Andrew Vu - CS156_HW5

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1 CS156 (Introduction to AI), Spring 2022

2 Homework 5 submission

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Any special notes or anything you would like to communicate to me about this homework submission goes in here.

2.1 References and sources

List all your references and sources here. This includes all sites/discussion boards/blogs/posts/etc. where you grabbed some code examples. - decisiontreesbreast file - https://datagy.io/reorder-pandas-columns/

2.2 Solution

Load libraries and set random number generator seed

[23]:

```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
from sklearn.model_selection import train_test_split

from sklearn.tree import DecisionTreeClassifier
from sklearn.model_selection import cross_val_score
from sklearn.metrics import plot_confusion_matrix
from sklearn.ensemble import RandomForestClassifier
from sklearn import tree
```

[24]:

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

Code the solution

[25]:

```
airline_file = pd.read_csv(r'C:\Users\Andrew\CS156 Jupyter␣
 ↪Files\hw5input\homework5_input_data.csv')
```

2.2.1 1. Load Dataset

[26]:

```
df = pd.DataFrame(airline_file, columns=airline_file.columns)
df.head()
columns = df.columns[:-1]
X = df[columns]
Y = df['satisfaction']
df['satisfaction'] = Y

class_names = ['neutral or dissatisfied', 'satisfied']

print(X.shape, Y.shape)
```

```
(103594, 22) (103594,)
```

[27]:

```
df.describe()
```

[27]:

```
                 Age  Flight Distance  Inflight wifi service  \
count  103594.000000    103594.000000          103594.000000   
mean       39.380466      1189.325202               2.729753   
std        15.113125       997.297235               1.327866   
min         7.000000        31.000000               0.000000   
25%        27.000000       414.000000               2.000000   
50%        40.000000       842.000000               3.000000   
75%        51.000000      1743.000000               4.000000   
max        85.000000      4983.000000               5.000000   

       Departure/Arrival time convenient  Ease of Online booking  \
count                      103594.000000           103594.000000   
mean                            3.060081                2.756984   
std                             1.525233                1.398934   
min                             0.000000                0.000000   
25%                             2.000000                2.000000   
50%                             3.000000                3.000000   
75%                             4.000000                4.000000   
max                             5.000000                5.000000   

       Gate location  Food and drink  Online boarding   Seat comfort  \
count  103594.000000   103594.000000    103594.000000  103594.000000   
mean        2.977026        3.202126         3.250497       3.439765   
std         1.277723        1.329401         1.349433       1.318896   
min         0.000000        0.000000         0.000000       0.000000   
25%         2.000000        2.000000         2.000000       2.000000   
50%         3.000000        3.000000         3.000000       4.000000   
75%         4.000000        4.000000         4.000000       5.000000   
max         5.000000        5.000000         5.000000       5.000000   

       Inflight entertainment  On-board service  Leg room service  \
count           103594.000000     103594.000000     103594.000000
mean                 3.358341          3.382609          3.351401
std                  1.333030          1.288284          1.315409
min                  0.000000          0.000000          0.000000
25%                  2.000000          2.000000          2.000000
50%                  4.000000          4.000000          4.000000
75%                  4.000000          4.000000          4.000000
max                  5.000000          5.000000          5.000000

       Baggage handling  Checkin service  Inflight service    Cleanliness  \
count     103594.000000    103594.000000     103594.000000  103594.000000
mean           3.631687         3.304323          3.640761       3.286397
std            1.181051         1.265396          1.175603       1.312194
min            1.000000         0.000000          0.000000       0.000000
25%            3.000000         3.000000          3.000000       2.000000
50%            4.000000         3.000000          4.000000       3.000000
75%            5.000000         4.000000          5.000000       4.000000
max            5.000000         5.000000          5.000000       5.000000

       Departure Delay in Minutes  Arrival Delay in Minutes
count               103594.000000             103594.000000
mean                    14.747939                 15.178678
std                     38.116737                 38.698682
min                      0.000000                  0.000000
25%                      0.000000                  0.000000
50%                      0.000000                  0.000000
75%                     12.000000                 13.000000
max                   1592.000000               1584.000000
```

2.2.2 2. Convert categorical variables –> numeric format

[28]:

```
unconverted = ['Gender', 'Customer Type', 'Type of Travel', 'Class']

# print(df.dtypes)

int_df = df.select_dtypes(include=['int64', 'float64']).copy()
# print(int_df)

df_numeric = pd.get_dummies(df, columns=unconverted, prefix=unconverted)
df_numeric

# new_df = pd.concat([df_numeric, int_df])

# print(new_df)
```

