Inam_Daudi_CIND820

November 9, 2021

[ ]:

```
#import libraries
#import pandas as pd
#import numpy as np
#import matplotlib.pyplot as plt
#from matplotlib.patches import Patch
#from matplotlib.lines import Line2D
#import seaborn as sns
#import sklearn as sk
#from sklearn import metrics
#from sklearn.metrics import classification_report
#from sklearn.linear_model import LogisticRegression
#from sklearn.tree import DecisionTreeClassifier
#from sklearn.neighbors import KNeighborsClassifier
#from sklearn.discriminant_analysis import LinearDiscriminantAnalysis
#from sklearn.naive_bayes import GaussianNB
#from sklearn.svm import SVC
#from sklearn.metrics import confusion_matrix
#from sklearn.ensemble import BaggingClassifier
#from sklearn.ensemble import GradientBoostingClassifier
```

[144]:

```
#import data
coupon_data = pd.read_csv('in-vehicle-coupon-recommendation.csv')
```

[145]:

```
#data attributes and their types
coupon_data.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 12684 entries, 0 to 12683
Data columns (total 26 columns):
 #   Column                Non-Null Count  Dtype
---  ------                --------------  -----
 0   destination           12684 non-null  object
 1   passanger             12684 non-null  object
 2   weather               12684 non-null  object
 3   temperature           12684 non-null  int64
 4   time                  12684 non-null  object
 5   coupon                12684 non-null  object
 6   expiration            12684 non-null  object
 7   gender                12684 non-null  object
 8   age                   12684 non-null  object
 9   maritalStatus         12684 non-null  object
 10  has_children          12684 non-null  int64
 11  education             12684 non-null  object
 12  occupation            12684 non-null  object
 13  income                12684 non-null  object
 14  car                   108 non-null    object
 15  Bar                   12577 non-null  object
 16  CoffeeHouse           12467 non-null  object
 17  CarryAway             12533 non-null  object
 18  RestaurantLessThan20  12554 non-null  object
 19  Restaurant20To50      12495 non-null  object
 20  toCoupon_GEQ5min      12684 non-null  int64
 21  toCoupon_GEQ15min     12684 non-null  int64
 22  toCoupon_GEQ25min     12684 non-null  int64
 23  direction_same        12684 non-null  int64
 24  direction_opp         12684 non-null  int64
 25  Y                     12684 non-null  int64
dtypes: int64(8), object(18)
memory usage: 2.5+ MB
```

```
[146]: #first few tuples in the dataset
       coupon_data.head()
```

```
[146]:        destination  passanger weather  temperature  time  \
       0  No Urgent Place      Alone   Sunny           55   2PM
       1  No Urgent Place  Friend(s)   Sunny           80  10AM
       2  No Urgent Place  Friend(s)   Sunny           80  10AM
       3  No Urgent Place  Friend(s)   Sunny           80   2PM
       4  No Urgent Place  Friend(s)   Sunny           80   2PM

                         coupon expiration  gender age      maritalStatus  …   \
       0        Restaurant(<20)         1d  Female  21  Unmarried partner  …
       1           Coffee House         2h  Female  21  Unmarried partner  …
       2  Carry out & Take away         2h  Female  21  Unmarried partner  …
       3           Coffee House         2h  Female  21  Unmarried partner  …
       4           Coffee House         1d  Female  21  Unmarried partner  …

         CoffeeHouse CarryAway RestaurantLessThan20 Restaurant20To50  \
       0       never       NaN                  4~8              1~3
       1       never       NaN                  4~8              1~3
       2       never       NaN                  4~8              1~3
       3       never       NaN                  4~8              1~3
       4       never       NaN                  4~8              1~3

        toCoupon_GEQ5min toCoupon_GEQ15min toCoupon_GEQ25min direction_same  \
0                 1                  0                  0                0
1                 1                  0                  0                0
2                 1                  1                  0                0
3                 1                  1                  0                0
4                 1                  1                  0                0

  direction_opp  Y
0             1  1
1             1  0
2             1  1
3             1  0
4             1  0

[5 rows x 26 columns]
```

