ImplementMLProjectPlan

August 12, 2023

1 Lab 8: Implement Your Machine Learning Project Plan

In this lab assignment, you will implement the machine learning project plan you created in the written assignment. You will:

1. Load your data set and save it to a Pandas DataFrame.
2. Perform exploratory data analysis on your data to determine which feature engineering and data preparation techniques you will use.
3. Prepare your data for your model and create features and a label.
4. Fit your model to the training data and evaluate your model.
5. Improve your model by performing model selection and/or feature selection techniques to find best model for your problem.

1.0.1 Import Packages

Before you get started, import a few packages.

[1]:
```
import pandas as pd
import numpy as np
import os
import matplotlib.pyplot as plt
import seaborn as sns
```

Task: In the code cell below, import additional packages that you have used in this course that you will need for this task.

[25]:
```
from sklearn.preprocessing import OneHotEncoder
from sklearn.model_selection import train_test_split, cross_val_score
from sklearn.ensemble import RandomForestRegressor, GradientBoostingRegressor,
 ↪StackingRegressor
from sklearn.tree import DecisionTreeRegressor
from sklearn.linear_model import LinearRegression
from sklearn.metrics import mean_squared_error, r2_score
```

1.1 Part 1: Load the Data Set

You have chosen to work with one of four data sets. The data sets are located in a folder named "data." The file names of the three data sets are as follows:

- The "adult" data set that contains Census information from 1994 is located in file `adultData.csv`
- The airbnb NYC "listings" data set is located in file `airbnbListingsData.csv`
- The World Happiness Report (WHR) data set is located in file `WHR2018Chapter2OnlineData.csv`
- The book review data set is located in file `bookReviewsData.csv`

Task: In the code cell below, use the same method you have been using to load your data using `pd.read_csv()` and save it to DataFrame `df`.

[3]:
```python
# YOUR CODE HERE
filename = os.path.join(os.getcwd(), 'data', 'airbnbListingsData.csv')
df = pd.read_csv(filename, low_memory=False, header=0)
df.head()
```

[3]:
```
                                                name  \
0                                 Skylit Midtown Castle
1  Whole flr w/private bdrm, bath & kitchen(pls r...
2           Spacious Brooklyn Duplex, Patio + Garden
3                   Large Furnished Room Near B'way
4                 Cozy Clean Guest Room - Family Apt

                                         description  \
0  Beautiful, spacious skylit studio in the heart...
1  Enjoy 500 s.f. top floor in 1899 brownstone, w...
2  We welcome you to stay in our lovely 2 br dupl...
3  Please dont expect the luxury here just a bas...
4  Our best guests are seeking a safe, clean, spa...

                              neighborhood_overview    host_name  \
0  Centrally located in the heart of Manhattan ju...     Jennifer
1  Just the right mix of urban center and local n...  LisaRoxanne
2                                               NaN      Rebecca
3    Theater district, many restaurants around here.     Shunichi
4  Our neighborhood is full of restaurants and ca...    MaryEllen

                      host_location  \
0  New York, New York, United States
1  New York, New York, United States
2  Brooklyn, New York, United States
3  New York, New York, United States
4  New York, New York, United States

                                          host_about  host_response_rate  \
0  A New Yorker since 2000! My passion is creatin...                0.80
1  Laid-back Native New Yorker (formerly bi-coast...                0.09
2  Rebecca is an artist/designer, and Henoch is i...                1.00
3  I used to work for a financial industry but no...                1.00
4  Welcome to family life with my oldest two away...                 NaN
```

```
   host_acceptance_rate  host_is_superhost  host_listings_count  ...  \
0                  0.17               True                  8.0  ...
1                  0.69               True                  1.0  ...
2                  0.25               True                  1.0  ...
3                  1.00               True                  1.0  ...
4                   NaN               True                  1.0  ...

   review_scores_communication  review_scores_location  review_scores_value  \
0                         4.79                    4.86                 4.41
1                         4.80                    4.71                 4.64
2                         5.00                    4.50                 5.00
3                         4.42                    4.87                 4.36
4                         4.95                    4.94                 4.92

  instant_bookable calculated_host_listings_count  \
0            False                              3
1            False                              1
2            False                              1
3            False                              1
4            False                              1

   calculated_host_listings_count_entire_homes  \
0                                            3
1                                            1
2                                            1
3                                            0
4                                            0

   calculated_host_listings_count_private_rooms  \
0                                             0
1                                             0
2                                             0
3                                             1
4                                             1

   calculated_host_listings_count_shared_rooms  reviews_per_month  \
0                                            0               0.33
1                                            0               4.86
2                                            0               0.02
3                                            0               3.68
4                                            0               0.87

  n_host_verifications
0                    9
1                    6
2                    3
```

```
3                       4
4                       7

[5 rows x 50 columns]
```

1.2 Part 2: Exploratory Data Analysis

The next step is to inspect and analyze your data set with your machine learning problem and project plan in mind.

This step will help you determine data preparation and feature engineering techniques you will need to apply to your data to build a balanced modeling data set for your problem and model. These data preparation techniques may include: * addressing missingness, such as replacing missing values with means * renaming features and labels * finding and replacing outliers * performing winsorization if needed * performing one-hot encoding on categorical features * performing vectorization for an NLP problem * addressing class imbalance in your data sample to promote fair AI

Think of the different techniques you have used to inspect and analyze your data in this course. These include using Pandas to apply data filters, using the Pandas `describe()` method to get insight into key statistics for each column, using the Pandas `dtypes` property to inspect the data type of each column, and using Matplotlib and Seaborn to detect outliers and visualize relationships between features and labels. If you are working on a classification problem, use techniques you have learned to determine if there is class imbalance.

