech     86.5   None       0       0         1   44
2      M  Comm&Mgmt     75.0   None       0       0         0   45
3      M   Sci&Tech     66.0   None       0       0         0   41
4      M  Comm&Mgmt     96.8    MBA      88       1         2   30
```

(3) Add more samples to DataFrame:

```python
# add more smples dataframe (from: 215, to: 5000):

samples = df.sample(n=(6000 - len(df)), replace=True,random_state=23)

# make noise:
num_col = ['etest_p', 'degree', 'year_exp', 'age']

for col in num_col:
    std = df[col].std()
    jitter = np.random.normal(loc=0, scale= 0.05*std, size=(6000 -
```

```
len(df)))
    samples[col] = (samples[col] + jitter).clip(lower=0, upper=100)

new_df = pd.concat([df, samples], ignore_index=True)

# display the new dataframe + count the classes:
print(new_df.head())
print(new_df['status'].value_counts())
```

```
  gender  bachelors  etest_p master  degree  status  year_exp   age
0      M    Sci&Tech     55.0     AI    85.0       0       4.0  23.0
1      M    Sci&Tech     86.5   None     0.0       0       1.0  44.0
2      M  Comm&Mgmt     75.0   None     0.0       0       0.0  45.0
3      M    Sci&Tech     66.0   None     0.0       0       0.0  41.0
4      M  Comm&Mgmt     96.8    MBA    88.0       1       2.0  30.0
status
0    5284
1     716
Name: count, dtype: int64
```

(4) Explore the new dataset (EDA):

```
# for numric values:
new_df.describe()
```

```
           etest_p        degree        status      year_exp           age
count  6000.000000  6000.000000  6000.000000  6000.000000  6000.000000
mean     72.211332    44.278945     0.119333     1.779538    35.130961
std      13.323206    37.925429     0.324207     1.875957     7.262261
min      48.254107     0.000000     0.000000     0.000000    22.046551
25%      60.238389     0.389970     0.000000     0.084428    28.894854
50%      70.778670    59.169548     0.000000     1.018810    35.874622
75%      83.645002    77.076263     0.000000     3.007897    41.733909
max      99.635964   100.000000     1.000000     6.294716    47.002651
```

```
# for categorical values:
new_df.describe(exclude='number')
```

```
        gender  bachelors  master
count      6000       6000    6000
unique        2          2       4
top           M  Comm&Mgmt     MBA
freq       3938       4017    2489
```

```
# comperhensive explore:
new_df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 6000 entries, 0 to 5999
Data columns (total 8 columns):
 #   Column      Non-Null Count  Dtype
```

```
 ---   ------       --------------   -----
  0    gender       6000 non-null    object
  1    bachelors    6000 non-null    object
  2    etest_p      6000 non-null    float64
  3    master       6000 non-null    object
  4    degree       6000 non-null    float64
  5    status       6000 non-null    int32
  6    year_exp     6000 non-null    float64
  7    age          6000 non-null    float64
dtypes: float64(4), int32(1), object(3)
memory usage: 351.7+ KB
```

(5) Split the Data:

```
x = new_df.drop(columns=['status'])
y = new_df['status']
```

(6) Encode Categorical Data :

use: ColumnTransformer() function.

```
from sklearn.compose import ColumnTransformer


oe = OrdinalEncoder()
ohe = OneHotEncoder(sparse_output=False,handle_unknown='ignore')

ct = ColumnTransformer(transformers= [('oe', oe, [0,1]),('ohe', ohe,
[3])], remainder='passthrough')