[147]:
```
#data description
coupon_data.describe(include='all')
```

[147]:
```
             destination passanger weather   temperature   time        coupon  \
count              12684     12684   12684  12684.000000  12684         12684
unique                 3         4       3           NaN      5             5
top      No Urgent Place     Alone   Sunny           NaN    6PM  Coffee House
freq                6283      7305   10069           NaN   3230          3996
mean                 NaN       NaN     NaN     63.301798    NaN           NaN
std                  NaN       NaN     NaN     19.154486    NaN           NaN
min                  NaN       NaN     NaN     30.000000    NaN           NaN
25%                  NaN       NaN     NaN     55.000000    NaN           NaN
50%                  NaN       NaN     NaN     80.000000    NaN           NaN
75%                  NaN       NaN     NaN     80.000000    NaN           NaN
max                  NaN       NaN     NaN     80.000000    NaN           NaN

       expiration  gender    age    maritalStatus  …  CoffeeHouse CarryAway  \
count       12684   12684  12684            12684  …        12467     12533
unique          2       2      8                5  …            5         5
top            1d  Female     21  Married partner  …        less1       1~3
freq         7091    6511   2653             5100  …         3385      4672
mean          NaN     NaN    NaN              NaN  …          NaN       NaN
std           NaN     NaN    NaN              NaN  …          NaN       NaN
min           NaN     NaN    NaN              NaN  …          NaN       NaN
25%           NaN     NaN    NaN              NaN  …          NaN       NaN
50%           NaN     NaN    NaN              NaN  …          NaN       NaN
75%           NaN     NaN    NaN              NaN  …          NaN       NaN
max           NaN     NaN    NaN              NaN  …          NaN       NaN

       RestaurantLessThan20 Restaurant20To50 toCoupon_GEQ5min  \
count                 12554            12495          12684.0
unique                    5                5              NaN
```

```
top                      1~3            less1              NaN
freq                    5376             6077              NaN
mean                     NaN              NaN              1.0
std                      NaN              NaN              0.0
min                      NaN              NaN              1.0
25%                      NaN              NaN              1.0
50%                      NaN              NaN              1.0
75%                      NaN              NaN              1.0
max                      NaN              NaN              1.0

       toCoupon_GEQ15min toCoupon_GEQ25min direction_same direction_opp  \
count       12684.000000      12684.000000   12684.000000  12684.000000
unique               NaN               NaN            NaN           NaN
top                  NaN               NaN            NaN           NaN
freq                 NaN               NaN            NaN           NaN
mean            0.561495          0.119126       0.214759      0.785241
std             0.496224          0.323950       0.410671      0.410671
min             0.000000          0.000000       0.000000      0.000000
25%             0.000000          0.000000       0.000000      1.000000
50%             1.000000          0.000000       0.000000      1.000000
75%             1.000000          0.000000       0.000000      1.000000
max             1.000000          1.000000       1.000000      1.000000

                   Y
count   12684.000000
unique           NaN
top              NaN
freq             NaN
mean        0.568433
std         0.495314
min         0.000000
25%         0.000000
50%         1.000000
75%         1.000000
max         1.000000

[11 rows x 26 columns]
```

[148]:

```
#change the temperature attribute to the 'category' type
coupon_data['temperature']=coupon_data['temperature'].astype('category')
```

[149]:

```
#checking the types and counts of the cars attribute
coupon_data["car"].value_counts()
```

[149]:

```
Mazda5                                      22
Scooter and motorcycle                      22
do not drive                                22
```

```
Car that is too old to install Onstar :D    21
crossover                                   21
Name: car, dtype: int64
```

[150]:

```
#dropping the car column
coupon_data.drop('car', inplace=True, axis=1)
```