Task: Use the techniques you have learned in this course to inspect and analyze your data.

Note: You can add code cells if needed by going to the Insert menu and clicking on Insert Cell Below in the drop-drown menu.

[4]:
```
df.shape
```

[4]:
```
(28022, 50)
```

[5]:
```
df.columns
```

[5]:
```
Index(['name', 'description', 'neighborhood_overview', 'host_name',
       'host_location', 'host_about', 'host_response_rate',
       'host_acceptance_rate', 'host_is_superhost', 'host_listings_count',
       'host_total_listings_count', 'host_has_profile_pic',
       'host_identity_verified', 'neighbourhood_group_cleansed', 'room_type',
       'accommodates', 'bathrooms', 'bedrooms', 'beds', 'amenities', 'price',
       'minimum_nights', 'maximum_nights', 'minimum_minimum_nights',
       'maximum_minimum_nights', 'minimum_maximum_nights',
       'maximum_maximum_nights', 'minimum_nights_avg_ntm',
       'maximum_nights_avg_ntm', 'has_availability', 'availability_30',
       'availability_60', 'availability_90', 'availability_365',
       'number_of_reviews', 'number_of_reviews_ltm', 'number_of_reviews_l30d',
       'review_scores_rating', 'review_scores_cleanliness',
       'review_scores_checkin', 'review_scores_communication',
       'review_scores_location', 'review_scores_value', 'instant_bookable',
       'calculated_host_listings_count',
       'calculated_host_listings_count_entire_homes',
```

```
       'calculated_host_listings_count_private_rooms',
       'calculated_host_listings_count_shared_rooms', 'reviews_per_month',
       'n_host_verifications'],
      dtype='object')
```

[6]:
```
df['review_scores_rating'].head(10)
```

[6]:
```
0    4.70
1    4.45
2    5.00
3    4.21
4    4.91
5    4.70
6    4.56
7    4.88
8    4.86
9    4.87
Name: review_scores_rating, dtype: float64
```

[7]:
```
df.dtypes
```

[7]:
```
name                                             object
description                                      object
neighborhood_overview                            object
host_name                                        object
host_location                                    object
host_about                                       object
host_response_rate                              float64
host_acceptance_rate                            float64
host_is_superhost                                  bool
host_listings_count                             float64
host_total_listings_count                       float64
host_has_profile_pic                               bool
host_identity_verified                             bool
neighbourhood_group_cleansed                     object
room_type                                        object
accommodates                                      int64
bathrooms                                       float64
bedrooms                                        float64
beds                                            float64
amenities                                        object
price                                           float64
minimum_nights                                    int64
maximum_nights                                    int64
minimum_minimum_nights                          float64
maximum_minimum_nights                          float64
minimum_maximum_nights                          float64
maximum_maximum_nights                          float64
minimum_nights_avg_ntm                          float64
```

```
maximum_nights_avg_ntm                          float64
has_availability                                   bool
availability_30                                   int64
availability_60                                   int64
availability_90                                   int64
availability_365                                  int64
number_of_reviews                                 int64
number_of_reviews_ltm                             int64
number_of_reviews_l30d                            int64
review_scores_rating                            float64
review_scores_cleanliness                       float64
review_scores_checkin                           float64
review_scores_communication                     float64
review_scores_location                          float64
review_scores_value                             float64
instant_bookable                                   bool
calculated_host_listings_count                    int64
calculated_host_listings_count_entire_homes       int64
calculated_host_listings_count_private_rooms      int64
calculated_host_listings_count_shared_rooms       int64
reviews_per_month                               float64
n_host_verifications                              int64
dtype: object
```

[8]:
```
# dropping columns with unstructured text, and feature leakage (review_scores_)
dropped_colnames = list(['description', 'name', 'neighborhood_overview',␣
↪'host_about', 'host_name',
                         'host_location', 'amenities',␣
↪'review_scores_cleanliness',
                         'review_scores_checkin', 'review_scores_communication',
                         'review_scores_location', 'review_scores_value'])
# , 'review_scores_cleanliness', 'review_scores_checkin',␣
↪'review_scores_communication', 'review_scores_location',␣
↪'review_scores_value'
dropped_colnames
```

[8]:
```
['description',
 'name',
 'neighborhood_overview',
 'host_about',
 'host_name',
 'host_location',
 'amenities',
 'review_scores_cleanliness',
 'review_scores_checkin',
 'review_scores_communication',
 'review_scores_location',
 'review_scores_value']
```