ct_x = ct.fit_transform(x)
feature_list = ct.get_feature_names_out().tolist()
```

Feature names:

- gender: (1 : Male -- 0 : Female)
- bachelors: (1 : Sci&Tech -- 0 : Comm&Mgmt)
- master__AI
- master__Data Engineer
- master__MBA
- master__None
- remainder__etest_p
- remainder__degree
- remainder__year_exp
- remainder__age

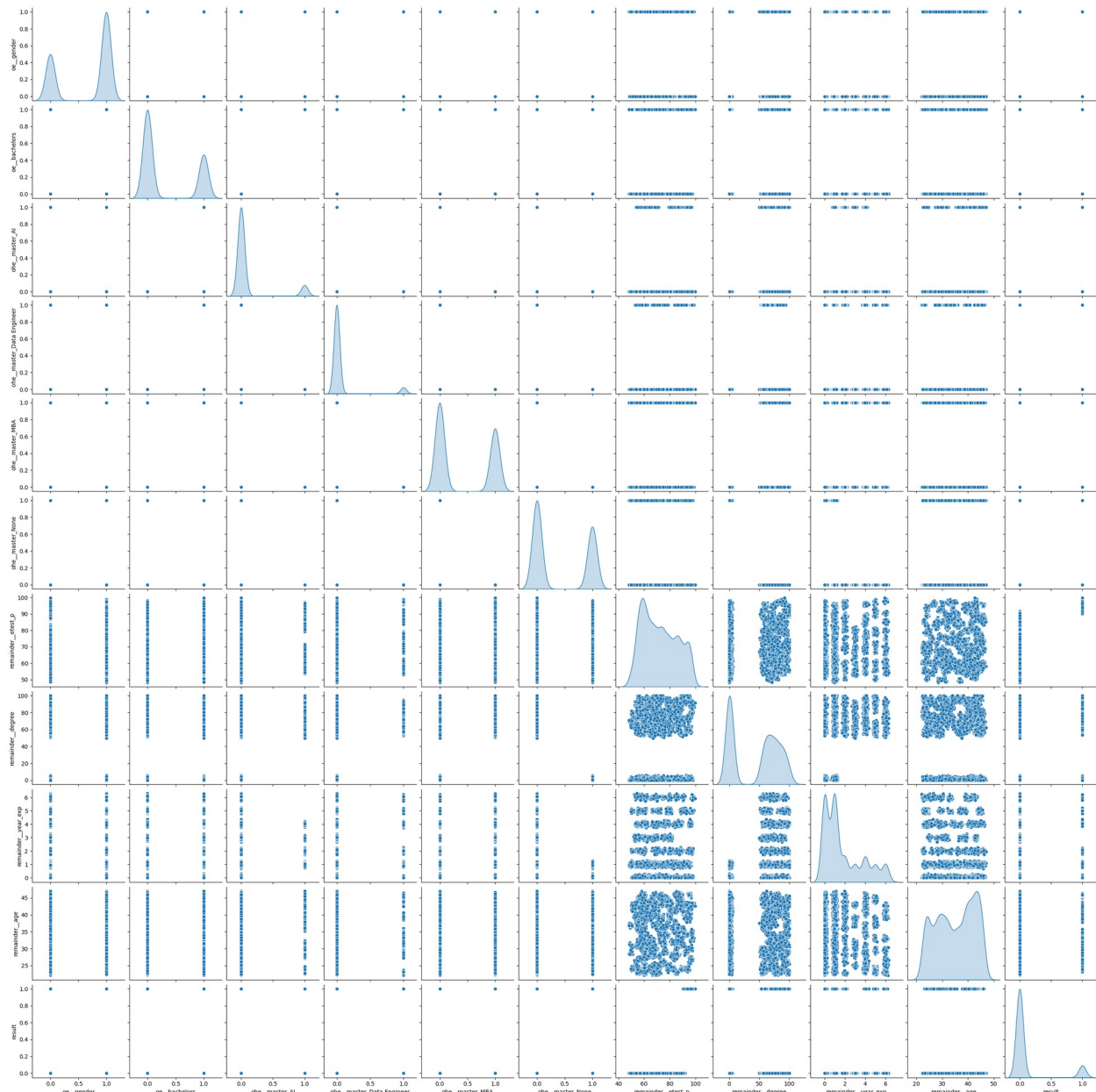## (7) Draw the relations:

```
# collect the values in Dataframe:
encoded_df = pd.DataFrame(ct_x, columns=feature_list)
encoded_df['result'] = y
encoded_df.head()

   oe__gender  oe__bachelors  ...  remainder__age  result
0         1.0            1.0  ...            23.0       0
1         1.0            1.0  ...            44.0       0
2         1.0            0.0  ...            45.0       0
3         1.0            1.0  ...            41.0       0
4         1.0            0.0  ...            30.0       1

[5 rows x 11 columns]

# draw the pairplot:

sn.pairplot(data=encoded_df,diag_kind='kde')
plt.show()
```

insights:

- From the graph we see that the data is non-linear (has no straight line in relationships), so keep this information in mind when choose the ML algorithm.
- The data have imbalance classification, which will decreace the performance of model predictions to unseen data.

(8) Dimentional reduction to data:

by 2 methods:

- feature selection; correlation, and chi 2 test, finall using RandomForest.

- • feature extraction: use t-SNE; to minimize the dimentions for non-linear data to draw the classification of data (At the final step of project).

```python
# Correlation:
corr_df = encoded_df.corr()

