National Institute of Technology Rourkela, Odisha, India, 769008

Department of Computer Science Engineering

Laborotary-4

(Data Science Laborotary)

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Linear Regression

Importing libraries

```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
```

```
C:\Users\ADMIN\AppData\Local\Temp\ipykernel_11428\2080034654.py:2: DeprecationWarning:
Pyarrow will become a required dependency of pandas in the next major release of pandas (pandas 3.0),
(to allow more performant data types, such as the Arrow string type, and better interoperability with other libraries)
but was not found to be installed on your system.
If this would cause problems for you,
please provide us feedback at https://github.com/pandas-dev/pandas/issues/54466

  import pandas as pd
```

Read the salary dataset

```
# your answer here
dataSet_salary = pd.read_csv('Salary_Data.csv')
```

Show the first 10 rows of the dataset

```
# your answer here
dataSet_salary.head(10)
```

	YearsExperience	Salary
0	1.1	39343.0
1	1.3	46205.0
2	1.5	37731.0
3	2.0	43525.0
4	2.2	39891.0
5	2.9	56642.0
6	3.0	60150.0
7	3.2	54445.0
8	3.2	64445.0
9	3.7	57189.0

Show the dimensions (No. of rows and coulmns) of the dataset

```
# your answer here
dataSet_salary.shape
```

```
(30, 2)
```

Print all the column names of the dataset

```
# your answer here
dataSet_salary.columns
```

```
Index(['YearsExperience', 'Salary'], dtype='object')
```

Print general information of the dataset like column, and datatype.

```
# your answer here
dataSet_salary.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 30 entries, 0 to 29
Data columns (total 2 columns):
 #   Column           Non-Null Count  Dtype  
---  ------           --------------  -----  
 0   YearsExperience  30 non-null     float64
 1   Salary           30 non-null     float64
dtypes: float64(2)
memory usage: 612.0 bytes
```

Extract independent and dependent features and store it in two different variables.

```
# your answer here
yearsExperience = dataSet_salary['YearsExperience']
salary = dataSet_salary['Salary']
```

Split the dataset into train and test set

```
from sklearn.model_selection import train_test_split
```

```
# your answer here

X_train, X_test, y_train, y_test = train_test_split(yearsExperience, salary, test_size=0.2, random_state=0)
print(X_train.shape, X_test.shape, y_train.shape, y_test.shape)
```

```
(24,) (6,) (24,) (6,)
```

Training the Simple Linear Regression model on the Training set

```
from sklearn.linear_model import LinearRegression
```

```
# your answer here
model = LinearRegression()
model.fit(X_train.values.reshape(-1,1), y_train)
```

```
LinearRegression
LinearRegression()
```

Predict the Test set results

```
# your answer here
predictions = model.predict(X_test.values.reshape(-1,1))
```

Visualize the linear regression on training data using scatterplot.

```
# your answer here
plt.scatter(X_train, y_train, color='red')
plt.plot(X_train, model.predict(X_train.values.reshape(-1,1)), color='blue')
plt.title('Salary vs Experience (Training set)')
plt.xlabel('Years of Experience')
plt.ylabel('Salary')
plt.show()
```

Visualize the linear regression on test data using scatterplot.

```
# your answer here
plt.scatter(X_test, y_test, color='red')
plt.plot(X_train, model.predict(X_train.values.reshape(-1,1)), color='blue')
plt.title('Salary vs Experience (Test set)')
plt.xlabel('Years of Experience')
plt.ylabel('Salary')
plt.show()
```

Finding R^2 score

```
from sklearn.metrics import r2_score

# your answer here
r2_score(y_test, predictions)
```

```
0.988169515729126
```

Ridge Regression

```
from sklearn.linear_model import Ridge


model = Ridge(alpha=0.5)
model.fit(X_train.values.reshape(-1,1), y_train)
predictions = model.predict(X_test.values.reshape(-1,1))
print(r2_score(y_test, predictions))
```

```
0.987891303817413
```

```
plt.scatter(X_train, y_train, color='red')
plt.plot(X_train, model.predict(X_train.values.reshape(-1,1)), color='blue')
plt.title('Salary vs Experience (Training set)')
plt.xlabel('Years of Experience')
plt.ylabel('Salary')
plt.show()
```