[9]:
```
df = df.drop(dropped_colnames, axis=1)
```

[10]:
```
df.head()
```

[10]:
```
   host_response_rate  host_acceptance_rate  host_is_superhost  \
0                0.80                  0.17               True
1                0.09                  0.69               True
2                1.00                  0.25               True
3                1.00                  1.00               True
4                 NaN                   NaN               True

   host_listings_count  host_total_listings_count  host_has_profile_pic  \
0                  8.0                        8.0                  True
1                  1.0                        1.0                  True
2                  1.0                        1.0                  True
3                  1.0                        1.0                  True
4                  1.0                        1.0                  True

   host_identity_verified neighbourhood_group_cleansed        room_type  \
0                    True                    Manhattan  Entire home/apt
1                    True                     Brooklyn  Entire home/apt
2                    True                     Brooklyn  Entire home/apt
3                    True                    Manhattan     Private room
4                    True                    Manhattan     Private room

   accommodates  ...  number_of_reviews_ltm  number_of_reviews_l30d  \
0             1  ...                      0                       0
1             3  ...                     32                       0
2             4  ...                      1                       0
3             2  ...                     33                       2
4             1  ...                      0                       0

   review_scores_rating  instant_bookable  calculated_host_listings_count  \
0                  4.70             False                               3
1                  4.45             False                               1
2                  5.00             False                               1
3                  4.21             False                               1
4                  4.91             False                               1

   calculated_host_listings_count_entire_homes  \
0                                            3
1                                            1
2                                            1
3                                            0
4                                            0

   calculated_host_listings_count_private_rooms  \
0                                             0
```

```
1                                              0
2                                              0
3                                              1
4                                              1

   calculated_host_listings_count_shared_rooms  reviews_per_month  \
0                                            0               0.33
1                                            0               4.86
2                                            0               0.02
3                                            0               3.68
4                                            0               0.87

   n_host_verifications
0                     9
1                     6
2                     3
3                     4
4                     7

[5 rows x 38 columns]
```

[11]:
```
# One-Hot Encoding categorical values
to_encode = list(df.select_dtypes(include=['object']).columns)
df[to_encode].nunique()
```

[11]:
```
neighbourhood_group_cleansed    5
room_type                       4
dtype: int64
```

[12]:
```
# creating and applying the encoder
encoder = OneHotEncoder(handle_unknown='error', sparse=False)
df_enc = pd.DataFrame(encoder.fit_transform(df[to_encode]))

# reinstating original column names
df_enc.columns = encoder.get_feature_names(to_encode)

df_enc.head()
```

[12]:
```
   neighbourhood_group_cleansed_Bronx  neighbourhood_group_cleansed_Brooklyn  \
0                                 0.0                                    0.0
1                                 0.0                                    1.0
2                                 0.0                                    1.0
3                                 0.0                                    0.0
4                                 0.0                                    0.0

   neighbourhood_group_cleansed_Manhattan  \
0                                     1.0
1                                     0.0
2                                     0.0
```

```
3                                1.0
4                                1.0

   neighbourhood_group_cleansed_Queens  \
0                                  0.0
1                                  0.0
2                                  0.0
3                                  0.0
4                                  0.0

   neighbourhood_group_cleansed_Staten Island  room_type_Entire home/apt  \
0                                         0.0                        1.0
1                                         0.0                        1.0
2                                         0.0                        1.0
3                                         0.0                        0.0
4                                         0.0                        0.0

   room_type_Hotel room  room_type_Private room  room_type_Shared room
0                   0.0                     0.0                    0.0
1                   0.0                     0.0                    0.0
2                   0.0                     0.0                    0.0
3                   0.0                     1.0                    0.0
4                   0.0                     1.0                    0.0
```

[13]:
```
# dropping original columns we transformed from DataFrame 'df'
df.drop(columns=to_encode, axis=1, inplace=True)
df.head()
```

[13]:
```
   host_response_rate  host_acceptance_rate  host_is_superhost  \
0                0.80                  0.17               True
1                0.09                  0.69               True
2                1.00                  0.25               True
3                1.00                  1.00               True
4                 NaN                   NaN               True

   host_listings_count  host_total_listings_count  host_has_profile_pic  \
0                  8.0                        8.0                  True
1                  1.0                        1.0                  True
2                  1.0                        1.0                  True
3                  1.0                        1.0                  True
4                  1.0                        1.0                  True

   host_identity_verified  accommodates  bathrooms  bedrooms  ...  \
0                    True             1        1.0       NaN  ...
1                    True             3        1.0       1.0  ...
2                    True             4        1.5       2.0  ...
3                    True             2        1.0       1.0  ...
4                    True             1        1.0       1.0  ...
```

```
   number_of_reviews_ltm  number_of_reviews_l30d  review_scores_rating  \
0                      0                       0                  4.70
1                     32                       0                  4.45
2                      1                       0                  5.00
3                     33                       2                  4.21
4                      0                       0                  4.91

   instant_bookable  calculated_host_listings_count  \
0             False                               3
1             False                               1
2             False                               1
3             False                               1
4             False                               1

   calculated_host_listings_count_entire_homes  \
0                                            3
1                                            1
2                                            1
3                                            0
4                                            0

   calculated_host_listings_count_private_rooms  \
0                                             0
1                                             0
2                                             0
3                                             1
4                                             1

   calculated_host_listings_count_shared_rooms  reviews_per_month  \
0                                            0               0.33
1                                            0               4.86
2                                            0               0.02
3                                            0               3.68
4                                            0               0.87

   n_host_verifications
0                     9
1                     6
2                     3
3                     4
4                     7

[5 rows x 36 columns]
```

[14]:
```
# joining categorical features in df_enc with df
df = df.join(df_enc)
```

```
df.columns
```