# draw heatmap:
plt.figure(figsize=(10,10))
sn.heatmap(data=corr_df,
annot=True,cmap='magma',linewidths=0.8,square=True)
plt.show()
```
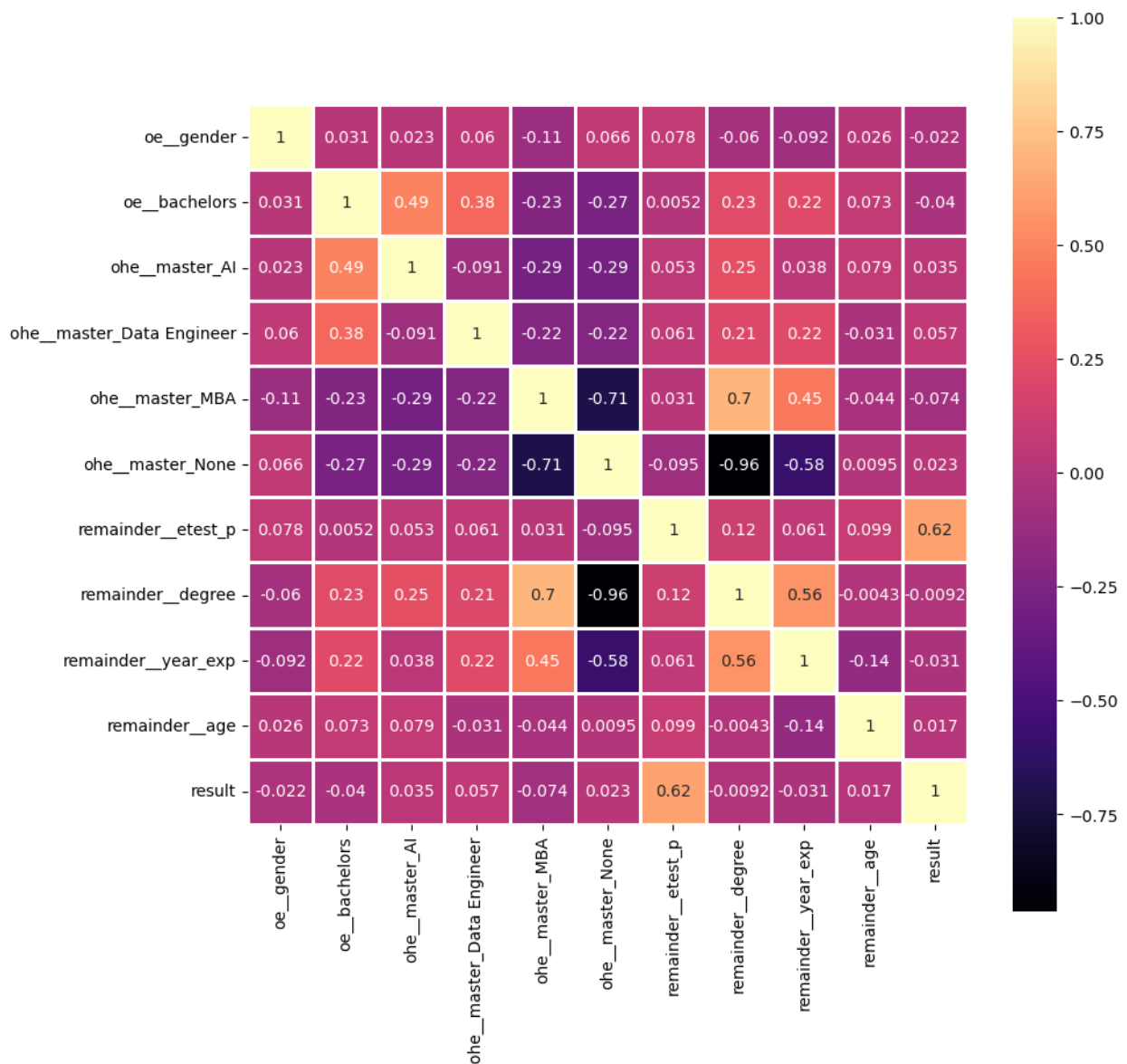

insight:

- From heatmap, we see that the high correlation was between master_MBA and degree, which mean it'will drop one of them; so maybe drop master_MBA.
- If see the relation between degree and master_None it considred as to oppsite, and this is logical relationship, because if you don't take master, then you won't have a degree for master.

```python
# chi 2 test:
from sklearn.feature_selection import chi2, RFE, SelectKBest

# Just choose categorical columns:
x_chi2, y_chi2 = encoded_df.loc[:, ['oe__gender', 'oe__bachelors',
'ohe__master_AI', 'ohe__master_Data Engineer', 'ohe__master_MBA',
'ohe__master_None']], encoded_df['result']

# choose the best 3 categorical features:
best_cat = SelectKBest(chi2,k=3)
selected_feature_x = best_cat.fit_transform(x_chi2, y_chi2)

# print the results:
print(f'The new shape: {selected_feature_x.shape}\n Feature names:
{best_cat.get_feature_names_out()}\n Values:
{best_cat.get_support()}')

The new shape: (6000, 3)
 Feature names: ['ohe__master_AI' 'ohe__master_Data Engineer'
'ohe__master_MBA']
 Values: [False False  True   True   True False]
```

The result for categorical selection: From the heatmap, we decided to drop master_MBA, but after doing chi2 test.

```python
# use RandomForest:
from sklearn.ensemble import RandomForestClassifier

# split the data:
x_random, y_random =
encoded_df.drop(columns=['result']).loc[0:1000, :],
encoded_df['result'].loc[0:1000]

# create the model:
random_forest = RandomForestClassifier(n_estimators=180, max_depth=5)
random_forest.fit(x_random, y_random)

dic = {column: random_forest.feature_importances_[i] for i, column in
enumerate(x_random.columns)}

print(sorted(dic.items(),key=lambda item: item[1], reverse=True))

[('remainder__etest_p', np.float64(0.8653980902249392)),
('remainder__age', np.float64(0.04726837084109614)),
('remainder__degree', np.float64(0.03648308151211223)),
```

```
('remainder__year_exp', np.float64(0.023486991883556466)),
('oe__bachelors', np.float64(0.01072118151406151)), ('oe__gender',
np.float64(0.005067576974255987)), ('ohe__master_MBA',
np.float64(0.004569072194331675)), ('ohe__master_Data Engineer',
np.float64(0.002687642163060185)), ('ohe__master_AI',
np.float64(0.002680819544017524)), ('ohe__master_None',
np.float64(0.001637173148569157))]
```

The most important features:

- etest_p (Job intreview score).
- age.
- degree (degree of master).
- year_exp.
- bachelors.
- master_AI
- master_Data Engineer
- master_MBA We can see the most important features were numric data.

```python
# Drop ohe__master_None, oe_gender, columns:
droped_df = encoded_df.drop(columns=['oe__gender',
'ohe__master_None'])
```

(9) Create the model and train it:

steps:

1- Split data to train and test. 2- Standaraizing the data. 3- Create the model. 4- Train the model.
5- Fine-tuning. **note:** use pipline to gather scale data, train, fine-tuning, and make prediction
from model.