[151]:

```
#fill missing values with the most common value
for x in coupon_data.columns[coupon_data.isna().any()]:
    coupon_data = coupon_data.fillna({x: coupon_data[x].value_counts().
 ↪idxmax()})
```

[154]:

```
#changing object datatypes to categorical datatypes
coupon_data_obj = coupon_data.select_dtypes(include=['object']).copy()

for col in coupon_data_obj.columns:
    coupon_data[col]=coupon_data[col].astype('category')
```

[155]:

```
#counting unique values in the columns with numeric values
coupon_data.select_dtypes('int64').nunique()
```

[155]:

```
has_children          2
toCoupon_GEQ5min      1
toCoupon_GEQ15min     2
toCoupon_GEQ25min     2
direction_same        2
direction_opp         2
Y                     2
dtype: int64
```

[156]:

```
#dropping the toCoupon_GEQ5min column as it only has 1 value
coupon_data.drop(columns=['toCoupon_GEQ5min'], inplace=True)
```

[157]:

```
#data attributes and their types
coupon_data.info()
```

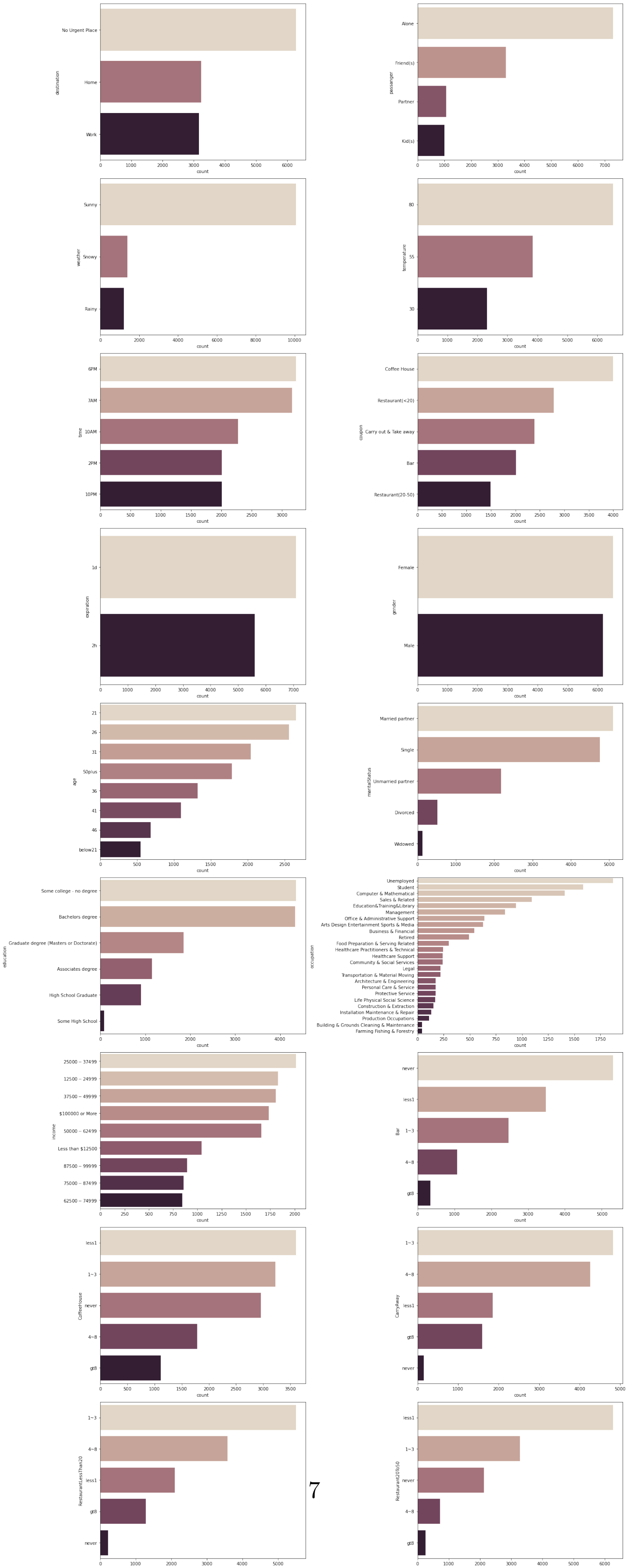
```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 12684 entries, 0 to 12683
Data columns (total 24 columns):
 #   Column                Non-Null Count  Dtype
---  ------                --------------  -----
 0   destination           12684 non-null  category
 1   passanger             12684 non-null  category
 2   weather               12684 non-null  category
 3   temperature           12684 non-null  category
 4   time                  12684 non-null  category
 5   coupon                12684 non-null  category
 6   expiration            12684 non-null  category
 7   gender                12684 non-null  category
 8   age                   12684 non-null  category
 9   maritalStatus         12684 non-null  category
 10  has_children          12684 non-null  int64
 11  education             12684 non-null  category
 12  occupation            12684 non-null  category
 13  income                12684 non-null  category
 14  Bar                   12684 non-null  category
 15  CoffeeHouse           12684 non-null  category
 16  CarryAway             12684 non-null  category
 17  RestaurantLessThan20  12684 non-null  category
 18  Restaurant20To50      12684 non-null  category
 19  toCoupon_GEQ15min     12684 non-null  int64
 20  toCoupon_GEQ25min     12684 non-null  int64
 21  direction_same        12684 non-null  int64
 22  direction_opp         12684 non-null  int64
 23  Y                     12684 non-null  int64
dtypes: category(18), int64(6)
memory usage: 821.7 KB
```