[14]:
```
Index(['host_response_rate', 'host_acceptance_rate', 'host_is_superhost',
       'host_listings_count', 'host_total_listings_count',
       'host_has_profile_pic', 'host_identity_verified', 'accommodates',
       'bathrooms', 'bedrooms', 'beds', 'price', 'minimum_nights',
       'maximum_nights', 'minimum_minimum_nights', 'maximum_minimum_nights',
       'minimum_maximum_nights', 'maximum_maximum_nights',
       'minimum_nights_avg_ntm', 'maximum_nights_avg_ntm', 'has_availability',
       'availability_30', 'availability_60', 'availability_90',
       'availability_365', 'number_of_reviews', 'number_of_reviews_ltm',
       'number_of_reviews_l30d', 'review_scores_rating', 'instant_bookable',
       'calculated_host_listings_count',
       'calculated_host_listings_count_entire_homes',
       'calculated_host_listings_count_private_rooms',
       'calculated_host_listings_count_shared_rooms', 'reviews_per_month',
       'n_host_verifications', 'neighbourhood_group_cleansed_Bronx',
       'neighbourhood_group_cleansed_Brooklyn',
       'neighbourhood_group_cleansed_Manhattan',
       'neighbourhood_group_cleansed_Queens',
       'neighbourhood_group_cleansed_Staten Island',
       'room_type_Entire home/apt', 'room_type_Hotel room',
       'room_type_Private room', 'room_type_Shared room'],
      dtype='object')
```

[15]:
```
# identifying missingness
nan_count = np.sum(df.isnull(), axis=0)
nan_count
```

[15]:
```
host_response_rate                            11843
host_acceptance_rate                          11113
host_is_superhost                                 0
host_listings_count                               0
host_total_listings_count                         0
host_has_profile_pic                              0
host_identity_verified                            0
accommodates                                      0
bathrooms                                         0
bedrooms                                       2918
beds                                           1354
price                                             0
minimum_nights                                    0
maximum_nights                                    0
minimum_minimum_nights                            0
maximum_minimum_nights                            0
minimum_maximum_nights                            0
maximum_maximum_nights                            0
minimum_nights_avg_ntm                            0
```

```
maximum_nights_avg_ntm                              0
has_availability                                    0
availability_30                                     0
availability_60                                     0
availability_90                                     0
availability_365                                    0
number_of_reviews                                   0
number_of_reviews_ltm                               0
number_of_reviews_l30d                              0
review_scores_rating                                0
instant_bookable                                    0
calculated_host_listings_count                      0
calculated_host_listings_count_entire_homes         0
calculated_host_listings_count_private_rooms        0
calculated_host_listings_count_shared_rooms         0
reviews_per_month                                   0
n_host_verifications                                0
neighbourhood_group_cleansed_Bronx                  0
neighbourhood_group_cleansed_Brooklyn               0
neighbourhood_group_cleansed_Manhattan              0
neighbourhood_group_cleansed_Queens                 0
neighbourhood_group_cleansed_Staten Island          0
room_type_Entire home/apt                           0
room_type_Hotel room                                0
room_type_Private room                              0
room_type_Shared room                               0
dtype: int64
```

[16]:
```
# series of T/F values indicating whether missing values is not 0
nan_detected = nan_count > 0

# series of T/F values indicating whether type of column is int64 or float64
is_int_or_float = df.dtypes != 'object'

# combining binary series values into 'to_impute'
to_impute = nan_detected & is_int_or_float

df.columns[to_impute]
```

[16]:
```
Index(['host_response_rate', 'host_acceptance_rate', 'bedrooms', 'beds'],
dtype='object')
```

[17]:
```
to_impute_selected = ['host_response_rate', 'host_acceptance_rate', 'bedrooms',␣
 ↪'beds']

# creating dummy variables in new series of T/F values indicating missingness␣
 ↪of values
for colname in to_impute_selected:
```

```
    df[colname + '_na'] = df[colname].isnull()

df.head()
```

[17]:

```
   host_response_rate  host_acceptance_rate  host_is_superhost  \
0                0.80                  0.17               True
1                0.09                  0.69               True
2                1.00                  0.25               True
3                1.00                  1.00               True
4                 NaN                   NaN               True

   host_listings_count  host_total_listings_count  host_has_profile_pic  \
0                  8.0                        8.0                  True
1                  1.0                        1.0                  True
2                  1.0                        1.0                  True
3                  1.0                        1.0                  True
4                  1.0                        1.0                  True

   host_identity_verified  accommodates  bathrooms  bedrooms  ...  \
0                    True             1        1.0       NaN  ...
1                    True             3        1.0       1.0  ...
2                    True             4        1.5       2.0  ...
3                    True             2        1.0       1.0  ...
4                    True             1        1.0       1.0  ...

   neighbourhood_group_cleansed_Queens  \
0                                  0.0
1                                  0.0
2                                  0.0
3                                  0.0
4                                  0.0

   neighbourhood_group_cleansed_Staten Island  room_type_Entire home/apt  \
0                                         0.0                        1.0
1                                         0.0                        1.0
2                                         0.0                        1.0
3                                         0.0                        0.0
4                                         0.0                        0.0

   room_type_Hotel room  room_type_Private room  room_type_Shared room  \
0                   0.0                     0.0                    0.0
1                   0.0                     0.0                    0.0
2                   0.0                     0.0                    0.0
3                   0.0                     1.0                    0.0
4                   0.0                     1.0                    0.0

   host_response_rate_na  host_acceptance_rate_na  bedrooms_na  beds_na
```

```
0                  False                     False        True    False
1                  False                     False       False    False
2                  False                     False       False    False
3                  False                     False       False    False
4                   True                      True       False    False

[5 rows x 49 columns]
```

[18]:
```
# replacing missing values with mean values of columns
for colname in to_impute_selected:
    df[colname].fillna(value=df[colname].mean(), inplace=True)

for colname in to_impute_selected:
    print('{} missing values count: {}'.format(colname, np.sum(df[colname].
 ↪isnull(), axis=0)))
```

```
host_response_rate missing values count: 0
host_acceptance_rate missing values count: 0
bedrooms missing values count: 0
beds missing values count: 0
```