```python
# (1) split the data:
x, y = droped_df.drop(columns=['result']), droped_df['result']

x_train, x_test, y_train, y_test = train_test_split(x, y,
test_size=0.2, random_state=23)

print(f'Train Size: {x_train.shape[0]} -- Test Size:
{x_test.shape[0]}')

Train Size: 4800 -- Test Size: 1200

# check which columns needed for Standraization (numric values):
x.columns.tolist() # [4,5,6,7]

['oe__bachelors',
 'ohe__master_AI',
 'ohe__master_Data Engineer',
 'ohe__master_MBA',
```

```
 'remainder__etest_p',
 'remainder__degree',
 'remainder__year_exp',
 'remainder__age']
```

(2) Standraizing the numric data:

```
data_standard = ColumnTransformer(transformers=[('standard2',
StandardScaler(), ['remainder__etest_p', 'remainder__degree',
'remainder__year_exp', 'remainder__age'])], remainder='passthrough')
```

(3,4,5) create, train, fine-tuning the model(remamber: the data is
non-linear):

```
from sklearn.pipeline import make_pipeline
from sklearn.model_selection import GridSearchCV
from sklearn.svm import SVC

power = np.arange(-4,4,1)
num = [np.power(10, power[i], dtype=np.float64) for i in
range(len(power))]

grid_param = {'C' : num, 'gamma' : num, 'kernel' : ['rbf']}
clf = make_pipeline(data_standard, GridSearchCV(estimator=SVC(),
param_grid=grid_param, cv=10, verbose=2, refit=True))

clf.fit(x_train, y_train)

Fitting 10 folds for each of 64 candidates, totalling 640 fits
[CV] END .................C=0.0001, gamma=0.0001, kernel=rbf; total
time=   0.1s
[CV] END .................C=0.0001, gamma=0.0001, kernel=rbf; total
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[CV] END ...................C=0.0001, gamma=0.001, kernel=rbf; total
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[CV] END ....................C=0.0001, gamma=0.1, kernel=rbf; total
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[CV] END ...................C=0.0001, gamma=10.0, kernel=rbf; total
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time=   0.1s
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[CV] END ..................C=0.0001, gamma=1000.0, kernel=rbf; total
time=   0.1s
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time=   0.0s
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time=   0.0s
[CV] END ...................C=0.001, gamma=0.0001, kernel=rbf; total
time=   0.0s
```

```
[CV] END ...................C=0.001, gamma=0.0001, kernel=rbf; total
time=    0.0s
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time=    0.0s
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time=    0.0s
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time=    0.1s
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time=    0.0s
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time=    0.1s
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time=    0.0s
[CV] END ...................C=0.001, gamma=0.01, kernel=rbf; total
```

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time=    0.0s
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time=    0.0s
```

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time=   0.1s
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time=   0.1s
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time=   0.1s
[CV] END ..................C=0.001, gamma=1000.0, kernel=rbf; total
```

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time=   0.1s
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time=   0.1s
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time=   0.1s
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time=   0.0s
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time=   0.2s
[CV] END .....................C=0.01, gamma=0.01, kernel=rbf; total
time=   0.1s
```

```
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[CV] END .....................C=0.01, gamma=1.0, kernel=rbf; total
time=   0.2s
[CV] END .....................C=0.01, gamma=1.0, kernel=rbf; total
```

```
time=   0.2s
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time=   0.2s
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time=   0.9s
```

```
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time=   0.1s
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time=   0.1s
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time=   0.1s
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time=   0.1s
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time=   0.3s
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time=   0.1s
[CV] END .....................C=0.1, gamma=0.001, kernel=rbf; total
time=   0.1s
[CV] END .....................C=0.1, gamma=0.001, kernel=rbf; total
time=   0.1s
```

```
[CV] END ......................C=0.1, gamma=0.001, kernel=rbf; total
time=    0.1s
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time=    0.1s
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time=    0.1s
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time=    0.1s
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time=    0.1s
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time=    0.1s
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time=    0.1s
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time=    0.2s
[CV] END ........................C=0.1, gamma=0.1, kernel=rbf; total
time=    0.2s
[CV] END ........................C=0.1, gamma=0.1, kernel=rbf; total
time=    0.1s
[CV] END ........................C=0.1, gamma=0.1, kernel=rbf; total
time=    0.1s
[CV] END ........................C=0.1, gamma=0.1, kernel=rbf; total
time=    0.1s
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time=    0.2s
[CV] END ........................C=0.1, gamma=0.1, kernel=rbf; total
time=    0.1s
[CV] END ........................C=0.1, gamma=0.1, kernel=rbf; total
time=    0.2s
[CV] END ........................C=0.1, gamma=1.0, kernel=rbf; total
```

```
time=   0.1s
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time=   0.1s
[CV] END .......................C=0.1, gamma=1.0, kernel=rbf; total
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[CV] END .......................C=0.1, gamma=1.0, kernel=rbf; total
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time=   0.1s
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time=   0.1s
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time=   0.1s
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time=   0.1s
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time=   0.1s
[CV] END .......................C=0.1, gamma=1.0, kernel=rbf; total
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time=   0.2s
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time=   0.2s
[CV] END ......................C=0.1, gamma=10.0, kernel=rbf; total
time=   0.2s
[CV] END ......................C=0.1, gamma=10.0, kernel=rbf; total
time=   0.2s
[CV] END .....................C=0.1, gamma=100.0, kernel=rbf; total
time=   0.7s
[CV] END .....................C=0.1, gamma=100.0, kernel=rbf; total
time=   0.8s
[CV] END .....................C=0.1, gamma=100.0, kernel=rbf; total
time=   0.7s
[CV] END .....................C=0.1, gamma=100.0, kernel=rbf; total
time=   0.7s
[CV] END .....................C=0.1, gamma=100.0, kernel=rbf; total
time=   0.7s
```

```
[CV] END ......................C=0.1, gamma=100.0, kernel=rbf; total
time=   0.7s
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time=   0.7s
[CV] END ......................C=0.1, gamma=100.0, kernel=rbf; total
time=   0.7s
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time=   0.7s
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time=   0.7s
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time=   1.1s
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time=   1.4s
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time=   1.4s
[CV] END ....................C=0.1, gamma=1000.0, kernel=rbf; total
time=   1.2s
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time=   0.9s
[CV] END ....................C=0.1, gamma=1000.0, kernel=rbf; total
time=   0.9s
[CV] END ....................C=0.1, gamma=1000.0, kernel=rbf; total
time=   0.9s
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time=   0.9s
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time=   0.9s
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time=   0.9s
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time=   0.1s
[CV] END ....................C=1.0, gamma=0.0001, kernel=rbf; total
time=   0.1s
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time=   0.1s
[CV] END ....................C=1.0, gamma=0.0001, kernel=rbf; total
time=   0.2s
[CV] END ....................C=1.0, gamma=0.0001, kernel=rbf; total
time=   0.1s
[CV] END ....................C=1.0, gamma=0.0001, kernel=rbf; total
time=   0.1s
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time=   0.1s
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time=   0.1s
[CV] END ....................C=1.0, gamma=0.0001, kernel=rbf; total
time=   0.2s
[CV] END ....................C=1.0, gamma=0.0001, kernel=rbf; total
```

```
time=    0.1s
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time=    0.1s
[CV] END ......................C=1.0, gamma=0.001, kernel=rbf; total
time=    0.1s
[CV] END ......................C=1.0, gamma=0.001, kernel=rbf; total
time=    0.1s
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time=    0.1s
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time=    0.1s
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[CV] END .......................C=1.0, gamma=0.01, kernel=rbf; total
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time=    0.0s
[CV] END ........................C=1.0, gamma=0.1, kernel=rbf; total
time=    0.0s
[CV] END ........................C=1.0, gamma=0.1, kernel=rbf; total
time=    0.0s
```