Huber

```
from sklearn.linear_model import HuberRegressor


model = HuberRegressor()
model.fit(X_train.values.reshape(-1,1), y_train)
predictions = model.predict(X_test.values.reshape(-1,1))
print(r2_score(y_test, predictions))
```

```
0.9870632883295445
```

```
plt.scatter(X_train, y_train, color='red')
plt.plot(X_train, model.predict(X_train.values.reshape(-1,1)), color='blue')
plt.title('Salary vs Experience (Training set)')
plt.xlabel('Years of Experience')
plt.ylabel('Salary')
plt.show()
```

ElasticNet

```
from sklearn.linear_model import ElasticNet


model = ElasticNet()
model.fit(X_train.values.reshape(-1,1), y_train)
predictions = model.predict(X_test.values.reshape(-1,1))
print(r2_score(y_test, predictions))
```

```
0.9772686017240042
```

```
plt.scatter(X_train, y_train, color='red')
plt.plot(X_train, model.predict(X_train.values.reshape(-1,1)), color='blue')
plt.title('Salary vs Experience (Training set)')
plt.xlabel('Years of Experience')
plt.ylabel('Salary')
plt.show()
```

Lasso

```
from sklearn.linear_model import Lasso


model = Lasso()
model.fit(X_train.values.reshape(-1,1), y_train)
predictions = model.predict(X_test.values.reshape(-1,1))
print(r2_score(y_test, predictions))
```

```
0.988168127365881
```

```
plt.scatter(X_train, y_train, color='red')
plt.plot(X_train, model.predict(X_train.values.reshape(-1,1)), color='blue')
plt.title('Salary vs Experience (Training set)')
plt.xlabel('Years of Experience')
plt.ylabel('Salary')
plt.show()
```

Logistic Regression

Import Libraries

```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
from sklearn.model_selection import train_test_split
from sklearn.model_selection import GridSearchCV
from sklearn.linear_model import LogisticRegression
from sklearn.metrics import accuracy_score, confusion_matrix, classification_report
```

Read the heart failure dataset

```
# your answer here
dataSet_heart = pd.read_csv('heart.csv')
```

Display the first five rows

```
# your answer here
dataSet_heart.head(5)
```

	Age	Sex	ChestPainType	RestingBP	Cholesterol	FastingBS	RestingECG	MaxHR	ExerciseAngina	Oldpeak	ST_Slope	HeartDisease
0	40	M	ATA	140	289	0	Normal	172	N	0.0	Up	0
1	49	F	NAP	160	180	0	Normal	156	N	1.0	Flat	1
2	37	M	ATA	130	283	0	ST	98	N	0.0	Up	0
3	48	F	ASY	138	214	0	Normal	108	Y	1.5	Flat	1
4	54	M	NAP	150	195	0	Normal	122	N	0.0	Up	0

Check for missing values

```
# your answer here
empty_count = {}
for column in dataSet_heart.columns:
    empty_count[column] = dataSet_heart[column].isnull().sum()

has_empty = False
for key, value in empty_count.items():
    if value != 0:
        has_empty = True
        print(key, value)

if not has_empty:
    print('No empty data')
```

```
No empty data
```

Describe numerical features

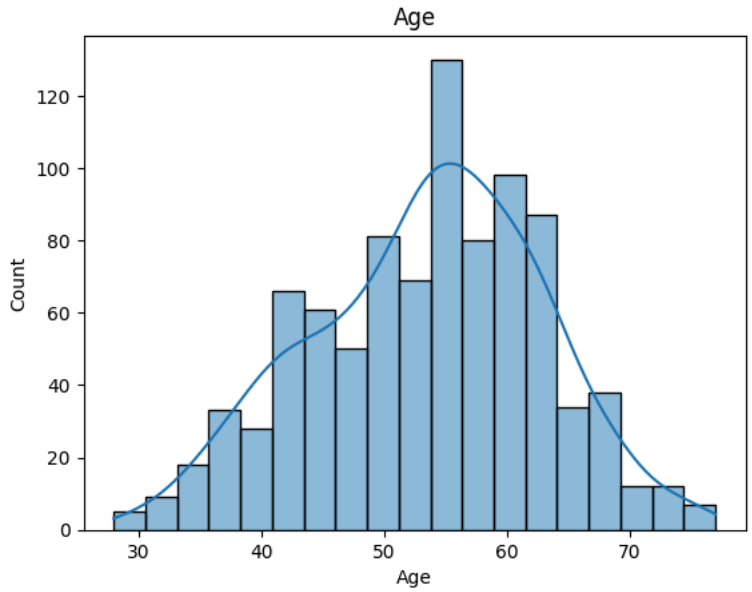
```
# your answer here
dataSet_heart.describe()
```