[28]:

```
        Age  Flight Distance  Inflight wifi service  \
0        13              460                      3
```

```
1        25              235                      3
2        26             1142                      2
3        25              562                      2
4        61              214                      3
…     …              …                    …
103589   23              192                      2
103590   49             2347                      4
103591   30             1995                      1
103592   22             1000                      1
103593   27             1723                      1

        Departure/Arrival time convenient  Ease of Online booking  \
0                                       4                       3
1                                       2                       3
2                                       2                       2
3                                       5                       5
4                                       3                       3
…                                   …                     …
103589                                  1                       2
103590                                  4                       4
103591                                  1                       1
103592                                  1                       1
103593                                  3                       3

        Gate location  Food and drink  Online boarding  Seat comfort  \
0                   1               5                3             5
1                   3               1                3             1
2                   2               5                5             5
3                   5               2                2             2
4                   3               4                5             5
…               …             …              …           …
103589              3               2                2             2
103590              4               2                4             5
103591              3               4                1             5
103592              5               1                1             1
103593              3               1                1             1

        Inflight entertainment  …             satisfaction  Gender_Female  \
0                            5  …   neutral or dissatisfied              0
1                            1  …   neutral or dissatisfied              0
2                            5  …                 satisfied              1
3                            2  …   neutral or dissatisfied              1
4                            3  …                 satisfied              0
…                        …  …                      …            …
103589                       2  …   neutral or dissatisfied              1
103590                       5  …                 satisfied              0
103591                       4  …   neutral or dissatisfied              0
```

```
103592                       1  …  neutral or dissatisfied              1
103593                       1  …  neutral or dissatisfied              0

        Gender_Male  Customer Type_Loyal Customer  \
0                 1                             1
1                 1                             0
2                 0                             1
3                 0                             1
4                 1                             1
…             …                           …
103589            0                             0
103590            1                             1
103591            1                             0
103592            0                             0
103593            1                             1

        Customer Type_disloyal Customer  Type of Travel_Business travel  \
0                                     0                               0
1                                     1                               1
2                                     0                               1
3                                     0                               1
4                                     0                               1
…                                 …                             …
103589                                1                               1
103590                                0                               1
103591                                1                               1
103592                                1                               1
103593                                0                               1

        Type of Travel_Personal Travel  Class_Business Class_Eco  \
0                                    1               0         0
1                                    0               1         0
2                                    0               1         0
3                                    0               1         0
4                                    0               1         0
…                                …             …       …
103589                               0               0         1
103590                               0               1         0
103591                               0               1         0
103592                               0               0         1
103593                               0               1         0

        Class_Eco Plus
0                    1
1                    0
2                    0
3                    0
```

```
4                    0
…                …
103589               0
103590               0
103591               0
103592               0
103593               0

[103594 rows x 28 columns]
```