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[CV] END .......................C=1.0, gamma=0.1, kernel=rbf; total
time=   0.0s
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time=   0.0s
[CV] END .......................C=1.0, gamma=1.0, kernel=rbf; total
time=   0.0s
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time=   0.2s
[CV] END .......................C=1.0, gamma=10.0, kernel=rbf; total
time=   0.2s
[CV] END .......................C=1.0, gamma=10.0, kernel=rbf; total
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time=   0.2s
[CV] END .......................C=1.0, gamma=10.0, kernel=rbf; total
time=   0.1s
[CV] END .......................C=1.0, gamma=10.0, kernel=rbf; total
time=   0.1s
[CV] END .......................C=1.0, gamma=10.0, kernel=rbf; total
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[CV] END .......................C=1.0, gamma=10.0, kernel=rbf; total
time=   0.1s
[CV] END .......................C=1.0, gamma=10.0, kernel=rbf; total
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time=   0.1s
[CV] END ......................C=1.0, gamma=10.0, kernel=rbf; total
time=   0.1s
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time=   1.3s
[CV] END .....................C=1.0, gamma=100.0, kernel=rbf; total
time=   0.9s
[CV] END .....................C=1.0, gamma=100.0, kernel=rbf; total
time=   0.9s
[CV] END .....................C=1.0, gamma=100.0, kernel=rbf; total
time=   0.9s
[CV] END .....................C=1.0, gamma=100.0, kernel=rbf; total
time=   0.7s
[CV] END .....................C=1.0, gamma=100.0, kernel=rbf; total
time=   1.1s
[CV] END .....................C=1.0, gamma=100.0, kernel=rbf; total
time=   0.9s
[CV] END .....................C=1.0, gamma=100.0, kernel=rbf; total
time=   0.9s
[CV] END .....................C=1.0, gamma=100.0, kernel=rbf; total
time=   0.9s
[CV] END .....................C=1.0, gamma=100.0, kernel=rbf; total
time=   0.7s
[CV] END ....................C=1.0, gamma=1000.0, kernel=rbf; total
time=   1.2s
[CV] END ....................C=1.0, gamma=1000.0, kernel=rbf; total
time=   1.3s
[CV] END ....................C=1.0, gamma=1000.0, kernel=rbf; total
time=   1.3s
[CV] END ....................C=1.0, gamma=1000.0, kernel=rbf; total
time=   1.1s
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time=   1.0s
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time=   1.0s
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time=   1.0s
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time=   1.0s
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time=   1.0s
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time=   1.0s
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time=   0.1s
[CV] END ...................C=10.0, gamma=0.0001, kernel=rbf; total
time=   0.1s
[CV] END ...................C=10.0, gamma=0.0001, kernel=rbf; total
time=   0.1s
```