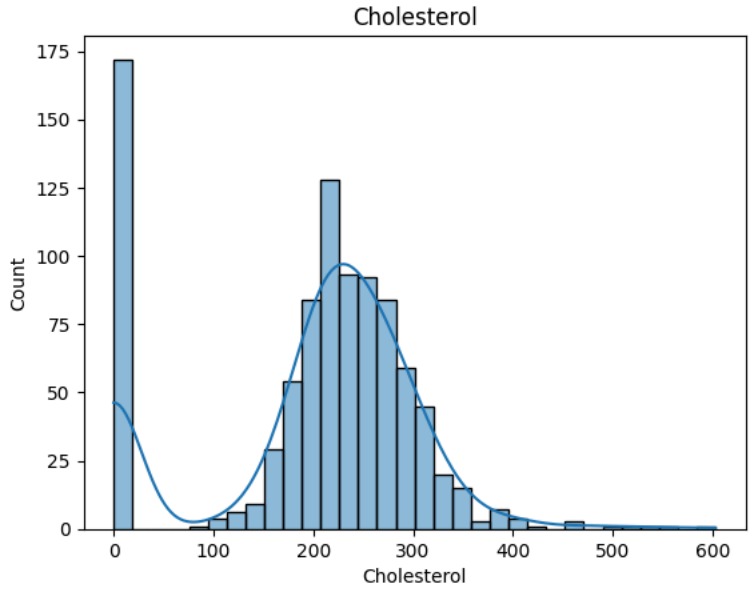
	Age	RestingBP	Cholesterol	FastingBS	MaxHR	Oldpeak	HeartDisease
count	918.000000	918.000000	918.000000	918.000000	918.000000	918.000000	918.000000
mean	53.510893	132.396514	198.799564	0.233115	136.809368	0.887364	0.553377
std	9.432617	18.514154	109.384145	0.423046	25.460334	1.066570	0.497414
min	28.000000	0.000000	0.000000	0.000000	60.000000	-2.600000	0.000000
25%	47.000000	120.000000	173.250000	0.000000	120.000000	0.000000	0.000000
50%	54.000000	130.000000	223.000000	0.000000	138.000000	0.600000	1.000000
75%	60.000000	140.000000	267.000000	0.000000	156.000000	1.500000	1.000000
max	77.000000	200.000000	603.000000	1.000000	202.000000	6.200000	1.000000

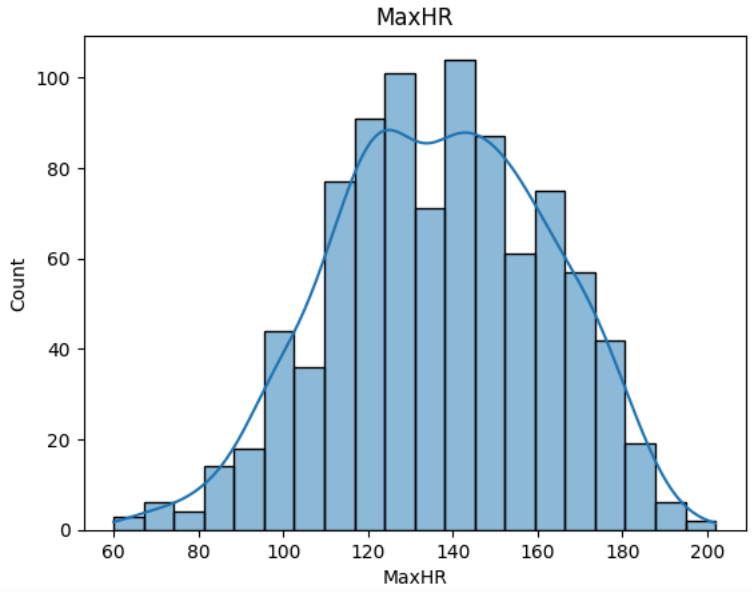
Visualize the distribution of key features (Age, Cholesterol, MaxHR) using histograms.

```
# your answer here
for col in ['Age', 'Cholesterol', 'MaxHR']:
    sns.histplot(dataSet_heart[col], kde=True)
    plt.title(col)
    plt.show()
```