[158]:

```
#plotting bar charts for all categorical attributes
fig, axes = plt.subplots(9, 2, figsize=(20,50))
axes = axes.flatten()

for ax, col in zip(axes, coupon_data.select_dtypes('category').columns):
    sns.countplot(y=col, data=coupon_data, ax=ax,
                  palette="ch:.25", order=coupon_data[col].value_counts().
 ↪index);

plt.tight_layout()
plt.show()
```



destination
No Urgent Place
Home
Work
count
0
1000
2000
3000
4000
5000
6000
passanger
Alone
Friend(s)
Partner
Kid(s)
count
0
1000
2000
3000
4000
5000
6000
7000
weather
Sunny
Snowy
Rainy
count
0
2000
4000
6000
8000
10000
temperature
80
55
30
count
0
1000
2000
3000
4000
5000
6000
time
6PM
7AM
10AM
2PM
10PM
count
0
500
1000
1500
2000
2500
3000
coupon
Coffee House
Restaurant(<20)
Carry out & Take away
Bar
Restaurant(20-50)
count
0
500
1000
1500
2000
2500
3000
3500
4000
expiration
1d
2h
count
0
1000
2000
3000
4000
5000
6000
7000
gender
Female
Male
count
0
1000
2000
3000
4000
5000
6000
age
21
26
31
50plus
36
41
46
below21
count
0
500
1000
1500
2000
2500
maritalStatus
Married partner
Single
Unmarried partner
Divorced
Widowed
count
0
1000
2000
3000
4000
5000
education
Some college - no degree
Bachelors degree
Graduate degree (Masters or Doctorate)
Associates degree
High School Graduate
Some High School
count
0
1000
2000
3000
4000
occupation
Unemployed
Student
Computer & Mathematical
Sales & Related
Education&Training&Library
Management
Office & Administrative Support
Arts Design Entertainment Sports & Media
Business & Financial
Retired
Food Preparation & Serving Related
Healthcare Practitioners & Technical
Healthcare Support
Community & Social Services
Legal
Transportation & Material Moving
Architecture & Engineering
Personal Care & Service
Protective Service
Life Physical Social Science
Construction & Extraction
Installation Maintenance & Repair
Production Occupations
Building & Grounds Cleaning & Maintenance
Farming Fishing & Forestry
count
0
250
500
750
1000
1250
1500
1750
income
$25000 - $37499
$12500 - $24999
$37500 - $49999
$100000 or More
$50000 - $62499
Less than $12500
$87500 - $99999
$75000 - $87499
$62500 - $74999
count
0
250
500
750
1000
1250
1500
1750
2000
Bar
never
less1
1~3
4~8
gt8
count
0
1000
2000
3000
4000
5000
CoffeeHouse
less1
1~3
never
4~8
gt8
count
0
500
1000
1500
2000
2500
3000
3500
CarryAway
1~3
4~8
less1
gt8
never
count
0
1000
2000
3000
4000
5000
RestaurantLessThan20
1~3
4~8
less1
gt8
never
count
0
1000
2000
3000
4000
5000
Restaurant20To50
less1
1~3
never
4~8
gt8
count
0
1000
2000
3000
4000
5000
6000

