pvdambtn7

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1 SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

1.1 MLSR - Regression Model

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[ ]:

```

```

2 1. Data Pre-processing

Import the required libraries

[3]:

```
import pandas as pd
import numpy as np
import seaborn as sns
import matplotlib.pyplot as plt
from sklearn import preprocessing



from warnings import filterwarnings
filterwarnings('ignore')
```

Load the CSV file

[4]:

```
df_airline = pd.read_excel("airfare_CT3-1.xlsx")
df_airline.head(3)
```

[4]:

```
       Airline        Date Departure Station Arrival Station  \
0       IndiGo  24/03/2019          Banglore       New Delhi
1    Air India   1/05/2019           Kolkata        Banglore
2  Jet Airways   9/06/2019             Delhi          Cochin

                Route Map Departure Time  Arrival Time Journey Time     Stops  \
0               BLR → DEL          22:20  01:10 22 Mar       2h 50m  non-stop
1   CCU → IXR → BBI → BLR          05:50         13:15       7h 25m   2 stops
2   DEL → LKO → BOM → COK          09:25  04:25 10 Jun          19h   2 stops
```

```
  Extra Info  Price
0    No info   3897
1    No info   7662
2    No info  13882
```

[5]:
```
df_airline.shape
```

[5]:
```
(9000, 11)
```

[6]:
```
df_airline.keys()
```

[6]:
```
Index(['Airline', 'Date', 'Departure Station', 'Arrival Station', 'Route Map',
       'Departure Time', 'Arrival Time', 'Journey Time', 'Stops', 'Extra Info',
       'Price'],
      dtype='object')
```

[7]:
```
df_airline.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 9000 entries, 0 to 8999
Data columns (total 11 columns):
 #   Column             Non-Null Count  Dtype
---  ------             --------------  -----
 0   Airline            9000 non-null   object
 1   Date               9000 non-null   object
 2   Departure Station  9000 non-null   object
 3   Arrival Station    9000 non-null   object
 4   Route Map          9000 non-null   object
 5   Departure Time     9000 non-null   object
 6   Arrival Time       9000 non-null   object
 7   Journey Time       9000 non-null   object
 8   Stops              9000 non-null   object
 9   Extra Info         9000 non-null   object
 10  Price              9000 non-null   int64
dtypes: int64(1), object(10)
memory usage: 773.6+ KB
```

2.0.1 Prepare the data

[8]:
```
df_airline.describe()
```

[8]:
```
             Price
count  9000.000000
mean   9087.764333
std    4605.498942
min    1759.000000
25%    5228.000000
```

```
50%       8369.000000
75%      12373.000000
max      79512.000000
```

[9]:

```
df_airline.dtypes
```

[9]:

```
Airline              object
Date                 object
Departure Station    object
Arrival Station      object
Route Map            object
Departure Time       object
Arrival Time         object
Journey Time         object
Stops                object
Extra Info           object
Price                 int64
dtype: object
```

We can see from the above result that we have price as a numerical data with dtype int and the other data type as object.

[ ]:

```

```

Perform missing value analysis

[10]:

```
# sort the variables on the basis of total null values in the variable
# 'isnull().sum()' returns the number of missing values in each variable

missing_total = df_airline.isnull().sum()
print(missing_total)
```

```
Airline              0
Date                 0
Departure Station    0
Arrival Station      0
Route Map            0
Departure Time       0
Arrival Time         0
Journey Time         0
Stops                0
Extra Info           0
Price                0
dtype: int64
```

[ ]:

```

```

[ ]:

```

```

There are no missing values present in the given dataset

```
[ ]:
```

```
[11]: print(df_airline['Departure Station'].unique())
```

```
['Banglore' 'Kolkata' 'Delhi' 'Chennai' 'Mumbai']
```

2.0.2 Replacing the departure values as per the station code

```
[12]: df_airline['Departure Station'] = df_airline['Departure Station'].
       ↪replace({'Banglore':'BLR',
                                                                       ␣
       ↪'Delhi' : 'DEL',
                                                                       ␣
       ↪'Kolkata' : 'CCU',
                                                                       ␣
       ↪'Chennai' : 'MAA',
                                                                       ␣
       ↪'Mumbai' : 'BOM'})
      print(df_airline['Departure Station'].unique())
```

```
['BLR' 'CCU' 'DEL' 'MAA' 'BOM']
```