[+]







List all categorical_features

```
# your answer here
for col in dataSet_heart.columns:
    if dataSet_heart[col].dtype == 'object':
        print(col)
        print(dataSet_heart[col].unique())
        print("count: ", len(dataSet_heart[col].unique()))
```

```
Sex
['M' 'F']
count:  2
ChestPainType
['ATA' 'NAP' 'ASY' 'TA']
count:  4
RestingECG
['Normal' 'ST' 'LVH']
count:  3
ExerciseAngina
['N' 'Y']
count:  2
ST_Slope
['Up' 'Flat' 'Down']
count:  3
```

Convert categorical variables into numerical format using label encoding.

```
# your answer here
label = {}
for col in dataSet_heart.columns:
    ind = 0
    if dataSet_heart[col].dtype == 'object':
        for val in dataSet_heart[col].unique():
            if col not in label:
                label[col] = {}
            label[col][val] = ind
            ind += 1

for col in label:
    print(label[col])

dataSet_label = dataSet_heart.copy()
for col in label:
    dataSet_label[f"{col}_label"] = dataSet_label[col].map(label[col])
    dataSet_label = dataSet_label.drop(col, axis=1)
    dataSet_label = dataSet_label.rename(columns={f"{col}_label": col})

dataSet_label.head(5)
```

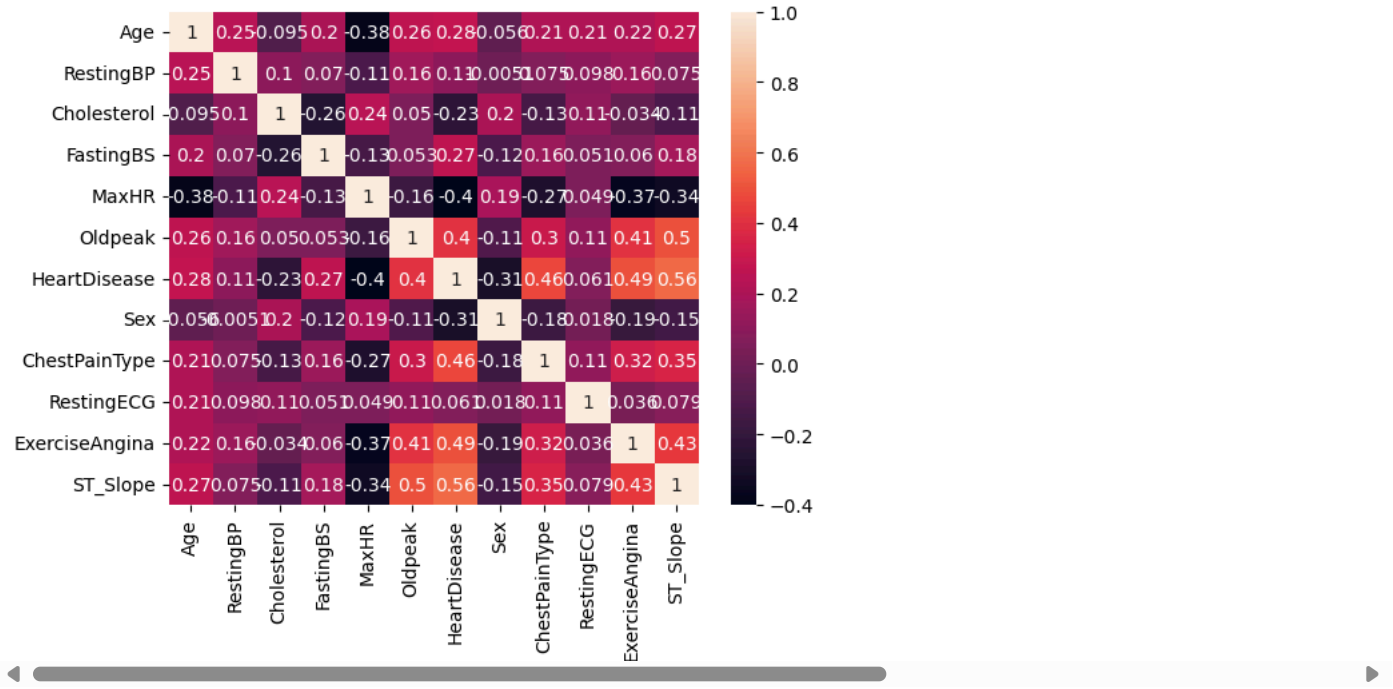
```
{'M': 0, 'F': 1}
{'ATA': 0, 'NAP': 1, 'ASY': 2, 'TA': 3}
{'Normal': 0, 'ST': 1, 'LVH': 2}
{'N': 0, 'Y': 1}
{'Up': 0, 'Flat': 1, 'Down': 2}
```