[159]:

```
#Transforming the data using LabelEnconder and OneHotEncoder
from sklearn.preprocessing import LabelEncoder, OneHotEncoder

enc = OneHotEncoder(dtype='int64')

coupon_data_cat = coupon_data.select_dtypes(include=['category']).copy()
coupon_data_int = coupon_data.select_dtypes(include=['int64']).copy()

coupon_data_enc = pd.DataFrame()
for col in coupon_data_cat.columns:
    enc_results = enc.fit_transform(coupon_data_cat[[col]])
    coupon_data0 = pd.DataFrame(enc_results.toarray(), columns=enc.categories_)
    coupon_data_enc = pd.concat([coupon_data_enc,coupon_data0], axis=1)

coupon_data_final = pd.concat([coupon_data_enc, coupon_data_int], axis=1)
```

[160]:

```
coupon_data_final
```

[160]:

```
       (Home,)  (No Urgent Place,)  (Work,)  (Alone,)  (Friend(s),)  \
0            0                   1        0         1             0
1            0                   1        0         0             1
2            0                   1        0         0             1
3            0                   1        0         0             1
4            0                   1        0         0             1
…        …                 …      …       …           …
12679        1                   0        0         0             0
12680        0                   0        1         1             0
12681        0                   0        1         1             0
12682        0                   0        1         1             0
12683        0                   0        1         1             0

       (Kid(s),)  (Partner,)  (Rainy,)  (Snowy,)  (Sunny,)  …  (4~8,)  \
0              0           0         0         0         1  …       0
1              0           0         0         0         1  …       0
2              0           0         0         0         1  …       0
3              0           0         0         0         1  …       0
4              0           0         0         0         1  …       0
…          …         …       …       …       …  …     …
12679          0           1         1         0         0  …       0
12680          0           0         1         0         0  …       0
12681          0           0         0         1         0  …       0
12682          0           0         0         1         0  …       0
12683          0           0         0         0         1  …       0

       (gt8,)  (less1,)  (never,)  has_children  toCoupon_GEQ15min  \
0           0         0         0             1                   0
1           0         0         0             1                   0
2           0         0         0             1                   1
3           0         0         0             1                   1
4           0         0         0             1                   1
…       …       …       …           …                 …
12679       0         0         0             0                   0
12680       0         0         0             0                   0
12681       0         0         0             0                   0
12682       0         0         0             0                   1
12683       0         0         0             0                   0

       toCoupon_GEQ25min  direction_same  direction_opp  Y
0                      0               0              1  1
1                      0               0              1  0
2                      0               0              1  1
3                      0               0              1  0
4                      0               0              1  0
…                  …             …            …  ..
12679                  0               1              0  1
12680                  0               0              1  1
12681                  0               1              0  0
12682                  1               0              1  0
12683                  0               1              0  0

[12684 rows x 111 columns]
```

[161]:

```
#Splitting the data into test and training
from sklearn.model_selection import train_test_split

train_set, test_set = train_test_split(coupon_data_final, test_size=.2, random_state=42, shuffle=True, stratify=df_final['Y'])
```