[19]:
```
# identifying features with the highest correlation with the label
corrs = df.corr()['review_scores_rating']
corrs
```

[19]:
```
host_response_rate                               0.092494
host_acceptance_rate                             0.009669
host_is_superhost                                     NaN
host_listings_count                             -0.033200
host_total_listings_count                       -0.033200
host_has_profile_pic                                  NaN
host_identity_verified                                NaN
accommodates                                     0.007798
bathrooms                                       -0.002080
bedrooms                                         0.010882
beds                                             0.000223
price                                            0.045067
minimum_nights                                  -0.034514
maximum_nights                                  -0.012175
minimum_minimum_nights                          -0.042011
maximum_minimum_nights                          -0.032373
minimum_maximum_nights                          -0.005249
maximum_maximum_nights                          -0.015691
minimum_nights_avg_ntm                          -0.032653
maximum_nights_avg_ntm                          -0.009140
has_availability                                 0.030396
availability_30                                 -0.130953
availability_60                                 -0.108681
```

```
availability_90                                  -0.092216
availability_365                                 -0.080430
number_of_reviews                                 0.067182
number_of_reviews_ltm                             0.045595
number_of_reviews_l30d                            0.067435
review_scores_rating                              1.000000
instant_bookable                                 -0.058469
calculated_host_listings_count                   -0.066378
calculated_host_listings_count_entire_homes      -0.006858
calculated_host_listings_count_private_rooms     -0.107384
calculated_host_listings_count_shared_rooms      -0.029324
reviews_per_month                                 0.039317
n_host_verifications                              0.050888
neighbourhood_group_cleansed_Bronx               -0.005404
neighbourhood_group_cleansed_Brooklyn             0.051198
neighbourhood_group_cleansed_Manhattan           -0.035686
neighbourhood_group_cleansed_Queens              -0.022995
neighbourhood_group_cleansed_Staten Island        0.014503
room_type_Entire home/apt                         0.096000
room_type_Hotel room                             -0.025586
room_type_Private room                           -0.088418
room_type_Shared room                            -0.019015
host_response_rate_na                             0.010937
host_acceptance_rate_na                          -0.003364
bedrooms_na                                      -0.019238
beds_na                                          -0.032018
Name: review_scores_rating, dtype: float64
```

[20]:
```python
# sorting corrs in descending order
corrs_sorted = corrs.sort_values(axis=0, ascending=False)
corrs_sorted
```

[20]:
```
review_scores_rating                              1.000000
room_type_Entire home/apt                         0.096000
host_response_rate                                0.092494
number_of_reviews_l30d                            0.067435
number_of_reviews                                 0.067182
neighbourhood_group_cleansed_Brooklyn             0.051198
n_host_verifications                              0.050888
number_of_reviews_ltm                             0.045595
price                                             0.045067
reviews_per_month                                 0.039317
has_availability                                  0.030396
neighbourhood_group_cleansed_Staten Island        0.014503
host_response_rate_na                             0.010937
bedrooms                                          0.010882
host_acceptance_rate                              0.009669
accommodates                                      0.007798
```