	Age	RestingBP	Cholesterol	FastingBS	MaxHR	Oldpeak	HeartDisease	Sex	ChestPainType	RestingECG	ExerciseAngina	ST_Slope
0	40	140	289	0	172	0.0	0	0	0	0	0	0
1	49	160	180	0	156	1.0	1	1	1	0	0	1
2	37	130	283	0	98	0.0	0	0	0	1	0	0
3	48	138	214	0	108	1.5	1	1	2	0	1	1
4	54	150	195	0	122	0.0	0	0	1	0	0	0

Analyze the correlation between features using a heatmap.

```
# your answer here
sns.heatmap(dataSet_label.corr(), annot=True)
```

```
<Axes: >
```



Split the dataset into training and testing sets (80-20 split).

```
# your answer here
dataSet = dataSet_label.copy()
X_train, X_test, y_train, y_test = train_test_split(dataSet.drop('HeartDisease', axis=1), dataSet['HeartDisease'], test_size=0.2, random_sta
print(X_train.shape, X_test.shape, y_train.shape, y_test.shape)
```

```
(734, 11) (184, 11) (734,) (184,)
```

Perform hyperparameter tuning on logistic regression using GridSearchCV to find the best parameters

```
# your answer here
parameters = {'C': [0.1, 1, 5, 10, 20, 100], 'penalty': ['l1', 'l2'], "solver": ['liblinear']}
model = LogisticRegression(max_iter=1000)
grid_search = GridSearchCV(model, parameters)
grid_search.fit(X_train, y_train)
print(grid_search.best_params_)
print(grid_search.best_score_)
```

```
{'C': 10, 'penalty': 'l2', 'solver': 'liblinear'}
0.8610287950796757
```

Train the logistic regression model using the best parameters obtained from GridSearchCV and evaluate its performance on the test set using accuracy, confusion matrix, and classification report.

```
# your answer here
model = LogisticRegression(C=grid_search.best_params_['C'], penalty=grid_search.best_params_['penalty'], solver=grid_search.best_params_['sc
model.fit(X_train, y_train)
predictions = model.predict(X_test)
print(accuracy_score(y_test, predictions))
```

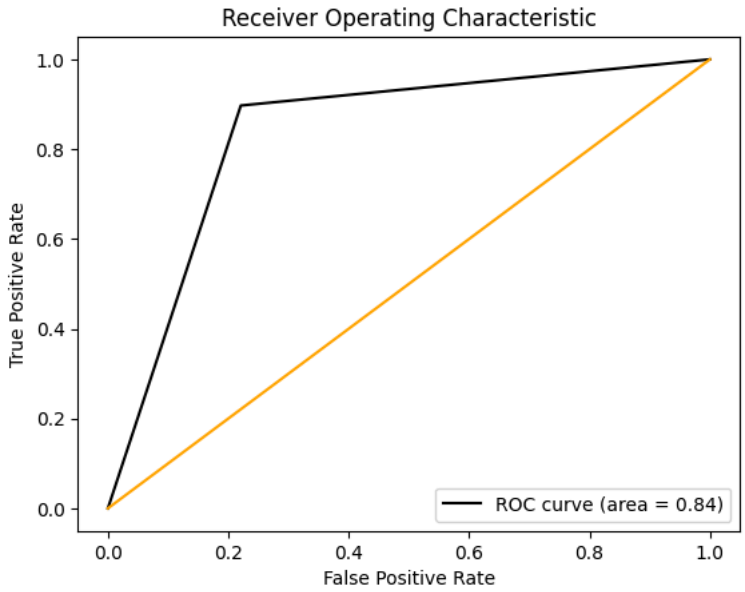
```
0.8478260869565217
```

```
from sklearn.metrics import roc_curve, auc
```

```
# your answer here

fpr, tpr, thresholds = roc_curve(y_test, predictions)
roc_auc = auc(fpr, tpr)
print(roc_auc)
plt.plot(fpr, tpr, color='black', label='ROC curve (area = %0.2f)' % roc_auc)
```

```
plt.plot([0,1], [0,1], color='orange', linestyle='-')
plt.xlabel('False Positive Rate')
plt.ylabel('True Positive Rate')
plt.title('Receiver Operating Characteristic')
plt.legend(loc="lower right")
plt.show()

print(confusion_matrix(y_test, predictions))
print(classification_report(y_test, predictions))
```

```
0.8382085204515112
```




```
[[60 17]
 [11 96]]
              precision    recall  f1-score   support

           0       0.85      0.78      0.81        77
           1       0.85      0.90      0.87       107

    accuracy                           0.85       184
   macro avg       0.85      0.84      0.84       184
weighted avg       0.85      0.85      0.85       184
```