We have replaced the the departure station values as per the location code

2.1 Replacing arrival station values as per the location code

```
[13]: print(df_airline['Arrival Station'].unique())
```

```
['New Delhi' 'Banglore' 'Cochin' 'Kolkata' 'Delhi' 'Hyderabad']
```

```
[14]: df_airline['Arrival Station'] = df_airline['Arrival Station'].
       ↪replace({'Banglore':'BLR',
                                                                     'New␣
       ↪Delhi' : 'DEL',
                                                                     'Cochin'␣
       ↪: 'COK',
                                                                     ␣
       ↪'Hyderabad' : 'HYD',
                                                                       ␣
       ↪'Delhi' : 'DEL',
                                                                       ␣
       ↪'Kolkata' : 'CCU',
                                                                       ␣
       ↪'Chennai' : 'MAA',
                                                                           ␣
 ↪'Mumbai' : 'BOM'})
print(df_airline['Arrival Station'].unique())
```

```
['DEL' 'BLR' 'COK' 'CCU' 'HYD']
```

[ ]:

```

```

[ ]:

```

```

2.1.1 Cleaning Extra info variable

[15]:

```
print(df_airline['Extra Info'].unique())
```

```
['No info' 'In-flight meal not included' 'No check-in baggage included'
 '1 Short layover' 'No Info' '1 Long layover' 'Change airports'
 'Business class' 'Red-eye flight']
```

[16]:

```
# There are two no info's {No info & No Info}.... Clearing those as the first␣
 ↪step

df_airline['Extra Info'] = df_airline['Extra Info'].replace({"No info":"No␣
 ↪Info"})
```

[17]:

```
print(df_airline['Extra Info'].unique())
```

```
['No Info' 'In-flight meal not included' 'No check-in baggage included'
 '1 Short layover' '1 Long layover' 'Change airports' 'Business class'
 'Red-eye flight']
```

[18]:

```
df_airline.groupby('Extra Info') ['Extra Info'].count()
```

[18]:

```
Extra Info
1 Long layover                    17
1 Short layover                    1
Business class                     3
Change airports                    4
In-flight meal not included     1649
No Info                         7055
No check-in baggage included     270
Red-eye flight                     1
Name: Extra Info, dtype: int64
```

[19]:

```
## Assigning the categories using map function for the above categories shown␣
 ↪in the result

df_airline['Extra Info'] = df_airline['Extra Info'].map({
    'No Info':0,
    'In-flight meal not included':1,
    'No check-in baggage included':2,
    '1 Long layover': 3,
    'Change airports':4,
    'Business class':5,
    '1 Short layover':6,
    'Red-eye flight':7
})
```

[20]:
```
print(df_airline['Extra Info'].unique())
```

```
[0 1 2 6 3 4 5 7]
```

2.1.2 Cleaning Stops variabel

[21]:
```
print(df_airline['Stops'].unique())
```

```
['non-stop' '2 stops' '1 stop' '3 stops']
```

[22]:
```
df_airline['Stops'] = df_airline['Stops'].replace({'non-stop': 0,
                                                   '1 stop' : 1,
                                                   '2 stops': 2,
                                                  '3 stops':3})
```

[23]:
```
print(df_airline['Stops'].unique())
```

```
[0 2 1 3]
```

2.1.3 Creating Day, Month, year variable from Date variable

[24]:
```
df_airline.head(2)
```

[24]:
```
     Airline        Date Departure Station Arrival Station  \
0     IndiGo  24/03/2019               BLR             DEL
1  Air India   1/05/2019               CCU             BLR

                Route Map Departure Time  Arrival Time Journey Time  Stops  \
0               BLR → DEL          22:20  01:10 22 Mar       2h 50m      0
1  CCU → IXR → BBI → BLR          05:50         13:15       7h 25m      2

   Extra Info  Price
0           0   3897
1           0   7662
```

