Proj_05_Naive_Bayes_Full_5

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1 EE915: Week-5 - Project-5 - Naive Bayes - Email Spam Detection and Purchase Prediction

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This project implements naive Bayes algorithm for purchase prediction and email spam detection using the data sets provided. The code includes pre-processing steps such as data normalization, feature selection, splitting the dataset into training.

The Gaussian Naive Bayes classifier is used for both spam detection and for purchase prediction. The evaluation metrics used include accuracy, F1 score, precision, recall, and area under the curve (AUC) score for spam detection and purchase prediction. Additionally, Laplace smoothing is applied for better accuracy in prediction - particularly in the spam and ham classification of the emails dataset.

[1]:
```
# Importing necessary libraries for breast cancer SVM classifier
from sklearn import datasets
from sklearn.model_selection import train_test_split
from sklearn.preprocessing import StandardScaler
from sklearn.metrics import accuracy_score
from sklearn.svm import SVC
import pandas as pd # for dataframe manipulation
from pandas.plotting import parallel_coordinates # for parallel coordinates␣
 ↪plot of breast cancer data set
import matplotlib.pyplot as plt # for plotting graphs
from sklearn.manifold import TSNE # for t-SNE plot
from sklearn.ensemble import RandomForestClassifier
from sklearn.metrics import auc, confusion_matrix, precision_score,␣
 ↪recall_score, roc_curve
from sklearn.model_selection import cross_val_score
from sklearn.metrics import f1_score
from sklearn.linear_model import LogisticRegression
from sklearn.naive_bayes import GaussianNB
from sklearn.neighbors import KNeighborsClassifier
from sklearn.tree import DecisionTreeClassifier
```

```
import seaborn as sns
from collections import Counter
import numpy as np
from sklearn.metrics import accuracy_score, f1_score, roc_curve, auc,␣
 ↪precision_recall_curve, confusion_matrix, ConfusionMatrixDisplay
from matplotlib.colors import ListedColormap
import seaborn as sns
import pandas as pd
import matplotlib.pyplot as plt
from sklearn.metrics import confusion_matrix
```

[2]:

```
# Define roll number, name, email
roll_number = "23156022"
name = "Venkateswar Reddy Melachervu"
email = "vmela23@iitk.ac.in"

# Load purchase data set
purchase_ds = pd.read_csv('Purchase_Logistic.csv')

X = purchase_ds.iloc[:, [2, 3]].values
Y = purchase_ds.iloc[:, 4].values

# Scale the data using standard scaler
scaler = StandardScaler()
standard_scaled_X = scaler.fit_transform(X)

# Display metadata about the purchase data dataset
# Set display option to show all columns
pd.set_option('display.max_columns', None)
pd.set_option('display.width', 1000)

df = purchase_ds.columns.tolist()
# Print the column names
print(f"Column/feature names are: {df}")
target_column_index = 4
target_column = purchase_ds.columns[target_column_index]
# Print the target column name
print(f"Target column name is: {target_column}\n")
```

```
Column/feature names are: ['User ID', 'Gender', 'Age', 'EstimatedSalary',
'Purchased']
Target column name is: Purchased
```