```
[CV] END ....................C=10.0, gamma=0.0001, kernel=rbf; total
time=   0.1s
[CV] END ....................C=10.0, gamma=0.0001, kernel=rbf; total
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[CV] END ....................C=10.0, gamma=0.0001, kernel=rbf; total
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time=   0.1s
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time=   0.0s
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time=   0.1s
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time=   0.0s
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time=   0.1s
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time=   0.0s
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time=   0.0s
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time=   0.0s
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time=   0.0s
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time=   0.0s
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time=   0.0s
[CV] END ....................C=10.0, gamma=0.01, kernel=rbf; total
```

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time=    0.0s
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time=    0.0s
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time=    0.0s
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time=    0.3s
[CV] END .....................C=10.0, gamma=10.0, kernel=rbf; total
time=    0.2s
```

```
[CV] END .....................C=10.0, gamma=10.0, kernel=rbf; total
time=   0.2s
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time=   0.2s
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time=   0.2s
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time=   1.1s
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time=   1.3s
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time=   1.0s
[CV] END .....................C=10.0, gamma=100.0, kernel=rbf; total
time=   0.9s
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time=   1.1s
[CV] END .....................C=10.0, gamma=100.0, kernel=rbf; total
time=   0.9s
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time=   0.9s
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time=   1.0s
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time=   1.0s
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time=   1.1s
[CV] END ...................C=10.0, gamma=1000.0, kernel=rbf; total
time=   1.2s
[CV] END ...................C=10.0, gamma=1000.0, kernel=rbf; total
time=   1.4s
[CV] END ...................C=10.0, gamma=1000.0, kernel=rbf; total
time=   1.4s
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time=   1.1s
[CV] END ...................C=10.0, gamma=1000.0, kernel=rbf; total
```

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time=   1.1s
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time=   1.1s
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time=   1.1s
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time=   0.1s
[CV] END ...................C=100.0, gamma=0.0001, kernel=rbf; total
time=   0.0s
[CV] END ...................C=100.0, gamma=0.0001, kernel=rbf; total
time=   0.1s
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time=   0.1s
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time=   0.0s
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time=   0.0s
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time=   0.0s
[CV] END .....................C=100.0, gamma=0.01, kernel=rbf; total
time=   0.0s
```

```
[CV] END .....................C=100.0, gamma=0.01, kernel=rbf; total
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[CV] END .....................C=100.0, gamma=0.01, kernel=rbf; total
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time=   0.0s
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[CV] END .....................C=100.0, gamma=1.0, kernel=rbf; total
time=   0.0s
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time=   0.0s
[CV] END .....................C=100.0, gamma=1.0, kernel=rbf; total
time=   0.0s
[CV] END .....................C=100.0, gamma=1.0, kernel=rbf; total
time=   0.0s
```

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[CV] END .....................C=100.0, gamma=1.0, kernel=rbf; total
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[CV] END .....................C=100.0, gamma=1.0, kernel=rbf; total
time=   0.0s
[CV] END ....................C=100.0, gamma=10.0, kernel=rbf; total
time=   0.1s
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[CV] END ....................C=100.0, gamma=10.0, kernel=rbf; total
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[CV] END ....................C=100.0, gamma=10.0, kernel=rbf; total
time=   0.2s
[CV] END ....................C=100.0, gamma=10.0, kernel=rbf; total
time=   0.2s
[CV] END ...................C=100.0, gamma=100.0, kernel=rbf; total
time=   1.2s
[CV] END ...................C=100.0, gamma=100.0, kernel=rbf; total
time=   1.6s
[CV] END ...................C=100.0, gamma=100.0, kernel=rbf; total
time=   1.0s
[CV] END ...................C=100.0, gamma=100.0, kernel=rbf; total
time=   0.9s
[CV] END ...................C=100.0, gamma=100.0, kernel=rbf; total
time=   1.2s
[CV] END ...................C=100.0, gamma=100.0, kernel=rbf; total
time=   1.0s
[CV] END ...................C=100.0, gamma=100.0, kernel=rbf; total
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[CV] END ...................C=100.0, gamma=100.0, kernel=rbf; total
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time=   0.9s
[CV] END ..................C=100.0, gamma=1000.0, kernel=rbf; total
```

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time=   1.1s
[CV] END ..................C=100.0, gamma=1000.0, kernel=rbf; total
time=   1.3s
[CV] END ..................C=100.0, gamma=1000.0, kernel=rbf; total
time=   1.1s
[CV] END ..................C=100.0, gamma=1000.0, kernel=rbf; total
time=   1.3s
[CV] END ..................C=100.0, gamma=1000.0, kernel=rbf; total
time=   1.3s
[CV] END ..................C=100.0, gamma=1000.0, kernel=rbf; total
time=   1.2s
[CV] END ..................C=100.0, gamma=1000.0, kernel=rbf; total
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[CV] END ..................C=100.0, gamma=1000.0, kernel=rbf; total
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[CV] END ...................C=1000.0, gamma=0.001, kernel=rbf; total
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[CV] END ...................C=1000.0, gamma=0.1, kernel=rbf; total
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time=   0.0s
[CV] END ....................C=1000.0, gamma=1.0, kernel=rbf; total
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[CV] END ....................C=1000.0, gamma=1.0, kernel=rbf; total
time=   0.0s
[CV] END ....................C=1000.0, gamma=10.0, kernel=rbf; total
time=   0.1s
[CV] END ....................C=1000.0, gamma=10.0, kernel=rbf; total
time=   0.1s
[CV] END ....................C=1000.0, gamma=10.0, kernel=rbf; total
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[CV] END ....................C=1000.0, gamma=10.0, kernel=rbf; total
time=   0.1s
[CV] END ...................C=1000.0, gamma=100.0, kernel=rbf; total
time=   1.0s
[CV] END ...................C=1000.0, gamma=100.0, kernel=rbf; total
time=   1.4s
[CV] END ...................C=1000.0, gamma=100.0, kernel=rbf; total
time=   1.1s
[CV] END ...................C=1000.0, gamma=100.0, kernel=rbf; total
time=   1.2s
```

