best_model_pred

January 23, 2023

[ ]:
```
# Import the necessary libraries
# import libraries
import pandas as pd
import numpy as np
import seaborn as sns
import matplotlib.pyplot as plt
```

[ ]:
```
# We have imported dataset of world

df = pd.read_csv('world_population.csv')
```

[ ]:
```
# check the data for understanding of data
df
```

[ ]:

	Rank	CCA3	Country/Territory	Capital	Continent	2022 Population	2020 Population	2015 Population	2010 Population
0	36	AFG	Afghanistan	Kabul	Asia	41128771	38972230	33753499	28189672
1	138	ALB	Albania	Tirana	Europe	2842321	2866849	2882481	2913399
2	34	DZA	Algeria	Algiers	Africa	44903225	43451666	39543154	35856344
3	213	ASM	American Samoa	Pago Pago	Oceania	44273	46189	51368	54849
4	203	AND	Andorra	Andorra la Vella	Europe	79824	77700	71746	71519
..	…	…	…	…	…	…	…	…	…
229	226	WLF	Wallis and Futuna	Mata-Utu	Oceania	11572	11655	12182	13142
230	172	ESH	Western Sahara	El Aaiún	Africa	575986	556048	491824	413296
231	46	YEM	Yemen	Sanaa	Asia	33696614	32284046	28516545	24743946
232	63	ZMB	Zambia	Lusaka	Africa	20017675	18927715	16248230	13792086

```
233         16320537         15669666         14154937         12839771

     2000 Population  1990 Population  1980 Population  1970 Population  \
0           19542982         10694796         12486631         10752971
1            3182021          3295066          2941651          2324731
2           30774621         25518074         18739378         13795915
3              58230            47818            32886            27075
4              66097            53569            35611            19860
..               …                …                …                …
229            14723            13454            11315             9377
230           270375           178529           116775            76371
231         18628700         13375121          9204938          6843607
232          9891136          7686401          5720438          4281671
233         11834676         10113893          7049926          5202918

     Area (km²)  Density (per km²)  Growth Rate  World Population Percentage
0        652230            63.0587       1.0257                         0.52
1         28748            98.8702       0.9957                         0.04
2       2381741            18.8531       1.0164                         0.56
3           199           222.4774       0.9831                         0.00
4           468           170.5641       1.0100                         0.00
..          …                  …            …                            …
229         142            81.4930       0.9953                         0.00
230      266000             2.1654       1.0184                         0.01
231      527968            63.8232       1.0217                         0.42
232      752612            26.5976       1.0280                         0.25
233      390757            41.7665       1.0204                         0.20

[234 rows x 17 columns]
```

[ ]:
```
# Verified the data type and Null values
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 234 entries, 0 to 233
Data columns (total 17 columns):
 #   Column                      Non-Null Count  Dtype
---  ------                      --------------  -----
 0   Rank                        234 non-null    int64
 1   CCA3                        234 non-null    object
 2   Country/Territory           234 non-null    object
 3   Capital                     234 non-null    object
 4   Continent                   234 non-null    object
 5   2022 Population             234 non-null    int64
 6   2020 Population             234 non-null    int64
 7   2015 Population             234 non-null    int64
 8   2010 Population             234 non-null    int64
 9   2000 Population             234 non-null    int64
```

```
 10  1990 Population              234 non-null    int64
 11  1980 Population              234 non-null    int64
 12  1970 Population              234 non-null    int64
 13  Area (km²)                   234 non-null    int64
 14  Density (per km²)            234 non-null    float64
 15  Growth Rate                  234 non-null    float64
 16  World Population Percentage  234 non-null    float64
dtypes: float64(3), int64(10), object(4)
memory usage: 31.2+ KB
```

[ ]:
```
# Printed columns name for X and y
df.columns
```

[ ]:
```
Index(['Rank', 'CCA3', 'Country/Territory', 'Capital', 'Continent',
       '2022 Population', '2020 Population', '2015 Population',
       '2010 Population', '2000 Population', '1990 Population',
       '1980 Population', '1970 Population', 'Area (km²)', 'Density (per km²)',
       'Growth Rate', 'World Population Percentage'],
      dtype='object')
```