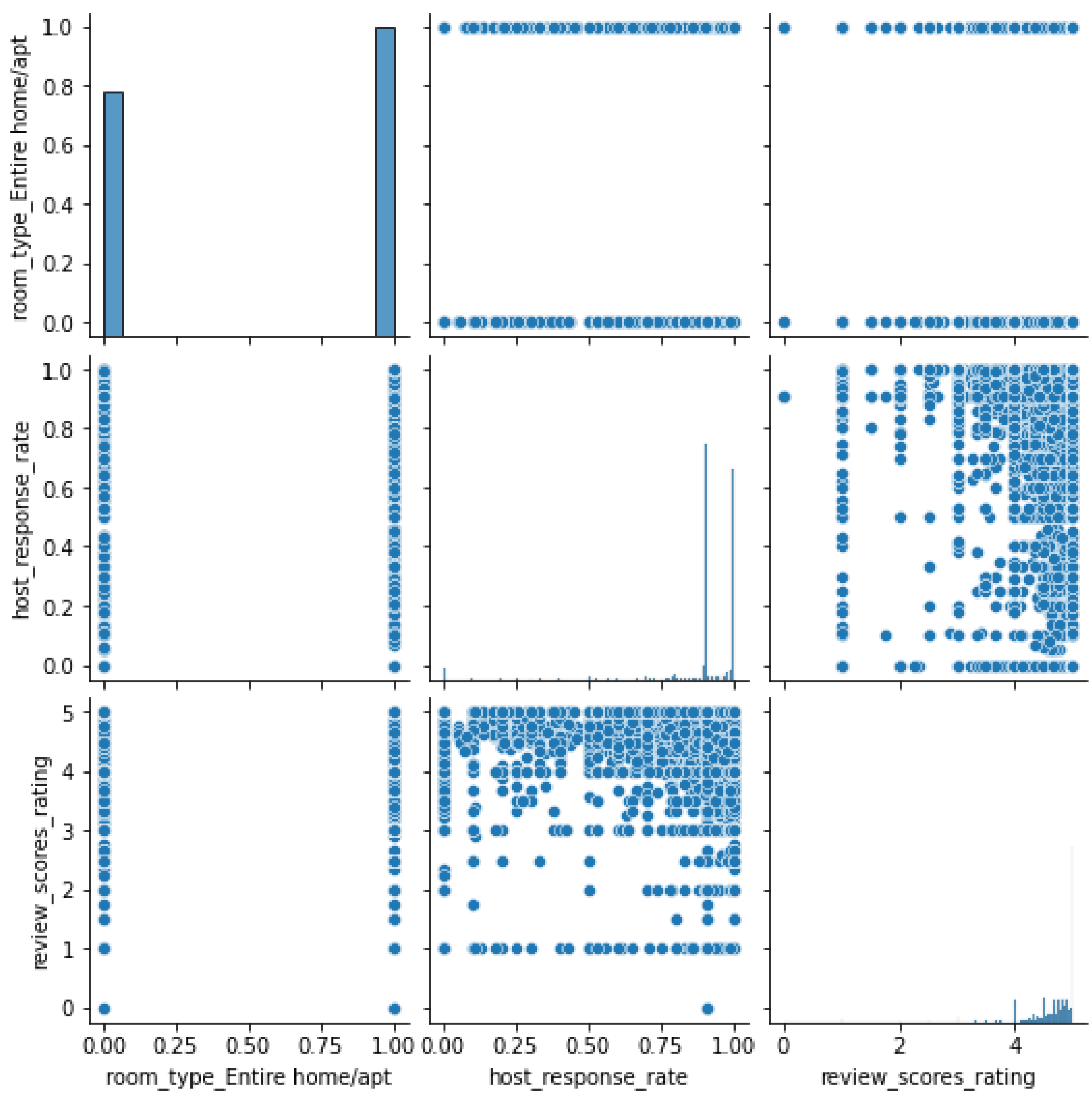
```
beds                                            0.000223
bathrooms                                      -0.002080
host_acceptance_rate_na                        -0.003364
minimum_maximum_nights                         -0.005249
neighbourhood_group_cleansed_Bronx             -0.005404
calculated_host_listings_count_entire_homes    -0.006858
maximum_nights_avg_ntm                         -0.009140
maximum_nights                                 -0.012175
maximum_maximum_nights                         -0.015691
room_type_Shared room                          -0.019015
bedrooms_na                                    -0.019238
neighbourhood_group_cleansed_Queens            -0.022995
room_type_Hotel room                           -0.025586
calculated_host_listings_count_shared_rooms    -0.029324
beds_na                                        -0.032018
maximum_minimum_nights                         -0.032373
minimum_nights_avg_ntm                         -0.032653
host_total_listings_count                      -0.033200
host_listings_count                            -0.033200
minimum_nights                                 -0.034514
neighbourhood_group_cleansed_Manhattan         -0.035686
minimum_minimum_nights                         -0.042011
instant_bookable                               -0.058469
calculated_host_listings_count                 -0.066378
availability_365                               -0.080430
room_type_Private room                         -0.088418
availability_90                                -0.092216
calculated_host_listings_count_private_rooms   -0.107384
availability_60                                -0.108681
availability_30                                -0.130953
host_is_superhost                                    NaN
host_has_profile_pic                                 NaN
host_identity_verified                               NaN
Name: review_scores_rating, dtype: float64
```

[21]:
```
# saving the relevant correlation values to analyze relationships between the␣
↪features in plots
corrs_list = list(corrs_sorted.index[1:3])
corrs_list
```

[21]:
```
['room_type_Entire home/apt', 'host_response_rate']
```

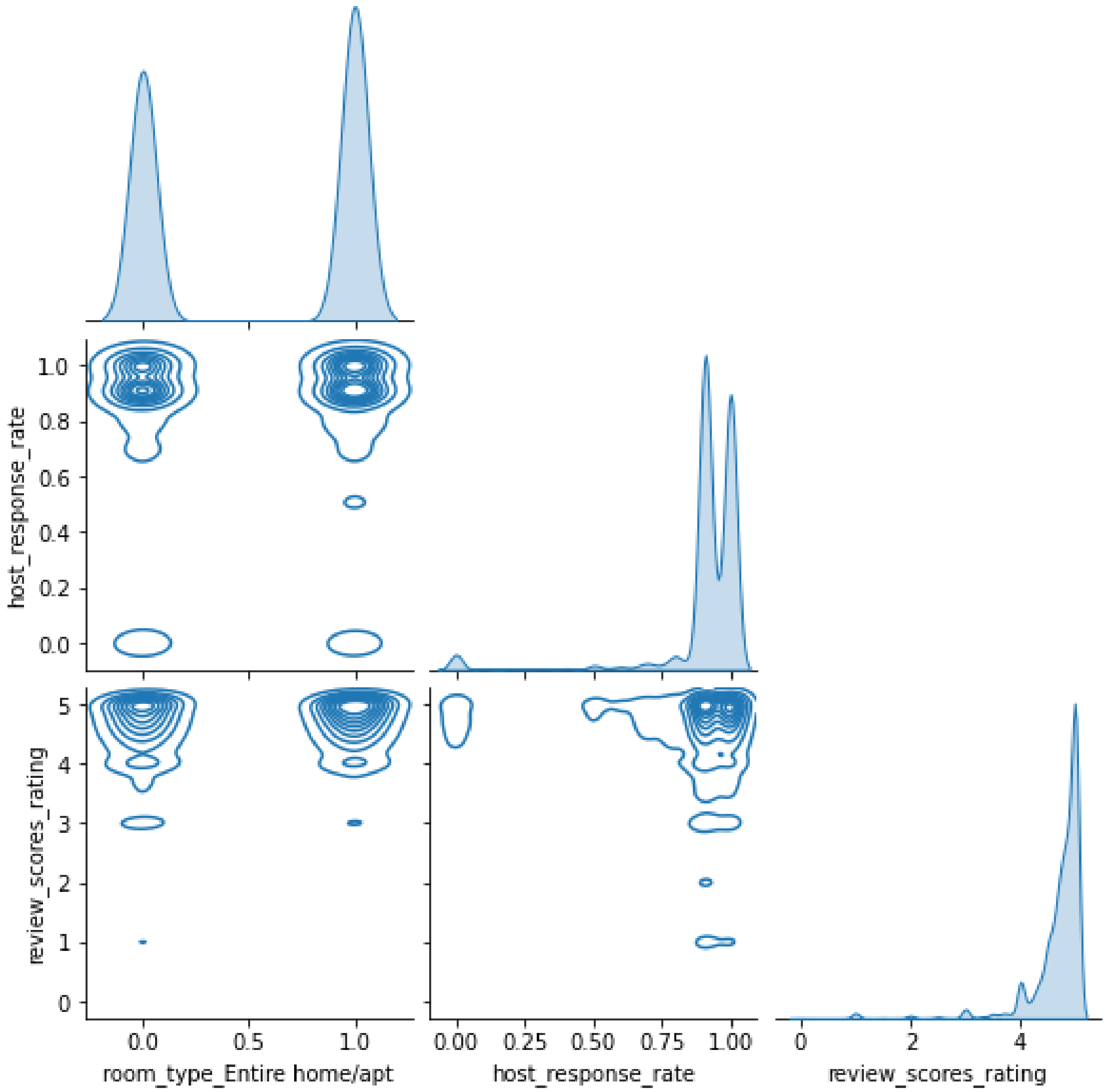
[22]:
```
# producing bivariate plots for label and its top correlates
corrs_list.append('review_scores_rating')

df_sub = df[corrs_list]

sns.pairplot(data=df_sub)
```