[29]:

```
# reordering the df so that satisfaction is at the end
satisfaction_col = df_numeric['satisfaction']
df_numeric = df_numeric.drop(columns=['satisfaction'])
df_numeric.insert(loc=27, column='satisfaction', value=satisfaction_col)

print(df_numeric)

new_columns = df_numeric.columns[:-1]
X_new = df_numeric[new_columns]
Y_new = df_numeric['satisfaction']

print(Y_new)
df_numeric['satisfaction'] = Y_new
```

```
        Age  Flight Distance  Inflight wifi service  \
0        13              460                      3
1        25              235                      3
2        26             1142                      2
3        25              562                      2
4        61              214                      3
…     …              …                    …
103589   23              192                      2
103590   49             2347                      4
103591   30             1995                      1
103592   22             1000                      1
103593   27             1723                      1

        Departure/Arrival time convenient  Ease of Online booking  \
0                                       4                       3
1                                       2                       3
2                                       2                       2
3                                       5                       5
4                                       3                       3
…                                   …                     …
103589                                  1                       2
103590                                  4                       4
103591                                  1                       1
103592                                  1                       1
```

```
103593                                  3                       3

        Gate location  Food and drink  Online boarding  Seat comfort  \
0                   1               5                3             5
1                   3               1                3             1
2                   2               5                5             5
3                   5               2                2             2
4                   3               4                5             5
…               …             …              …           …
103589              3               2                2             2
103590              4               2                4             5
103591              3               4                1             5
103592              5               1                1             1
103593              3               1                1             1

        Inflight entertainment  …  Gender_Female  Gender_Male  \
0                            5  …              0            1
1                            1  …              0            1
2                            5  …              1            0
3                            2  …              1            0
4                            3  …              0            1
…                        …  …            …          …
103589                       2  …              1            0
103590                       5  …              0            1
103591                       4  …              0            1
103592                       1  …              1            0
103593                       1  …              0            1

        Customer Type_Loyal Customer  Customer Type_disloyal Customer  \
0                                  1                                0
1                                  0                                1
2                                  1                                0
3                                  1                                0
4                                  1                                0
…                              …                              …
103589                             0                                1
103590                             1                                0
103591                             0                                1
103592                             0                                1
103593                             1                                0

        Type of Travel_Business travel  Type of Travel_Personal Travel  \
0                                    0                               1
1                                    1                               0
2                                    1                               0
3                                    1                               0
4                                    1                               0
…                                …                             …
```

```
103589                               1                               0
103590                               1                               0
103591                               1                               0
103592                               1                               0
103593                               1                               0

        Class_Business  Class_Eco  Class_Eco Plus             satisfaction
0                    0          0               1  neutral or dissatisfied
1                    1          0               0  neutral or dissatisfied
2                    1          0               0                satisfied
3                    1          0               0  neutral or dissatisfied
4                    1          0               0                satisfied
…                 …        …             …                       …
103589               0          1               0  neutral or dissatisfied
103590               1          0               0                satisfied
103591               1          0               0  neutral or dissatisfied
103592               0          1               0  neutral or dissatisfied
103593               1          0               0  neutral or dissatisfied

[103594 rows x 28 columns]
0          neutral or dissatisfied
1          neutral or dissatisfied
2                        satisfied
3          neutral or dissatisfied
4                        satisfied
                    …
103589     neutral or dissatisfied
103590                   satisfied
103591     neutral or dissatisfied
103592     neutral or dissatisfied
103593     neutral or dissatisfied
Name: satisfaction, Length: 103594, dtype: object
```

2.2.3 3. Break data into training & test datasets

[30]:

```python
X_train, X_test, Y_train, Y_test = train_test_split(X_new, Y_new, test_size=0.2, random_state=0)
X_train.shape, Y_train.shape, X_test.shape, Y_test.shape
```

[30]:

```
((82875, 27), (82875,), (20719, 27), (20719,))
```

2.2.4 4. Train Decision Tree Model and Report 5-fold cross-validation accuracy & mean accuracy

[31]:

```python
model = DecisionTreeClassifier(random_state=0)

cross_vals = cross_val_score(model, X_train, Y_train, cv=5)
```

```
print('Individual cross-validation accuracies: ' + str(cross_vals))
print('Mean cross validation accuracy: ' + str(cross_vals.mean()))
```

```
Individual cross-validation accuracies: [0.94365008 0.94129713 0.94449472
0.94533937 0.94292609]
Mean cross validation accuracy: 0.9435414781297133
```