[ ]:
```
# defining variables for X and y
X = df[[
       '2022 Population', '2020 Population', '2015 Population',
       '2010 Population', '2000 Population', '1990 Population']]
a = df['World Population Percentage'] # y is replaced with a in this step and␣
 ↪in next
```

[ ]:
```
# Imported required Libraries for Machine learning
from sklearn.linear_model import LogisticRegression
from sklearn.svm import SVC
from sklearn.tree import DecisionTreeClassifier
from sklearn.ensemble import RandomForestClassifier
from sklearn.neighbors import KNeighborsClassifier
from sklearn.metrics import accuracy_score, f1_score, precision_score,␣
 ↪recall_score
from sklearn.model_selection import train_test_split
```

[ ]:
```
# We changed the values by encoding as the y is countinous
from sklearn import preprocessing
from sklearn import utils
lab = preprocessing.LabelEncoder()
y = lab.fit_transform(a)
```

[ ]:
```
y
```

[ ]:
```
array([39,  4, 40,  0,  0, 34,  0,  0, 41,  3,  0, 27, 10, 12,  1,  2, 62,
        0, 11, 14,  1, 16,  0,  1, 14,  4,  3, 63,  0,  1,  9, 25, 15, 18,
       28, 37,  1,  0,  7, 19, 22, 69, 44,  1,  0,  6,  5, 13,  0,  2, 12,
```

```
 7,  1,  0, 13, 56, 20, 57,  8,  2,  5,  2,  2, 59,  0,  0,  1,  7,
48,  0,  0,  3,  3,  5, 52, 32,  0, 12,  0,  0,  0,  0, 19,  0, 16,
 3,  1, 14, 12,  9, 11,  0, 68, 66, 54, 40,  6,  0, 10, 46, 28,  4,
59,  0, 13, 21, 45,  0,  5,  8,  9,  2,  7,  3,  7,  9,  0,  3,  1,
 1, 29, 23, 33,  1, 25,  1,  0,  0,  6,  2,  0, 60,  0,  4,  0,  4,
 1,  0, 36, 31, 45,  3,  0, 30, 19,  0,  7,  9, 27, 64,  0, 27,  3,
 0,  7,  6, 65,  0,  7,  6, 12,  9, 33, 58, 38, 12,  4,  3,  7,  1,
22, 61, 16,  0,  0,  0,  0,  0,  0,  0,  0,  0, 35, 19,  9,  0, 10,
 7,  0,  7,  3,  1, 19, 47, 44, 13, 43, 24, 42,  1, 12, 10, 25, 26,
11, 49, 51,  2, 10,  0,  0,  2, 14, 53,  8,  0,  0, 42, 38, 11, 50,
67,  0,  4, 33,  0,  0, 28, 55,  0,  1, 32, 22, 17], dtype=int64)
```

[ ]:
```
#Splited the dataset in two parts for test and train, we used the random state␣
 ↪to get \
# the same results each time, if we select none everytime results will be␣
 ↪changed
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2,␣
 ↪random_state=42)
```

[ ]:
```
# we selected the Machine leaning models that we can use
models = [LogisticRegression(), SVC(), DecisionTreeClassifier(),␣
 ↪RandomForestClassifier(), KNeighborsClassifier()]
model_names = ['Logistic Regression', 'SVM', 'Decision Tree', 'Random Forest',␣
 ↪'KNN']
# this we loopthrough each model and save the accuracy score in model_name
models_scores = []
for model, model_name in zip(models, model_names):
    model.fit(X_train, y_train)
    y_pred = model.predict(X_test)
    accuracy = accuracy_score(y_test, y_pred)
    models_scores.append([model_name,accuracy])
# used the lambda function to loopthroug each score type and sort from a to z
sorted_models = sorted(models_scores, key=lambda x: x[1], reverse=True)
for model in sorted_models:
    print("Accuracy Score: ",f'{model[0]} : {model[1]:.2f}')
```

```
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packages\sklearn\linear_model\_logistic.py:458: ConvergenceWarning: lbfgs failed
to converge (status=1):
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Please also refer to the documentation for alternative solver options:
    https://scikit-learn.org/stable/modules/linear_model.html#logistic-
regression
  n_iter_i = _check_optimize_result(
```

```
Accuracy Score:  Random Forest : 0.62
Accuracy Score:  Decision Tree : 0.57
Accuracy Score:  KNN : 0.40
Accuracy Score:  SVM : 0.15
Accuracy Score:  Logistic Regression : 0.00
```