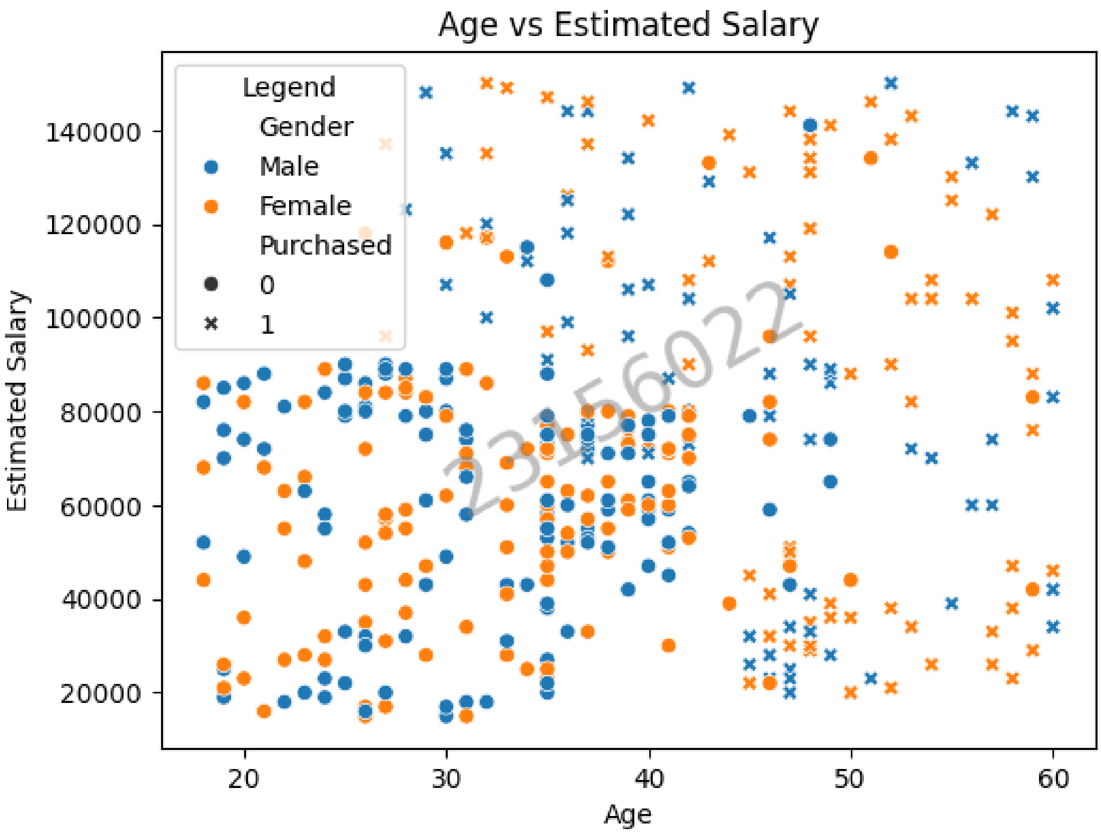
[3]:

```
# Display the first row of the data set
print('First row of purchase data set is:')
print(purchase_ds.iloc[0].to_dict())
```

```
First row of purchase data set is:
{'User ID': 15624510, 'Gender': 'Male', 'Age': 19, 'EstimatedSalary': 19000,
'Purchased': 0}
```

[4]:
```
# Create a scatter plot for Age vs EstimatedSalary, colored by Gender and␣
 ↪marked by Purchased status
sns.scatterplot(x='Age', y='EstimatedSalary', hue='Gender', style='Purchased',␣
 ↪data=purchase_ds)

# Optionally, add titles and labels
plt.title('Age vs Estimated Salary')
plt.xlabel('Age')
plt.ylabel('Estimated Salary')
plt.legend(title='Legend')
# Add watermark
plt.text(0.5, 0.5, roll_number, fontsize=30, color='gray', alpha=0.5,␣
 ↪ha='center', va='center', rotation=30, transform=plt.gca().transAxes)
plt.show()
```



[5]:

```
# function to display confusion matrix plot with watermark - wama
def print_confusion_matrix_wama(cm, labels, plot_name, Y_test, wama='23156022'):
    # Calculate counts for each class in the test set
    class_counts = Counter(Y_test)

    # Print the counts
    print("Data Count in Test Set:")
    for class_label, count in class_counts.items():
        if class_label == 0:
            print(f"\tNot Purchased: {count}")
        elif class_label == 1:
            print(f"\tPurchased: {count}")
        else:
            pass

    # Plot the confusion matrix
    plt.figure(figsize=(8, 6))
    sns.heatmap(cm, annot=True, fmt='d', cmap='Blues', xticklabels=labels,␣
 ↪yticklabels=labels)

    plt.xlabel('Predicted Label')
    plt.ylabel('True Label')
    plt.title(plot_name)

    # Add centered diagonal watermark
    plt.text(0.5, 0.5, wama, fontsize=50, color='gray', alpha=0.2,
             rotation=45, ha='center', va='center', transform=plt.gca().
 ↪transAxes)

    plt.show()
```