[22]: <seaborn.axisgrid.PairGrid at 0x7f529492f128>



[23]:
```
# pairplot specifying kernel density estimator for interpretability of data
sns.pairplot(data=df_sub, kind='kde', corner=True)
```

[23]: <seaborn.axisgrid.PairGrid at 0x7f521261ae80>



1.3 Part 3: Implement Your Project Plan

Task: Use the rest of this notebook to carry out your project plan. You will:

1. Prepare your data for your model and create features and a label.
2. Fit your model to the training data and evaluate your model.
3. Improve your model by performing model selection and/or feature selection techniques to find best model for your problem.

Add code cells below and populate the notebook with commentary, code, analyses, results, and figures as you see fit.

[26]:
```
# creating labeled examples from DataFrame 'df'
y = df['review_scores_rating']
```

```
X = df.drop(columns='review_scores_rating', axis=1)
```

[28]:
```
# splitting labeled examples into training and test sets
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.30,␣
↪random_state=1234)
```

[29]:
```
# specifying four models in a list of tuples

# running a GridSearch cross validation to find the optimal hyperparameters
# is computationally costly, so I specified a normal value for the␣
↪hyperparameters

estimators = [('DT', DecisionTreeRegressor(max_depth=8)),
              ('RF', RandomForestRegressor()),
              ('GBDT', GradientBoostingRegressor(n_estimators=100)),
              ('LR', LinearRegression())
             ]
```

[30]:
```
stacking_model = StackingRegressor(estimators=estimators, cv=5,␣
↪passthrough=False)
```

[31]:
```
# Obtaining 3-fold cross-validation RMSE scores from cross_val_score()
print('Start')

score = cross_val_score(stacking_model, X_train, y_train,␣
↪scoring='neg_root_mean_squared_error')
rmse_avg = np.mean(-1 * score)

print('End')
print('average score: {}'.format(rmse_avg))
```

```
Start
End
average score: 0.47517026790431816
```

[33]:
```
# Stacking
# fitting stacking_model to the training data
stacking_model.fit(X_train, y_train)

# using predict() to test use fitted model to make predictions on the test data
stacking_pred = stacking_model.predict(X_test)

# compute the Root Mean Squared Error using mean_squared_error()
rmse = mean_squared_error(y_test, stacking_pred, squared=False)

# compute the R-squared score using r2_score()
r2 = r2_score(y_test, stacking_pred)

print('[Stacking] Root Mean Squared Error: {0}'.format(rmse))
```

```python
print('[Stacking] R2: {0}'.format(r2))
```

```
[Stacking] Root Mean Squared Error: 0.46313757716339593
[Stacking] R2: 0.1404644625213508
```

[34]:

```python
# Linear Regression
lr_model = LinearRegression()
lr_model.fit(X_train, y_train)
y_lr_pred = lr_model.predict(X_test)
lr_rmse = mean_squared_error(y_test, y_lr_pred, squared=False)
lr_r2 = r2_score(y_test, y_lr_pred)

print('[LR] Root Mean Squared Error: {0}'.format(lr_rmse))
print('[LR] R2: {0}'.format(lr_r2))
```

```
[LR] Root Mean Squared Error: 0.48344439541818285
[LR] R2: 0.06343729826935596
```

[35]:

```python
# Decision Tree
dt_model = DecisionTreeRegressor(max_depth=8, min_samples_leaf=50)
dt_model.fit(X_train, y_train)
y_dt_pred = dt_model.predict(X_test)
dt_rmse = mean_squared_error(y_test, y_dt_pred, squared=False)
dt_r2 = r2_score(y_test, y_dt_pred)

print('[DT] Root Mean Squared Error: {0}'.format(dt_rmse))
print('[DT] R2: {0}'.format(dt_r2))
```

```
[DT] Root Mean Squared Error: 0.48249391154124927
[DT] R2: 0.06711636734932946
```