2.2.5 5. Train Tree on Training Data and Report Prediction Accuracy on Test Data

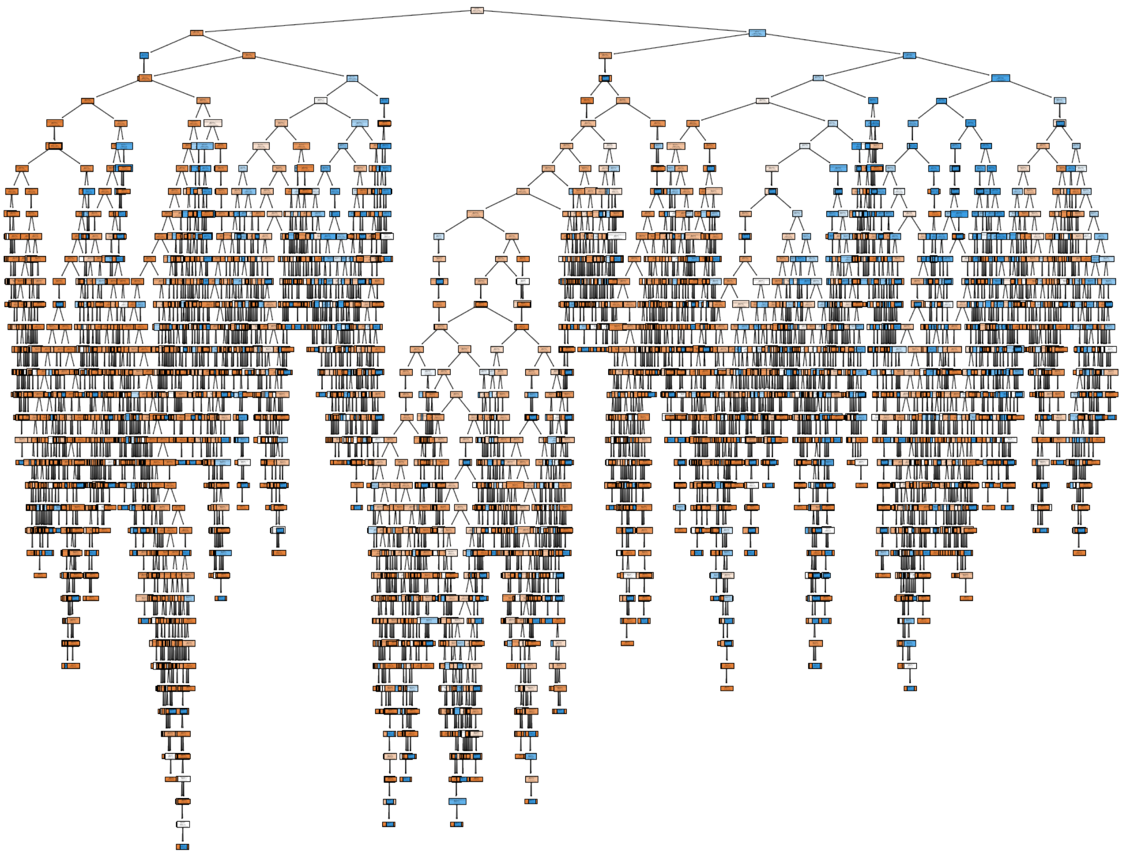
[32]:

```
model.fit(X_train, Y_train)

print('Accuracy of decision tree model on training set: {:.2f}'.format(model.
 ↪score(X_train, Y_train)))

print('Accuracy of decision tree model on test set: {:.2f}'.format(model.
 ↪score(X_test, Y_test)))
```

```
Accuracy of decision tree model on training set: 1.00
Accuracy of decision tree model on test set: 0.95
```

[33]:

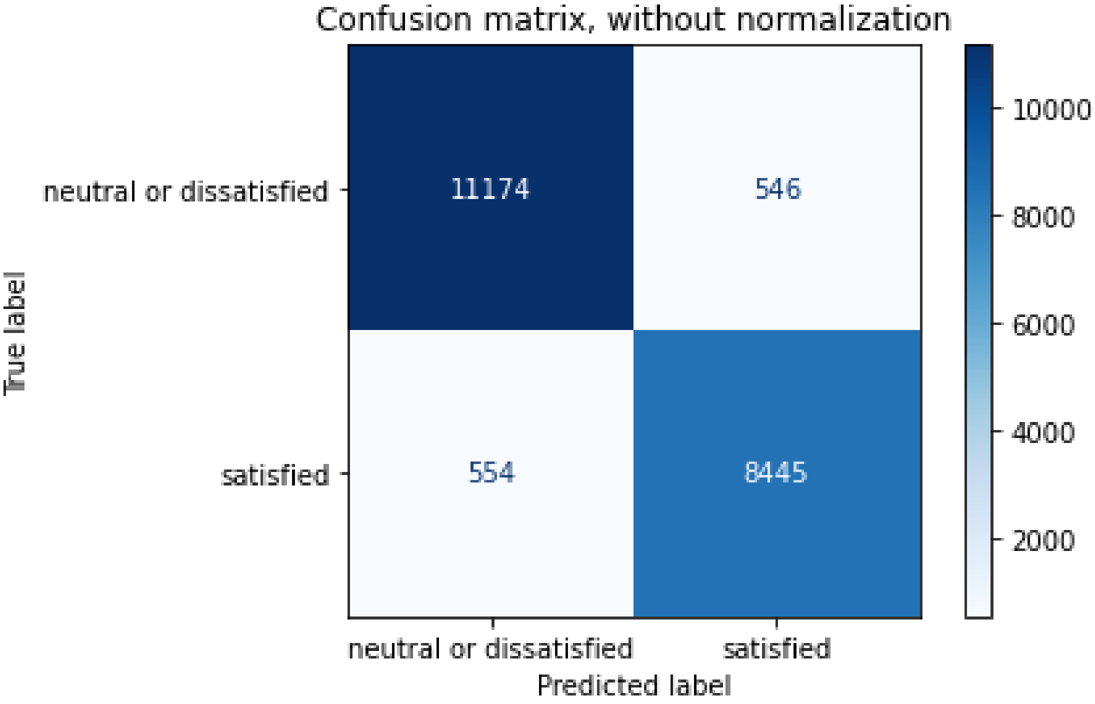
```
# Plotting tree
fig = plt.figure(figsize=(25,20))
_ = tree.plot_tree(model, feature_names=new_columns, class_names=class_names,␣
 ↪filled=True)
```