Linear Regression Tuning

Elastic

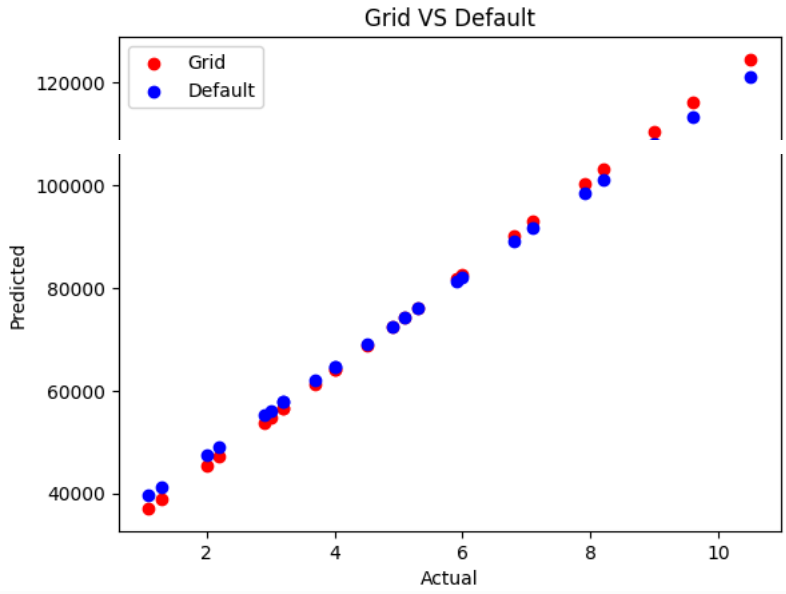
```
parameters = {'alpha': [0.001, 0.01, 0.1, 1], 'l1_ratio': [0.001, 0.1, 0.25, 0.5, 0.75, 1], 'max_iter': [1000]}
model = ElasticNet()
grid_search = GridSearchCV(model, parameters)
grid_search.fit(X_train, y_train)
print(grid_search.best_params_)
print(grid_search.best_score_)
```

```
{'alpha': 0.01, 'l1_ratio': 0.001, 'max_iter': 1000}
0.5178328889165776
```

```
model = ElasticNet(alpha=grid_search.best_params_['alpha'], l1_ratio=grid_search.best_params_['l1_ratio'], max_iter=grid_search.best_params_
X_train, X_test, y_train, y_test = train_test_split(dataSet_salary['YearsExperience'], dataSet_salary['Salary'], test_size=0.2, random_state
model.fit(X_train.values.reshape(-1,1), y_train)
predictions = model.predict(X_test.values.reshape(-1,1))
print("Grid: ", r2_score(y_test, predictions))

plt.scatter(X_train, model.predict(X_train.values.reshape(-1,1)), color='red')
plt.title('Grid VS Default')
```

```
plt.xlabel('Actual')
plt.ylabel('Predicted')

model = ElasticNet()
model.fit(X_train.values.reshape(-1,1), y_train)
predictions = model.predict(X_test.values.reshape(-1,1))
print("Default: ", r2_score(y_test, predictions))

plt.scatter(X_train, model.predict(X_train.values.reshape(-1,1)), color='blue')
plt.legend(['Grid', 'Default'])

plt.show()
```

```
Grid:  0.9880383226742803
Default:  0.9772686017240042
```