[36]:

```python
# Gradient Boosted Decision Tree
gbdt_model = GradientBoostingRegressor(max_depth=2, n_estimators=300)
gbdt_model.fit(X_train, y_train)
y_gbdt_pred = gbdt_model.predict(X_test)
gbdt_rmse = mean_squared_error(y_test, y_gbdt_pred, squared=False)
gbdt_r2 = r2_score(y_test, y_gbdt_pred)

print('[GBDT] Root Mean Squared Error: {0}'.format(gbdt_rmse))
print('[GBDT] R2: {0}'.format(gbdt_r2))
```

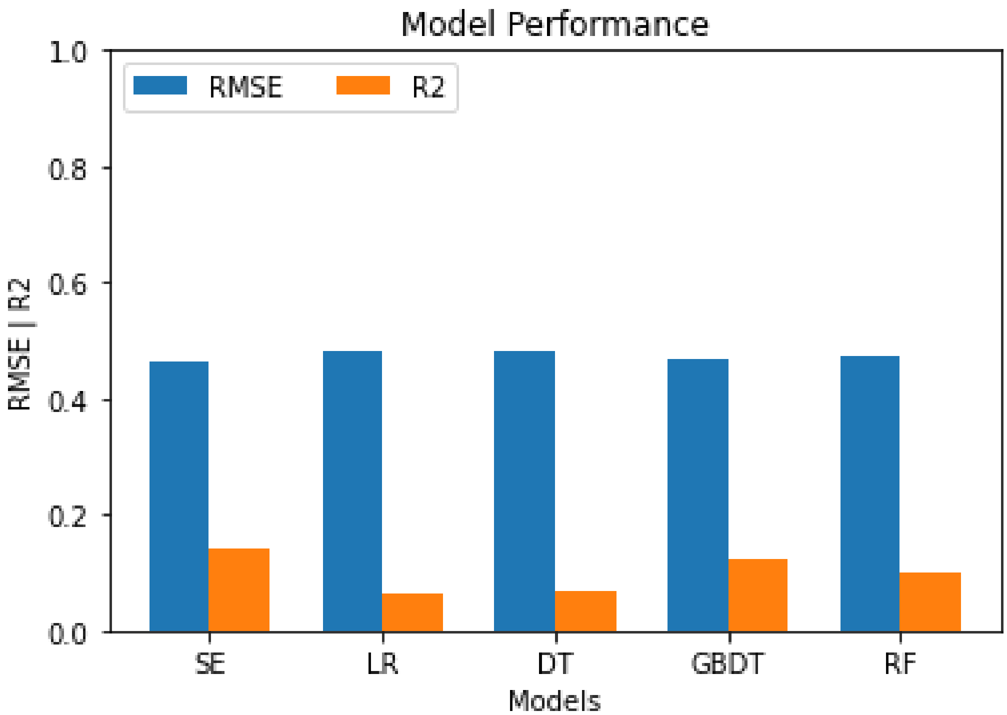
```
[GBDT] Root Mean Squared Error: 0.46721943674764427
[GBDT] R2: 0.12524667571424242
```

[37]:
```
# Random Forest
rf_model = RandomForestRegressor(max_depth=32, n_estimators=300)
rf_model.fit(X_train, y_train)
y_rf_pred = rf_model.predict(X_test)
rf_rmse = mean_squared_error(y_test, y_rf_pred, squared=False)
rf_r2 = r2_score(y_test, y_rf_pred)

print('[RF] Root Mean Squared Error: {0}'.format(rf_rmse))
print('[RF] R2: {0}'.format(rf_r2))
```

```
[RF] Root Mean Squared Error: 0.47331414512804576
[RF] R2: 0.10227614466820589
```

[39]:
```
# Plotting the RMSE and R2 score for stacked ensemble model and each  regressor
rmse_results = [rmse, lr_rmse, dt_rmse, gbdt_rmse, rf_rmse]
r2_results = [r2, lr_r2, dt_r2, gbdt_r2, rf_r2]
labels = ['SE', 'LR', 'DT', 'GBDT', 'RF']

rg = np.arange(5)
width = 0.35

# creating bar plots with RMSE and R2 results
plt.bar(rg, rmse_results, width, label='RMSE')
plt.bar(rg + width, r2_results, width, label='R2')

# calling plt.xticks() to add labels under bars
plt.xticks(rg + width/2, labels)

plt.xlabel('Models')
plt.ylabel('RMSE | R2')

plt.ylim([0,1])
plt.title('Model Performance')
plt.legend(loc='upper left', ncol=2)
plt.show
```

[39]:
```
<function matplotlib.pyplot.show>
```



Analysis: Analyzing the model performance of our stacking model with the individual models, we can easily see that the none of the models performed well. The stacking ensemble seems to perform the best, with the lowest RMSE and highest R2 score. This makes sense because the higher the residual squared score is, the better fit the model is for the data. Overall, I think that model performance could be improved if I did not drop the features with high correlation to 'review_scores_rating', such as in the list ['review_scores_cleanliness', 'review_scores_checkin', 'review_scores_communication', 'review_scores_location', 'review_scores_value']. However, by analyzing the features in my dataset I figured that keeping these features would likely lead to feature leakage, which is not something we want when building and training an optimal model. I think that I could look into predicting other features rather than 'review_scores_rating' because there isn't a high correlation with the other features.