[9]:

```
# Split the data into training and test sets
X_train, X_test, Y_train, Y_test = train_test_split(X, Y, test_size = 0.25,␣
 ↪random_state = 0)

# Scale the data
scaler = StandardScaler()
X = scaler.fit_transform(X)
# Split the data across train and test
X_train, X_test, Y_train, Y_test = train_test_split(X, Y, test_size = 0.25,␣
 ↪random_state = 0)

# Create a Naive Bayes classifier
print('Creating Naive Bayes Classifier...')
# Create a Gaussian Naive Bayes classifier
from sklearn.naive_bayes import GaussianNB
naiveBayes = GaussianNB()
```

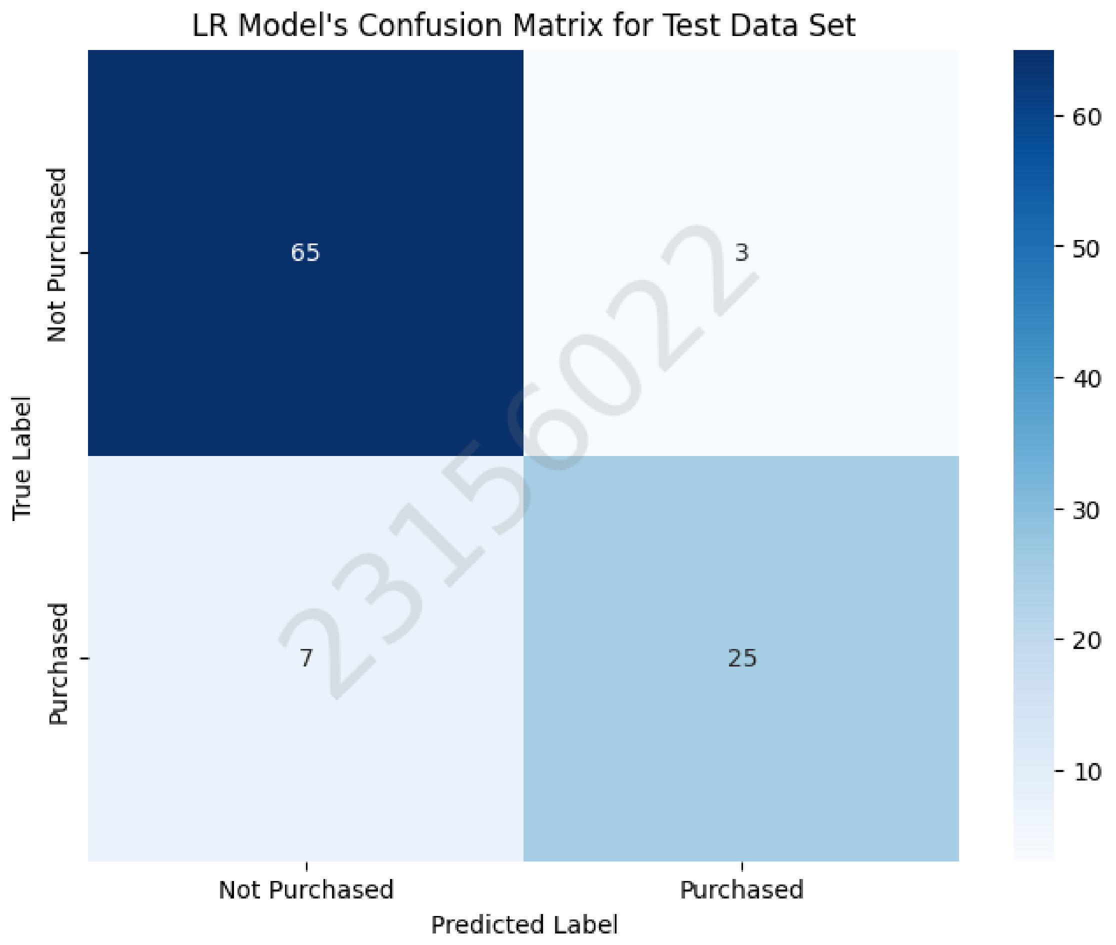
```python

# Train the classifier
print('Training the model...')
naiveBayes.fit(X_train, Y_train)
print('Training Score: ', naiveBayes.score(X_train, Y_train))
# Make predictions
print('Making predictions...')
Y_pred = naiveBayes.predict(X_test)

# Evaluate the model
accuracy = accuracy_score(Y_test, Y_pred)
f1 = f1_score(Y_test, Y_pred)
print(f"Accuracy: {accuracy}")
print(f"F1 Score: {f1}")

# Create the Confusion Matrix and plot it with watermark
labels = ['Not Purchased', 'Purchased']  # replace with your actual class␣
  ↪labels if different
plot_name = 'LR Model\'s Confusion Matrix for Test Data Set'
print('Printing Confusion Matrix...')
# confusion matrix
cmat = confusion_matrix(Y_test, Y_pred)
print_confusion_matrix_wama(cmat, labels, plot_name, Y_test)
```