[25]:
```
df_airline['Day'],df_airline['Month'],df_airline['Year'] = df_airline['Date'].
 ↪str.split('/',3).str
```

[26]:

```python
df_airline.head(2)
```

[26]:

```
     Airline        Date Departure Station Arrival Station  \
0     IndiGo  24/03/2019               BLR             DEL
1  Air India   1/05/2019               CCU             BLR

               Route Map Departure Time  Arrival Time Journey Time  Stops  \
0              BLR → DEL          22:20  01:10 22 Mar       2h 50m      0
1  CCU → IXR → BBI → BLR          05:50         13:15       7h 25m      2

   Extra Info  Price Day Month  Year
0           0   3897  24    03  2019
1           0   7662   1    05  2019
```

2.1.4 Dropping unwanted columns from the dataset

[27]:

```python
df_airline.drop('Date', axis='columns', inplace=True)
df_airline.drop('Arrival Time', axis='columns', inplace=True)
df_airline.drop('Year', axis='columns', inplace=True)
```

[28]:

```python
df_airline.head(2)
```

[28]:

```
     Airline Departure Station Arrival Station              Route Map  \
0     IndiGo               BLR             DEL              BLR → DEL
1  Air India               CCU             BLR  CCU → IXR → BBI → BLR

  Departure Time Journey Time  Stops  Extra Info  Price Day Month
0          22:20       2h 50m      0           0   3897  24    03
1          05:50       7h 25m      2           0   7662   1    05
```

[29]:

```python
df_airline.shape
```

[29]:

```
(9000, 11)
```

2.2 3. Feature Engineering

2.2.1 Calculating distance

[30]:

```python
df_air_distance = pd.read_csv("air_distance.csv")
```

[31]:

```python
df_air_distance.head(2)
```

[31]:

```
   Unnamed: 0 Source Dest  Distance(Km)
0           0    BLR  DEL       1709.71
1           1    CCU  IXR        327.84
```

[32]:

```
import math

def getDistance(route):
    distance = 0.0
    route="".join(route.split())
    routeArray = route.split('→')
    i=0
    if len(routeArray) > 1:
        while i < (len(routeArray)-1):
            df_dist = df_air_distance[(df_air_distance['Source'] ==␣
 ↪routeArray[i]) & (df_air_distance['Dest'] == routeArray[i+1])]
            if (df_dist.empty):
                df_dist = df_air_distance[(df_air_distance['Source'] ==␣
 ↪routeArray[i+1]) & (df_air_distance['Dest'] == routeArray[i])]
            distValue = df_dist['Distance(Km)'].item()
            distance = distance + distValue
            i += 1
    return round(distance,2)
```

[33]:

```
# df_airline['Distance(km)'] = distSeries.assign(distance =  :␣
 ↪getDistance(route))

df_airline['Distance(km)'] = df_airline['Route Map'].apply(lambda x:␣
 ↪getDistance(x))

df_airline.head(3)
```

[33]:

```
       Airline Departure Station Arrival Station              Route Map  \
0       IndiGo               BLR             DEL              BLR → DEL
1    Air India               CCU             BLR  CCU → IXR → BBI → BLR
2  Jet Airways               DEL             COK  DEL → LKO → BOM → COK

  Departure Time Journey Time  Stops  Extra Info  Price Day Month  \
0          22:20       2h 50m      0           0   3897  24    03
1          05:50       7h 25m      2           0   7662   1    05
2          09:25          19h      2           0  13882   9    06

   Distance(km)
0       1709.71
1       1838.55
2       2671.33
```

2.2.2 Creating arrival & departure hour, Minutes from arrival time and departure time

[34]:
```
df_airline['Dep_Hr'],df_airline['Dep_Min'] = df_airline['Departure Time'].str.
  ↪split(':',2).str
df_airline['Duration'] = df_airline['Journey Time'].str.replace('h ',':').str.
  ↪replace('m','')
df_airline['Duration_Hr'],df_airline['Duration_Min'] = df_airline['Duration'].
  ↪str.split(':',2).str
```