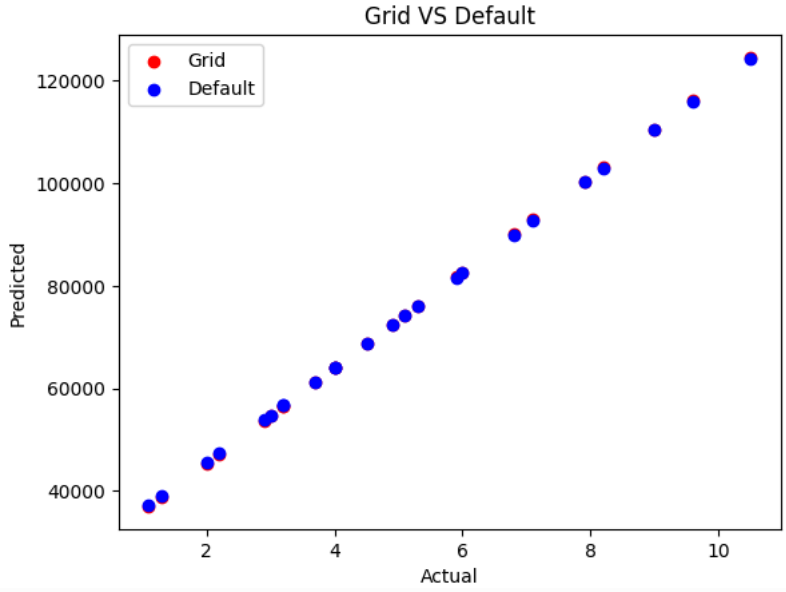
Ridge

```
parameters = {'alpha': [0.001, 0.01, 0.1, 1], 'fit_intercept': [True, False], 'max_iter': [1000]}
model = Ridge()
grid_search = GridSearchCV(model, parameters)
grid_search.fit(X_train.values.reshape(-1,1), y_train)
print(grid_search.best_params_)
print(grid_search.best_score_)
```

```
{'alpha': 0.001, 'fit_intercept': True, 'max_iter': 1000}
0.9272137573042315
```

```
model = Ridge(alpha=grid_search.best_params_['alpha'], fit_intercept=grid_search.best_params_['fit_intercept'], max_iter=grid_search.best_pa
X_train, X_test, y_train, y_test = train_test_split(dataSet_salary['YearsExperience'], dataSet_salary['Salary'], test_size=0.2, random_state
model.fit(X_train.values.reshape(-1,1), y_train)
predictions = model.predict(X_test.values.reshape(-1,1))
print("Grid: ", r2_score(y_test, predictions))

plt.scatter(X_train, model.predict(X_train.values.reshape(-1,1)), color='red')
plt.title('Grid VS Default')
plt.xlabel('Actual')
plt.ylabel('Predicted')

model = Ridge()
model.fit(X_train.values.reshape(-1,1), y_train)
predictions = model.predict(X_test.values.reshape(-1,1))
print("Default: ", r2_score(y_test, predictions))

plt.scatter(X_train, model.predict(X_train.values.reshape(-1,1)), color='blue')
plt.legend(['Grid', 'Default'])

plt.show()
```

```
Grid:  0.9881689770761223
Default:  0.9875955163095868
```