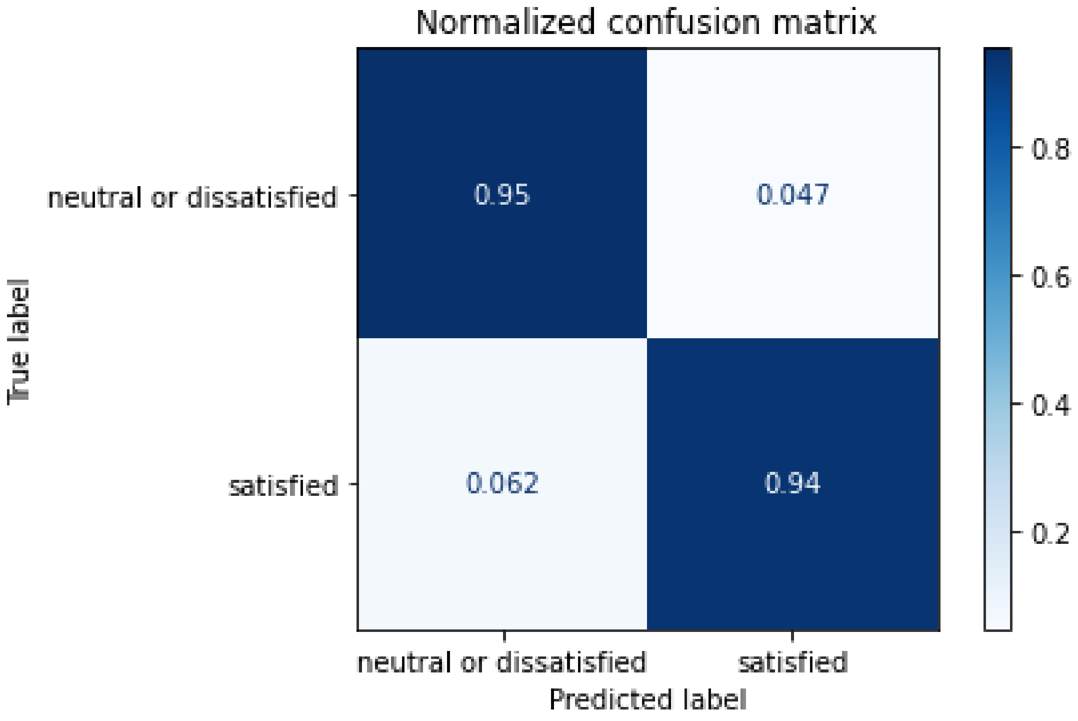


2.2.6 6. Plot confusion matrices

[34]:
```
# this code is adopted from this example:
# https://scikit-learn.org/stable/auto_examples/model_selection/
↪plot_confusion_matrix.html

np.set_printoptions(precision=2)
titles_options = [("Confusion matrix, without normalization", None),
                  ("Normalized confusion matrix", 'true')]
for title, normalize in titles_options:
    disp = plot_confusion_matrix(model, X_test, Y_test,
                                 display_labels=class_names,
                                 cmap=plt.cm.Blues,
                                 normalize=normalize)
    disp.ax_.set_title(title)

    print(title)
    print(disp.confusion_matrix)

plt.show()
```

```
Confusion matrix, without normalization
[[11174   546]
 [  554  8445]]
Normalized confusion matrix
[[0.95 0.05]
 [0.06 0.94]]
```





Normalized confusion matrix
True label
neutral or dissatisfied
satisfied
0.95
0.047
0.062
0.94
neutral or dissatisfied
satisfied
Predicted label
0.8
0.6
0.4
0.2