[ ]:
```
models = [LogisticRegression(), SVC(), DecisionTreeClassifier(),␣
 ↪RandomForestClassifier(), KNeighborsClassifier()]
model_names = ['Logistic Regression', 'SVM', 'Decision Tree', 'Random Forest',␣
 ↪'KNN']
models_scores = []
for model, model_name in zip(models, model_names):
    model.fit(X_train, y_train)
    y_pred = model.predict(X_test)
    Precision = precision_score(y_test, y_pred, average='micro') # Included␣
 ↪average='micro' for calcluating averaging score of each value
    models_scores.append([model_name,Precision])

sorted_models = sorted(models_scores, key=lambda x: x[1], reverse=True)
for model in sorted_models:
    print("Precision Score: ", f'{model[0]} : {model[1]:.2f}')
```

```
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regression
  n_iter_i = _check_optimize_result(

Precision Score:  Decision Tree : 0.60
Precision Score:  Random Forest : 0.60
Precision Score:  KNN : 0.40
Precision Score:  SVM : 0.15
Precision Score:  Logistic Regression : 0.00
```

[ ]:
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models = [LogisticRegression(), SVC(), DecisionTreeClassifier(),␣
 ↪RandomForestClassifier(), KNeighborsClassifier()]
model_names = ['Logistic Regression', 'SVM', 'Decision Tree', 'Random Forest',␣
 ↪'KNN']
models_scores = []
for model, model_name in zip(models, model_names):
    model.fit(X_train, y_train)
    y_pred = model.predict(X_test)
```

```
    Recall = recall_score(y_test, y_pred, average='micro')
    models_scores.append([model_name,Recall])

sorted_models = sorted(models_scores, key=lambda x: x[1], reverse=True)
for model in sorted_models:
    print("Precision Score: ", f'{model[0]} : {model[1]:.2f}')
```

```
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  n_iter_i = _check_optimize_result(

Precision Score:  Random Forest : 0.60
Precision Score:  Decision Tree : 0.57
Precision Score:  KNN : 0.40
Precision Score:  SVM : 0.15
Precision Score:  Logistic Regression : 0.00
```

[ ]:
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models = [LogisticRegression(), SVC(), DecisionTreeClassifier(),␣
 ↪RandomForestClassifier(), KNeighborsClassifier()]
model_names = ['Logistic Regression', 'SVM', 'Decision Tree', 'Random Forest',␣
 ↪'KNN']
models_scores = []
for model, model_name in zip(models, model_names):
    model.fit(X_train, y_train)
    y_pred = model.predict(X_test)
    F1 = f1_score(y_test, y_pred, average='micro')
    models_scores.append([model_name,F1])

sorted_models = sorted(models_scores, key=lambda x: x[1], reverse=True)
for model in sorted_models:
    print("F1 Score: ",f'{model[0]} : {model[1]:.2f}')
```

```
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```