Lasso

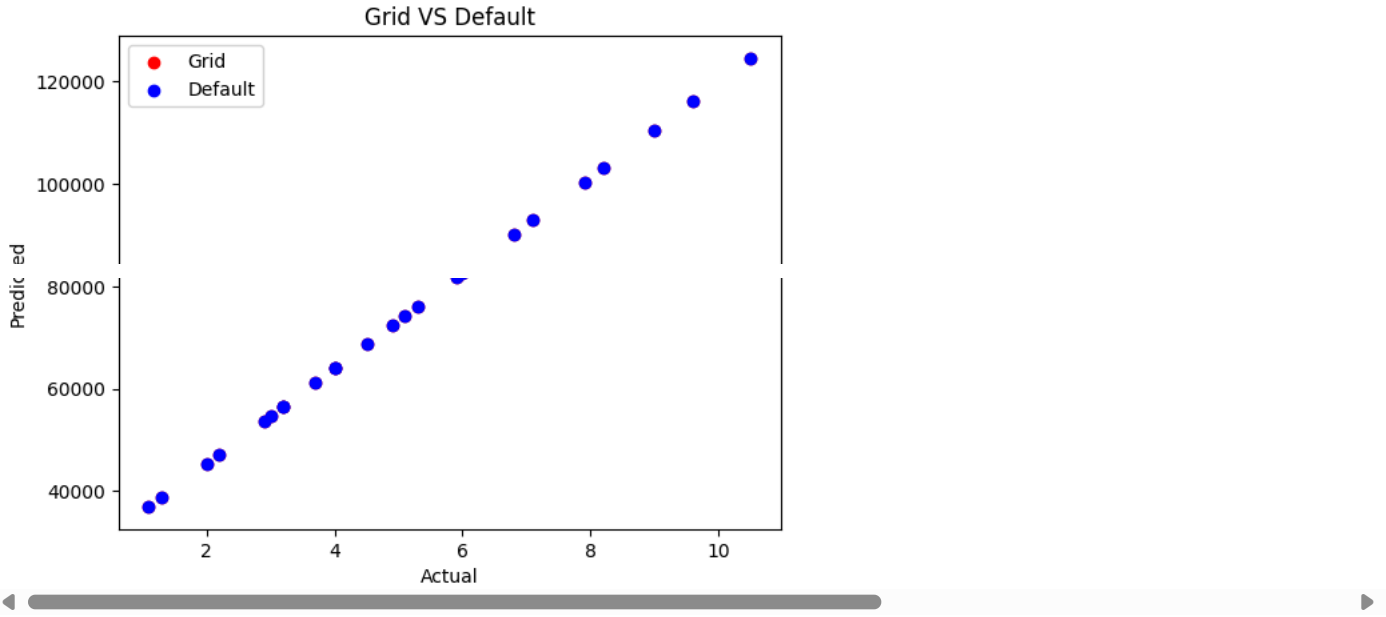
```
parameters = {'alpha': [0.001, 0.01, 0.1, 1], 'fit_intercept': [True, False], 'max_iter': [1000]}
model = Lasso()
grid_search = GridSearchCV(model, parameters)
grid_search.fit(X_train.values.reshape(-1,1), y_train)
print(grid_search.best_params_)
print(grid_search.best_score_)
```

```
{'alpha': 0.001, 'fit_intercept': True, 'max_iter': 1000}
0.9272138116883252
```

```
model = Lasso(alpha=grid_search.best_params_['alpha'], fit_intercept=grid_search.best_params_['fit_intercept'], max_iter=grid_search.best_pa
X_train, X_test, y_train, y_test = train_test_split(dataSet_salary['YearsExperience'], dataSet_salary['Salary'], test_size=0.2, random_state
model.fit(X_train.values.reshape(-1,1), y_train)
predictions = model.predict(X_test.values.reshape(-1,1))
print("Grid: ", r2_score(y_test, predictions))

plt.scatter(X_train, model.predict(X_train.values.reshape(-1,1)), color='red')
plt.title('Grid VS Default')
plt.xlabel('Actual')
plt.ylabel('Predicted')

model = Lasso()
model.fit(X_train.values.reshape(-1,1), y_train)
```

```
predictions = model.predict(X_test.values.reshape(-1,1))
print("Default: ", r2_score(y_test, predictions))

plt.scatter(X_train, model.predict(X_train.values.reshape(-1,1)), color='blue')
plt.legend(['Grid', 'Default'])

plt.show()
```

```
Grid:  0.988169514341023
Default:  0.988168127365881
```



HuberRegressor

```
parameters = {'epsilon': [1, 1.35, 1.5, 1.75, 1.9], 'max_iter': [1000], 'alpha': [0.0001, 0.0001, 0.001, 0.01, 0.1]}
model = HuberRegressor()
grid_search = GridSearchCV(model, parameters)
grid_search.fit(X_train.values.reshape(-1,1), y_train)
print(grid_search.best_params_)
print(grid_search.best_score_)
```

```
{'alpha': 0.0001, 'epsilon': 1.5, 'max_iter': 1000}
0.9270353658559995
```

```
model = HuberRegressor(epsilon=grid_search.best_params_['epsilon'], max_iter=grid_search.best_params_['max_iter'], alpha=grid_search.best_pa
X_train, X_test, y_train, y_test = train_test_split(dataSet_salary['YearsExperience'], dataSet_salary['Salary'], test_size=0.2, random_state
model.fit(X_train.values.reshape(-1,1), y_train)
predictions = model.predict(X_test.values.reshape(-1,1))
print("Grid: ", r2_score(y_test, predictions))
```