[162]:

```
#Creating the dependent and indepdent variables
X_train = train_set.iloc[:, :-1].values
X_test = test_set.iloc[:, :-1].values

y_train = train_set.iloc[:, -1].values
y_test = test_set.iloc[:, -1].values
```

[163]:

```
#Applying Logistic Regression
LR = LogisticRegression(random_state=0, solver='lbfgs', multi_class='ovr').fit(X_train, y_train)

y_pred_LR = LR.predict(X_test)

print(classification_report(y_test, y_pred_LR))
```

```
#Logistic Regression Confusion Matrix
cm_LR = confusion_matrix(y_test,y_pred_LR)
pd.crosstab(y_test, y_pred_LR, rownames = ['Truth'], colnames =['Predicted'],␣
 ↪margins = True)
```

```
              precision    recall  f1-score   support

           0       0.65      0.56      0.60      1095
           1       0.70      0.77      0.73      1442

    accuracy                           0.68      2537
   macro avg       0.68      0.67      0.67      2537
weighted avg       0.68      0.68      0.68      2537
```

[163]:

```
Predicted    0     1   All
Truth
0          615   480  1095
1          327  1115  1442
All        942  1595  2537
```

[164]:

```
#Applying Decision Tree
DTC = DecisionTreeClassifier().fit(X_train, y_train)

y_pred_DTC = DTC.predict(X_test)

print(classification_report(y_test, y_pred_DTC))

#Decision Tree Confusion Matrix
cm_DTC = confusion_matrix(y_test,y_pred_DTC)
pd.crosstab(y_test, y_pred_DTC, rownames = ['Truth'], colnames =['Predicted'],␣
 ↪margins = True)
```

```
              precision    recall  f1-score   support

           0       0.62      0.62      0.62      1095
           1       0.71      0.71      0.71      1442

    accuracy                           0.67      2537
   macro avg       0.67      0.67      0.67      2537
weighted avg       0.67      0.67      0.67      2537
```

[164]:

```
Predicted     0     1   All
Truth
0           680   415  1095
```

```
1             412  1030  1442
All          1092  1445  2537
```

[165]:
```
#Applying Decision Tree Ensemble Bagging
BC = BaggingClassifier().fit(X_train, y_train)

y_pred_BC = BC.predict(X_test)

print(classification_report(y_test, y_pred_BC))

#Decision Tree Ensemble Bagging Confusion Matrix
cm_BC = confusion_matrix(y_test,y_pred_BC)
pd.crosstab(y_test, y_pred_BC, rownames = ['Truth'], colnames =['Predicted'],␣
 ↪margins = True)
```

```
              precision    recall  f1-score   support

           0       0.68      0.71      0.69      1095
           1       0.77      0.75      0.76      1442

    accuracy                           0.73      2537
   macro avg       0.73      0.73      0.73      2537
weighted avg       0.73      0.73      0.73      2537
```

[165]:
```
Predicted     0     1   All
Truth
0           776   319  1095
1           364  1078  1442
All        1140  1397  2537
```

[166]:
```
#Applying Decision Tree Ensemble Boosting
GBC = GradientBoostingClassifier().fit(X_train, y_train)

y_pred_GBC = GBC.predict(X_test)

print(classification_report(y_test, y_pred_GBC))

#Decision Tree Ensemble Gradient Boosting Confusion Matrix
cm_GBC = confusion_matrix(y_test,y_pred_GBC)
pd.crosstab(y_test, y_pred_GBC, rownames = ['Truth'], colnames =['Predicted'],␣
 ↪margins = True)
```

```
              precision    recall  f1-score   support

           0       0.73      0.60      0.65      1095
           1       0.73      0.83      0.78      1442
```

```
    accuracy                           0.73      2537
   macro avg       0.73      0.71      0.71      2537
weighted avg       0.73      0.73      0.72      2537
```