```
regression
  n_iter_i = _check_optimize_result(
```

```
F1 Score:  Decision Tree : 0.60
F1 Score:  Random Forest : 0.60
F1 Score:  KNN : 0.40
F1 Score:  SVM : 0.15
F1 Score:  Logistic Regression : 0.00
```

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

models = [LogisticRegression(), SVC(), DecisionTreeClassifier(),␣
 ↪RandomForestClassifier(), KNeighborsClassifier()]
model_names = ['Logistic Regression', 'SVM', 'Decision Tree', 'Random Forest',␣
 ↪'KNN']
models_scores = []

for model, model_name in zip(models, model_names):
    # Define the grid search parameters
    if model_name == 'Logistic Regression':
        params = {'C': [0.1, 1, 10]}
    elif model_name == 'SVM':
        params = {'C': [0.1, 1, 10], 'kernel': ['linear', 'rbf']}
    elif model_name == 'Decision Tree':
        params = {'max_depth': [1, 2, 3, 4, 5, 6, 7, 8, 9, 10]}
    elif model_name == 'Random Forest':
        params = {'n_estimators': [10, 50, 100], 'max_depth': [1, 2, 3, 4, 5,␣
 ↪6, 7, 8, 9, 10]}
    elif model_name == 'KNN':
        params = {'n_neighbors': [3, 5, 7, 9, 11, 13, 15]}
    else:
        params = {}
    # Perform the grid search
    grid_search = GridSearchCV(model, param_grid=params, cv=5)
    grid_search.fit(X_train, y_train)
    model = grid_search.best_estimator_
    y_pred = model.predict(X_test)
    Recall = recall_score(y_test, y_pred, average='micro')
    models_scores.append([model_name,Recall])

sorted_models = sorted(models_scores, key=lambda x: x[1], reverse=True)
for model in sorted_models:
    print("Precision Score: ", f'{model[0]} : {model[1]:.2f}')
# Print best parameters and best score
print("Best Parameters: ", grid_search.best_params_)
print("Best Score: ", grid_search.best_score_)
```

```
c:\Users\muham\AppData\Local\Programs\Python\Python311\Lib\site-
```

```
packages\sklearn\model_selection\_split.py:700: UserWarning: The least populated
class in y has only 1 members, which is less than n_splits=5.
  warnings.warn(
c:\Users\muham\AppData\Local\Programs\Python\Python311\Lib\site-
packages\sklearn\linear_model\_logistic.py:458: ConvergenceWarning: lbfgs failed
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```
regression
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    https://scikit-learn.org/stable/modules/linear_model.html#logistic-
regression
  n_iter_i = _check_optimize_result(
c:\Users\muham\AppData\Local\Programs\Python\Python311\Lib\site-
packages\sklearn\model_selection\_split.py:700: UserWarning: The least populated
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packages\sklearn\model_selection\_split.py:700: UserWarning: The least populated
class in y has only 1 members, which is less than n_splits=5.
  warnings.warn(
```

```
Precision Score:  Random Forest : 0.60
Precision Score:  SVM : 0.57
Precision Score:  Decision Tree : 0.55
Precision Score:  KNN : 0.47
Precision Score:  Logistic Regression : 0.00
Best Parameters:  {'n_neighbors': 3}
Best Score:  0.5453769559032717

c:\Users\muham\AppData\Local\Programs\Python\Python311\Lib\site-
packages\sklearn\model_selection\_split.py:700: UserWarning: The least populated
class in y has only 1 members, which is less than n_splits=5.
  warnings.warn(
```

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

models = [LogisticRegression(), SVC(), DecisionTreeClassifier(),␣
 ↪RandomForestClassifier(), KNeighborsClassifier()]
model_names = ['Logistic Regression', 'SVM', 'Decision Tree', 'Random Forest',␣
 ↪'KNN']
models_scores = []

for model, model_name in zip(models, model_names):
    # Define the grid search parameters
    if model_name == 'Logistic Regression':
        params = {'C': [0.1, 1, 10]}
    elif model_name == 'SVM':
        params = {'C': [0.1, 1, 10], 'kernel': ['linear', 'rbf']}
    elif model_name == 'Decision Tree':
        params = {'max_depth': [1, 2, 3, 4, 5, 6, 7, 8, 9, 10]}
    elif model_name == 'Random Forest':
        params = {'n_estimators': [10, 50, 100], 'max_depth': [1, 2, 3, 4, 5,␣
 ↪6, 7, 8, 9, 10]}
    elif model_name == 'KNN':
        params = {'n_neighbors': [3, 5, 7, 9, 11, 13, 15]}
    else:
        params = {}
    # Perform the grid search
    grid_search = GridSearchCV(model, param_grid=params, cv=5)
    grid_search.fit(X_train, y_train)
    model = grid_search.best_estimator_
    y_pred = model.predict(X_test)
    Recall = recall_score(y_test, y_pred, average='micro')
    models_scores.append([model_name,Recall])



# Print best parameters and best score
print("Best Parameters: ", grid_search.best_params_)
```

```python
print("Best Score: ", grid_search.best_score_)
```

```
c:\Users\muham\AppData\Local\Programs\Python\Python311\Lib\site-
packages\sklearn\model_selection\_split.py:700: UserWarning: The least populated
class in y has only 1 members, which is less than n_splits=5.
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    https://scikit-learn.org/stable/modules/linear_model.html#logistic-
```

```
regression
  n_iter_i = _check_optimize_result(
c:\Users\muham\AppData\Local\Programs\Python\Python311\Lib\site-
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  warnings.warn(
c:\Users\muham\AppData\Local\Programs\Python\Python311\Lib\site-
packages\sklearn\model_selection\_split.py:700: UserWarning: The least populated
```