```
[CV] END ..................C=1000.0, gamma=100.0, kernel=rbf; total
time=   1.6s
[CV] END ..................C=1000.0, gamma=100.0, kernel=rbf; total
time=   1.0s
[CV] END ..................C=1000.0, gamma=100.0, kernel=rbf; total
time=   0.9s
[CV] END ..................C=1000.0, gamma=100.0, kernel=rbf; total
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[CV] END ..................C=1000.0, gamma=100.0, kernel=rbf; total
time=   0.9s
[CV] END ..................C=1000.0, gamma=100.0, kernel=rbf; total
time=   1.0s
[CV] END ..................C=1000.0, gamma=1000.0, kernel=rbf; total
time=   1.1s
[CV] END ..................C=1000.0, gamma=1000.0, kernel=rbf; total
time=   1.1s
[CV] END ..................C=1000.0, gamma=1000.0, kernel=rbf; total
time=   1.1s
[CV] END ..................C=1000.0, gamma=1000.0, kernel=rbf; total
time=   1.1s
[CV] END ..................C=1000.0, gamma=1000.0, kernel=rbf; total
time=   1.1s
[CV] END ..................C=1000.0, gamma=1000.0, kernel=rbf; total
time=   1.1s
[CV] END ..................C=1000.0, gamma=1000.0, kernel=rbf; total
time=   1.4s
[CV] END ..................C=1000.0, gamma=1000.0, kernel=rbf; total
time=   1.4s
[CV] END ..................C=1000.0, gamma=1000.0, kernel=rbf; total
time=   1.2s
[CV] END ..................C=1000.0, gamma=1000.0, kernel=rbf; total
time=   1.1s

C:\Users\R1alm\Documents\anaconda\Lib\site-packages\sklearn\compose\
_column_transformer.py:1667: FutureWarning:
The format of the columns of the 'remainder' transformer in
ColumnTransformer.transformers_ will change in version 1.7 to match
the format of the other transformers.
At the moment the remainder columns are stored as indices (of type
int). With the same ColumnTransformer configuration, in the future
they will be stored as column names (of type str).
To use the new behavior now and suppress this warning, use
ColumnTransformer(force_int_remainder_cols=False).

  warnings.warn(

Pipeline(steps=[('columntransformer',
                 ColumnTransformer(remainder='passthrough',
                                   transformers=[('standard2',
StandardScaler(),
```

```
['remainder__etest_p',

'remainder__degree',

'remainder__year_exp',

'remainder__age'])])]),
                ('gridsearchcv',
                 GridSearchCV(cv=10, estimator=SVC(),
                              param_grid={'C': [np.float64(0.0001),
                                                np.float64(0.001),
                                                np.float64(0.01),
                                                np.float64(0.1),
                                                np.float64(1.0),
                                                np.float64(10.0),
                                                np.float64(100.0),
                                                np.float64(1000.0)],
                                          'gamma':
[np.float64(0.0001),
                                                   np.float64(0.001),
                                                   np.float64(0.01),
                                                   np.float64(0.1),
                                                   np.float64(1.0),
                                                   np.float64(10.0),
                                                   np.float64(100.0),

np.float64(1000.0)],
                                          'kernel': ['rbf']},
                              verbose=2))])
```

Discrebtion of steps:

- first: imported functions that needed.
- Second: make a pipeline that holds StandardScale for scale numric values in data, then pass them to GridSearchCV which hold ML algorithm.
- GridSearchCV: used SVC (svm for classification) with **'rbf' kernel** to refit and predict our data well, the reason to choose it because our data is non-linear, so the LogisticRegression is not suitable for that. Then pass multiaple values for 'gamma' and 'C' (inverse Regularization) to **fine-tune** the model with the best hyperparameters.
- Third: train of fit the model using the training data.
- (Cross-Validation) : GridSearchCV has embadded cross-validation in its function, which it will validate the data to give the best predictions, it use 'cv' for number of folds, and verbose for how much information is displayed.

```
# show the best hyperparametars:
clf.named_steps['gridsearchcv'].best_estimator_

SVC(C=np.float64(1.0), gamma=np.float64(10.0))
```

(10) Evaluate the model - first:

```python
from sklearn import metrics

# make predictions:
y_pred = clf.predict(x_test)

# calculate the accuracy score:
print(metrics.accuracy_score(y_true=y_test, y_pred=y_pred))

1.0

# show confiosion matrix:
metrics.confusion_matrix(y_true=y_test,y_pred=y_pred)

array([[1071,    0],
       [   0,  129]])
```

From confiusion matrix and accuracy score:

- see that our model predict in high quality for now, which equal to 100%.

for test: enter new fake data that already know its classes and see if the model can predict well or is infection by 'overfitting':