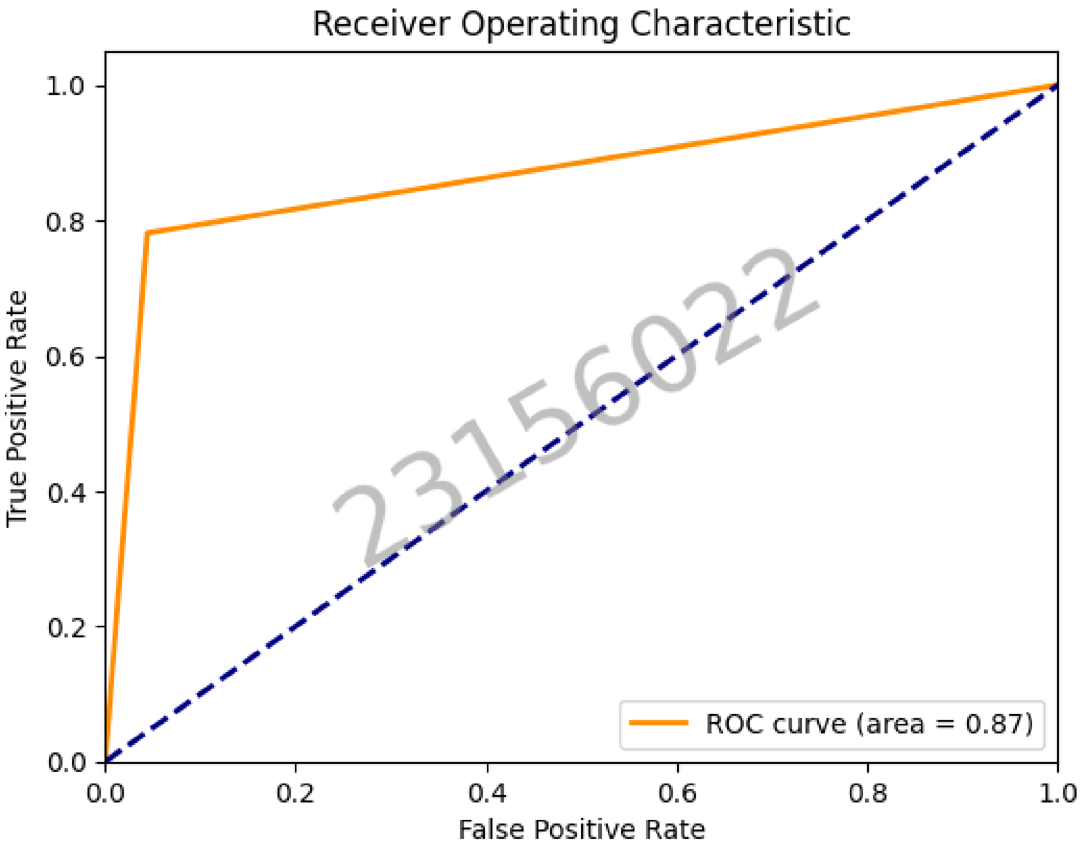
```
Creating Naive Bayes Classifier…
Training the model…
Training Score:  0.8833333333333333
Making predictions…
Accuracy: 0.9
F1 Score: 0.8333333333333334
Printing Confusion Matrix…
Data Count in Test Set:
        Not Purchased: 68
        Purchased: 32
```



[16]:

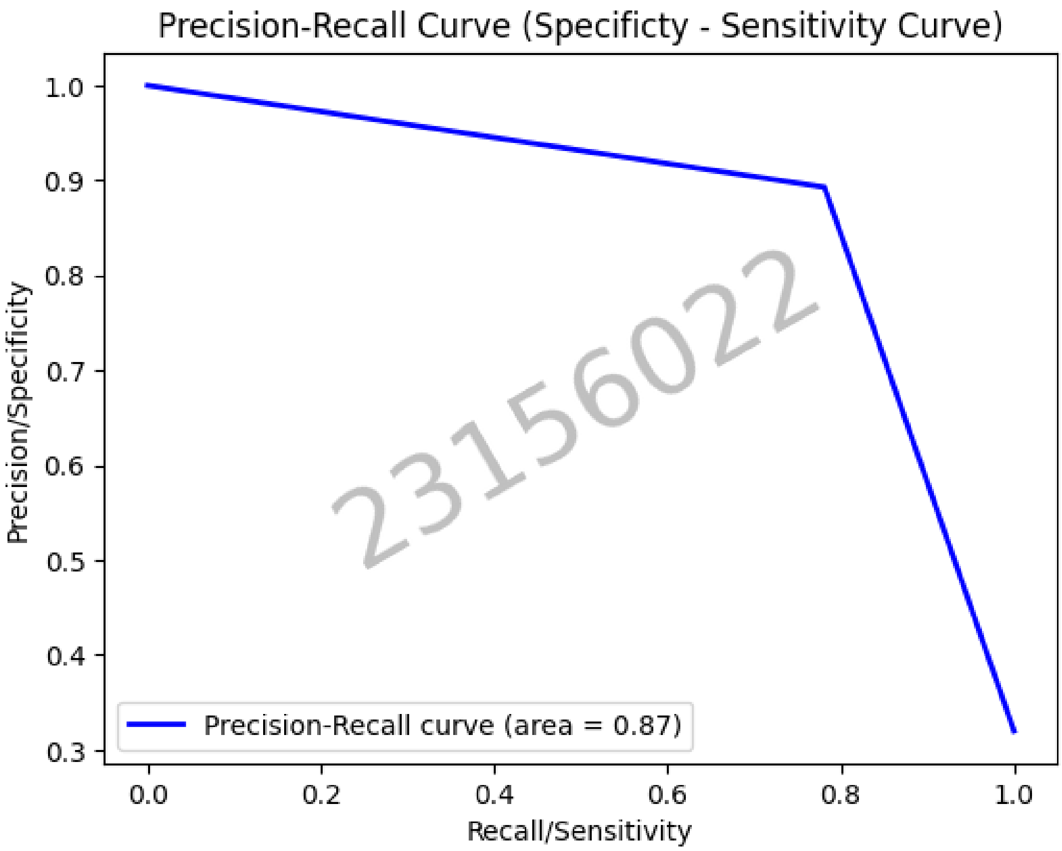
```
# Plot RoC curves
print('Plotting ROC and Precision-Recall curves...')
# Plot the ROC curve
fpr, tpr, thresholds = roc_curve(Y_test, Y_pred)
roc_auc = auc(fpr, tpr)
plt.figure()
plt.plot(fpr, tpr, color='darkorange', lw=2, label='ROC curve (area = %0.2f)' % roc_auc)
plt.plot([0, 1], [0, 1], color='navy', lw=2, linestyle='--')
plt.xlim([0.0, 1.0])
plt.ylim([0.0, 1.05])
plt.xlabel('False Positive Rate')
plt.ylabel('True Positive Rate')
plt.title('Receiver Operating Characteristic')
plt.legend(loc="lower right")
plt.text(0.5, 0.5, roll_number, fontsize=40, color='gray', alpha=0.5, ha='center', va='center', rotation=30, transform=plt.gca().transAxes)
plt.show()
```

```
Plotting ROC and Precision-Recall curves…
```



[23]:
```
# Plot Precision-Recall curve
print('Plotting Precision-Recall curve...')
# Plot the Precision-Recall curve
precision, recall, thresholds = precision_recall_curve(Y_test, Y_pred)
pr_auc = auc(recall, precision)
plt.figure()
plt.plot(recall, precision, color='blue', lw=2, label='Precision-Recall curve␣
  ↪(area = %0.2f)' % pr_auc)
plt.xlabel('Recall/Sensitivity')
plt.ylabel('Precision/Specificity')
plt.title('Precision-Recall Curve (Specificty - Sensitivity Curve)')
plt.legend(loc="lower left")
plt.text(0.5, 0.5, roll_number, fontsize=40, color='gray', alpha=0.5,␣
  ↪ha='center', va='center', rotation=30, transform=plt.gca().transAxes)
plt.show()
```