[166]:
```
Predicted    0     1   All
Truth
0          652   443  1095
1          247  1195  1442
All        899  1638  2537
```

[167]:
```
#Applying K Nearest Neighbors
KNN = KNeighborsClassifier().fit(X_train, y_train)

y_pred_KNN = KNN.predict(X_test)

print(classification_report(y_test, y_pred_KNN))

#K Nearest Neighbors Confusion Matrix
cm_LR = confusion_matrix(y_test,y_pred_KNN)
pd.crosstab(y_test, y_pred_KNN, rownames = ['Truth'], colnames =['Predicted'],␣
 ↪margins = True)
```

```
              precision    recall  f1-score   support

           0       0.61      0.54      0.57      1095
           1       0.68      0.74      0.71      1442

    accuracy                           0.65      2537
   macro avg       0.64      0.64      0.64      2537
weighted avg       0.65      0.65      0.65      2537
```

[167]:
```
Predicted    0     1   All
Truth
0          587   508  1095
1          373  1069  1442
All        960  1577  2537
```

[168]:
```
#Applying Linear Discriminant Analysis
LDA = LinearDiscriminantAnalysis().fit(X_train, y_train)

y_pred_LDA = LDA.predict(X_test)

print(classification_report(y_test, y_pred_LDA))

#Linear Discriminant Analysis Confusion Matrix
cm_LDA = confusion_matrix(y_test,y_pred_LDA)
```

```
pd.crosstab(y_test, y_pred_LDA, rownames = ['Truth'], colnames =['Predicted'],␣
 ↪margins = True)
```

```
              precision    recall  f1-score   support

           0       0.66      0.57      0.61      1095
           1       0.70      0.77      0.74      1442

    accuracy                           0.69      2537
   macro avg       0.68      0.67      0.67      2537
weighted avg       0.68      0.69      0.68      2537
```

```
[168]: Predicted    0     1   All
       Truth
       0          622   473  1095
       1          325  1117  1442
       All        947  1590  2537
```

```
[169]: #Applying Gaussian Naive Bayes
       GNB = GaussianNB().fit(X_train, y_train)

       y_pred_GNB = GNB.predict(X_test)

       print(classification_report(y_test, y_pred_GNB))

       #Gaussain Naive Bayes Confusion Matrix
       cm_GNB = confusion_matrix(y_test,y_pred_GNB)
       pd.crosstab(y_test, y_pred_GNB, rownames = ['Truth'], colnames =['Predicted'],␣
        ↪margins = True)
```

```
              precision    recall  f1-score   support

           0       0.56      0.62      0.59      1095
           1       0.69      0.62      0.65      1442

    accuracy                           0.62      2537
   macro avg       0.62      0.62      0.62      2537
weighted avg       0.63      0.62      0.63      2537
```

```
[169]: Predicted     0     1   All
       Truth
       0           683   412  1095
       1           543   899  1442
       All        1226  1311  2537
```

[170]:
```
#Applying Support Vector Machine
SVM = SVC(kernel="rbf", random_state=None, probability=True, cache_size=500,␣
 ↪gamma=0.1).fit(X_train, y_train)

y_pred_SVM = SVM.predict(X_test)

print(classification_report(y_test, y_pred_SVM))

#Support Vector Machine Confusion Matrix
cm_SVM = confusion_matrix(y_test,y_pred_SVM)
pd.crosstab(y_test, y_pred_SVM, rownames = ['Truth'], colnames =['Predicted'],␣
 ↪margins = True)
```

```
              precision    recall  f1-score   support

           0       0.75      0.67      0.71      1095
           1       0.77      0.83      0.80      1442

    accuracy                           0.76      2537
   macro avg       0.76      0.75      0.76      2537
weighted avg       0.76      0.76      0.76      2537
```

[170]:
```
Predicted    0     1   All
Truth
0          730   365  1095
1          242  1200  1442
All        972  1565  2537
```