```python
new_test_x = np.array([
    [1, 1, 0, 0, 90, 95, 1, 28, 1],
    [1, 0, 0, 0, 85, 0, 2, 25, 0],
    [1, 0, 1, 0, 50, 99, 4, 32, 0],
    [1, 0, 0, 0, 70, 0, 4, 32, 0],
    [1, 0, 0, 1, 82, 90, 7, 40, 1],
    [0, 0, 0, 1, 95, 70, 8, 40, 1],
    [0, 0, 0, 0, 51, 0, 6, 32, 0],
    [0, 0, 1, 0, 80, 70, 4, 42, 0],
    [1, 1, 0, 0, 99, 86, 8, 40, 1],
    [1, 0, 0, 0, 95, 0, 2, 23, 1]
])

test_df = pd.DataFrame(new_test_x, columns=droped_df.columns.tolist())
new_test_x = test_df.drop(columns=['result'])
new_test_y = test_df['result']

# predict:
predict_for_overfit = clf.predict(new_test_x)
print(predict_for_overfit)

[0 0 0 0 0 0 0 0 0 0]
```

Result:

- we can determain from result that our model infected by overfitting because imbalance classification, to solve need to oversampling for lower class 1.

(11) Solve Imbalance Classification by Oversampling:

```
from imblearn.over_sampling import SMOTE

x_train, x_test, y_train, y_test = train_test_split(x, y,
test_size=0.2, random_state=23)
smote = SMOTE(random_state=23,sampling_strategy='minority')
x_sm, y_sm = smote.fit_resample(x_train, y_train)
y_sm.value_counts()

result
0    4213
1    4213
Name: count, dtype: int64
```

(12) Create the new model with final Fine-Tuning - Evaluate The model - second:

```
# create new SVC model with best estimator hyperparameter in the last
model:
svm_model = SVC(kernel='rbf', C=1, gamma=10)

# new pipeline:
svm_pipline = make_pipeline(data_standard, svm_model)

# fit the model with new balanced data:
svm_pipline.fit(x_sm, y_sm)

# make predictions and count the accuaracy score:
y_pred_sm = svm_pipline.predict(x_test)

print(metrics.accuracy_score(y_true=y_test, y_pred=y_pred_sm))

1.0

# make predictions for the new data:
y_pred_sm = svm_pipline.predict(new_test_x)

print(metrics.accuracy_score(y_true=new_test_y, y_pred=y_pred_sm))

0.5
```

From results:

- let's manipulate new hyperparameters, because the values maybe lead to overfitting.

```
svm_pipline = make_pipeline(data_standard, SVC(kernel='rbf', C=100,
gamma=0.01))
```

```python
# fit the model
svm_pipline.fit(x_sm, y_sm)

 # make predictions:
y_pred_sm = svm_pipline.predict(x_test)

print(metrics.accuracy_score(y_true=y_test, y_pred=y_pred_sm))

0.9975

# make predictions for the new data:
y_pred_sm = svm_pipline.predict(new_test_x)

print(metrics.accuracy_score(y_true=new_test_y, y_pred=y_pred_sm))

0.9

# print confiosion matrix:

metrics.confusion_matrix(new_test_y, y_pred_sm)

array([[5, 0],
       [1, 4]])
```

Result:

- From the metrix, the model predict one employee incorrectly as the 'class (1)' and was from the 'class (0)'.

(13) Visualizing the Data:

```python
from sklearn.manifold import TSNE

t_sne = TSNE(n_components=3, perplexity=20)
t_sne_x = t_sne.fit_transform(x_sm)

t_sne_x.shape

(8426, 3)

# draw the chart:

tnse_df = pd.DataFrame(t_sne_x, columns=['x','y','z'])
tnse_df['result'] = y_sm
tnse_df['result'] = tnse_df['result'].astype('category')
tnse_df['result'] = tnse_df['result'].replace({1 : 'Yes', 0 : 'No'})

colors = {'Yes' : '#21BCFF', 'No' : '#FB2C36'}

 # the structure of graph:
fig = plt.figure(figsize=(30,28))
```

```
ax = fig.add_subplot(111, projection='3d')

# draw the graph with hue:
for label in tnse_df['result'].unique():
    sub = tnse_df[tnse_df['result'] == label]
    ax.scatter(sub['x'], sub['y'], sub['z'], label=label, cmap=colors,
alpha=0.5)

title_font = {'family': 'serif','color': 'black','size': 35,'weight':
'bold'}
label_font = {'family': 'sans-serif','color': 'black','size': 18}

ax.set_title('Distribution of Employee Nomination in SDAIA',
fontdict=title_font)
ax.set_xlabel('x', fontdict=label_font)
ax.set_ylabel('y', fontdict=label_font)
ax.set_zlabel('z', fontdict=label_font)

plt.legend(title='Employee Hire', fontsize=18, title_fontsize=20)
plt.show()
```

```
C:\Users\R1alm\AppData\Local\Temp\ipykernel_3292\1551910285.py:6:
FutureWarning: The behavior of Series.replace (and DataFrame.replace)
with CategoricalDtype is deprecated. In a future version, replace will
only be used for cases that preserve the categories. To change the
categories, use ser.cat.rename_categories instead.
  tnse_df['result'] = tnse_df['result'].replace({1 : 'Yes', 0 : 'No'})
C:\Users\R1alm\AppData\Local\Temp\ipykernel_3292\1551910285.py:17:
UserWarning: No data for colormapping provided via 'c'. Parameters
'cmap' will be ignored
  ax.scatter(sub['x'], sub['y'], sub['z'], label=label, cmap=colors,
alpha=0.5)
```

Distribution of Employee Nomination in SDAIA