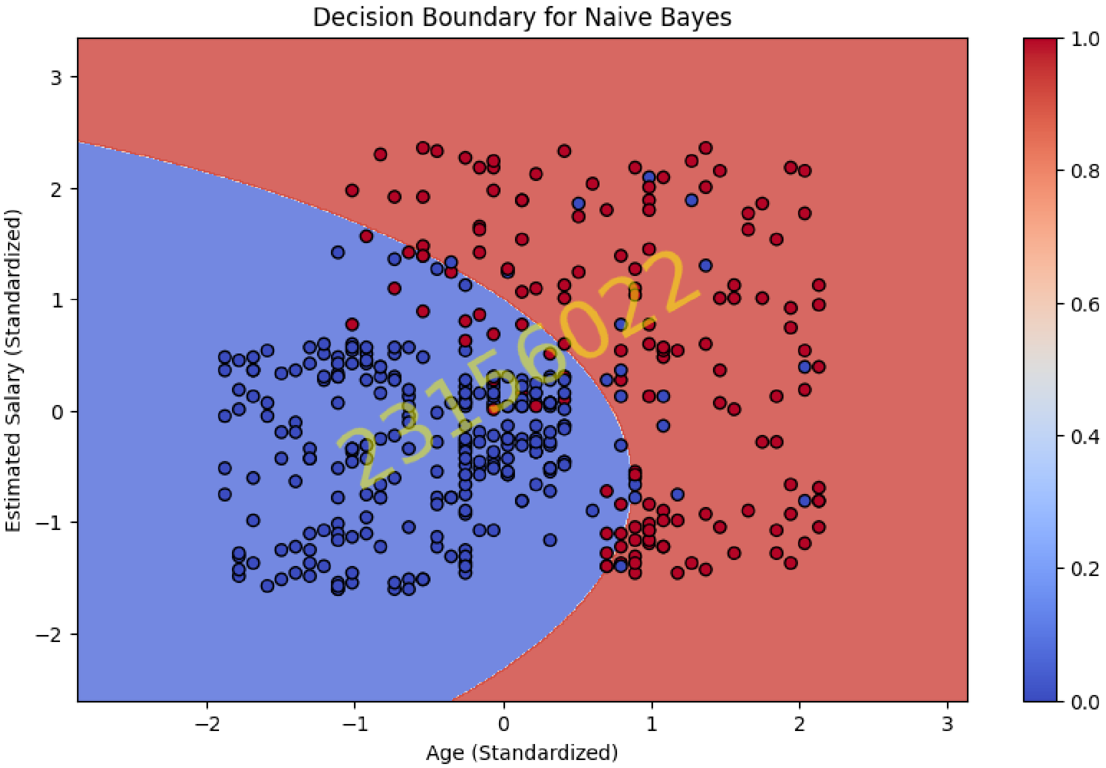
```
Plotting Precision-Recall curve…
```



[25]:

```python
# Plot decision boundary
# Create a mesh to plot in
x_min, x_max = X[:, 0].min() - 1, X[:, 0].max() + 1
y_min, y_max = X[:, 1].min() - 1, X[:, 1].max() + 1
xx, yy = np.meshgrid(np.arange(x_min, x_max, 0.01), np.arange(y_min, y_max, 0.01))

# Predict the classification
Z = naiveBayes.predict(np.c_[xx.ravel(), yy.ravel()])
Z = Z.reshape(xx.shape)
plt.figure(figsize=(10, 6))
plt.contourf(xx, yy, Z, alpha=0.8, cmap=plt.cm.coolwarm)
plt.scatter(X[:, 0], X[:, 1], c=Y, edgecolor='k', cmap=plt.cm.coolwarm)
plt.xlabel('Age (Standardized)')
plt.ylabel('Estimated Salary (Standardized)')
plt.title('Decision Boundary for Naive Bayes')
plt.colorbar()
plt.text(0.5, 0.5, roll_number, fontsize=40, color='yellow', alpha=0.5,␣
  ↪ha='center', va='center', rotation=30, transform=plt.gca().transAxes)
plt.show()
```



```
[ ]: !jupyter nbconvert --to pdf Proj_05_Naive_Bayes_Full_5.ipynb
```