```
class in y has only 1 members, which is less than n_splits=5.
  warnings.warn(

Best Parameters:  {'n_neighbors': 3}
Best Score:  0.5453769559032717

c:\Users\muham\AppData\Local\Programs\Python\Python311\Lib\site-
packages\sklearn\model_selection\_split.py:700: UserWarning: The least populated
class in y has only 1 members, which is less than n_splits=5.
  warnings.warn(
```

[ ]:
```
models = [LogisticRegression(), SVC(), DecisionTreeClassifier(),␣
 ↪RandomForestClassifier(), KNeighborsClassifier()]
model_names = ['Logistic Regression', 'SVM', 'Decision Tree', 'Random Forest',␣
 ↪'KNN']
models_scores = []
best_model = None
best_score = 0

for model, model_name in zip(models, model_names):
    # Define the grid search parameters
    if model_name == 'Logistic Regression':
        params = {'C': [0.1, 1, 10]}
    elif model_name == 'SVM':
        params = {'C': [0.1, 1, 10], 'kernel': ['linear', 'rbf']}
    elif model_name == 'Decision Tree':
        params = {'max_depth': [1, 2, 3, 4, 5, 6, 7, 8, 9, 10]}
    elif model_name == 'Random Forest':
        params = {'n_estimators': [10, 50, 100], 'max_depth': [1, 2, 3, 4, 5,␣
 ↪6, 7, 8, 9, 10]}
    elif model_name == 'KNN':
        params = {'n_neighbors': [3, 5, 7, 9, 11, 13, 15]}
    else:
        params = {}
    # Perform the grid search
    grid_search = GridSearchCV(model, param_grid=params, cv=5)
    grid_search.fit(X_train, y_train)
    model = grid_search.best_estimator_
    y_pred = model.predict(X_test)
    Recall = recall_score(y_test, y_pred, average='micro')
    models_scores.append([model_name,Recall])
    if grid_search.best_score_ > best_score:
        best_score = grid_search.best_score_
        best_model = model
    print("Best Parameters: ", grid_search.best_params_)
    print("Best Score: ", grid_search.best_score_)

print(f'Best Model: {best_model}')
```

```
c:\Users\muham\AppData\Local\Programs\Python\Python311\Lib\site-
packages\sklearn\model_selection\_split.py:700: UserWarning: The least populated
class in y has only 1 members, which is less than n_splits=5.
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  n_iter_i = _check_optimize_result(
```

```
c:\Users\muham\AppData\Local\Programs\Python\Python311\Lib\site-
packages\sklearn\linear_model\_logistic.py:458: ConvergenceWarning: lbfgs failed
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```
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c:\Users\muham\AppData\Local\Programs\Python\Python311\Lib\site-
packages\sklearn\model_selection\_split.py:700: UserWarning: The least populated
class in y has only 1 members, which is less than n_splits=5.
  warnings.warn(
```

```
Best Parameters:  {'C': 0.1}
Best Score:  0.0
Best Parameters:  {'C': 0.1, 'kernel': 'linear'}
Best Score:  0.6412517780938833
```

```
c:\Users\muham\AppData\Local\Programs\Python\Python311\Lib\site-
packages\sklearn\model_selection\_split.py:700: UserWarning: The least populated
class in y has only 1 members, which is less than n_splits=5.
```

```
  warnings.warn(

Best Parameters:  {'max_depth': 10}
Best Score:  0.614651493598862

c:\Users\muham\AppData\Local\Programs\Python\Python311\Lib\site-
packages\sklearn\model_selection\_split.py:700: UserWarning: The least populated
class in y has only 1 members, which is less than n_splits=5.
  warnings.warn(

Best Parameters:  {'max_depth': 10, 'n_estimators': 100}
Best Score:  0.6308677098150783
Best Parameters:  {'n_neighbors': 3}
Best Score:  0.5453769559032717
Best Model: SVC(C=0.1, kernel='linear')

c:\Users\muham\AppData\Local\Programs\Python\Python311\Lib\site-
packages\sklearn\model_selection\_split.py:700: UserWarning: The least populated
class in y has only 1 members, which is less than n_splits=5.
  warnings.warn(
```