2.2.3 Dropping unwanted columns

[35]:
```
df_airline.drop('Departure Time', axis='columns', inplace=True)
df_airline.drop('Journey Time', axis='columns', inplace=True)
df_airline.drop('Duration', axis='columns', inplace=True)
```

[36]:
```
df_airline.head(2)
```

[36]:
```
     Airline Departure Station Arrival Station              Route Map  Stops  \
0     IndiGo               BLR             DEL              BLR → DEL      0
1  Air India               CCU             BLR  CCU → IXR → BBI → BLR      2

   Extra Info  Price Day Month  Distance(km) Dep_Hr Dep_Min Duration_Hr  \
0           0   3897  24    03       1709.71     22      20           2
1           0   7662   1    05       1838.55     05      50           7

  Duration_Min
0           50
1           25
```

[37]:
```
df_airline.shape
```

[37]:
```
(9000, 14)
```

2.2.4 Chnaging the datatype as per our requirment and model design

[38]:
```
df_airline['Month'] = df_airline['Month'].astype(str).astype(int)
df_airline.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 9000 entries, 0 to 8999
Data columns (total 14 columns):
 #   Column             Non-Null Count  Dtype
---  ------             --------------  -----
 0   Airline            9000 non-null   object
 1   Departure Station  9000 non-null   object
 2   Arrival Station    9000 non-null   object
 3   Route Map          9000 non-null   object
 4   Stops              9000 non-null   int64
 5   Extra Info         9000 non-null   int64
 6   Price              9000 non-null   int64
 7   Day                9000 non-null   object
 8   Month              9000 non-null   int32
 9   Distance(km)       9000 non-null   float64
 10  Dep_Hr             9000 non-null   object
 11  Dep_Min            9000 non-null   object
 12  Duration_Hr        9000 non-null   object
 13  Duration_Min       8143 non-null   object
dtypes: float64(1), int32(1), int64(3), object(9)
memory usage: 949.3+ KB
```

[39]:
```
# Replace the null values as 0

df_airline.Duration_Min.replace(np.nan, 0,inplace=True)
```

[40]:
```
# String the duration_hr variable to remove unwanted spaces of special char

df_airline['Duration_Hr'] = df_airline['Duration_Hr'].str.rstrip('h')
df_airline.Duration_Hr.unique()
```

[40]:
```
array(['2', '7', '19', '5', '4', '15', '21', '25', '13', '12', '26', '22',
       '23', '20', '10', '6', '11', '8', '16', '3', '27', '1', '14', '9',
       '18', '17', '24', '30', '28', '29', '37', '34', '38', '35', '36',
       '47', '33', '32', '31', '42', '39', '41'], dtype=object)
```

[41]:
```
df_airline.head(2)
```

[41]:
```
     Airline Departure Station Arrival Station              Route Map  Stops  \
0     IndiGo               BLR             DEL              BLR → DEL      0
1  Air India               CCU             BLR  CCU → IXR → BBI → BLR      2

   Extra Info  Price Day  Month  Distance(km) Dep_Hr Dep_Min Duration_Hr  \
0           0   3897  24      3       1709.71     22      20           2
1           0   7662   1      5       1838.55     05      50           7

  Duration_Min
0           50
1           25
```

[ ]:
```

```

2.3 4. Regularization

2.4 Renaming few variable to our understanding

```
[42]: df_airline = df_airline.rename(columns={'Departure Station': 'Source',
                                               'Arrival Station': 'Dest',
                                              "Extra Info": "Info"})
```

```
[43]: df_airline.head(2)
```

```
[43]:     Airline Source Dest              Route Map  Stops  Info  Price Day  \
      0     IndiGo    BLR  DEL              BLR → DEL      0     0   3897  24
      1  Air India    CCU  BLR  CCU → IXR → BBI → BLR      2     0   7662   1

         Month  Distance(km) Dep_Hr Dep_Min Duration_Hr Duration_Min
      0      3       1709.71     22      20           2           50
      1      5       1838.55     05      50           7           25
```

2.4.1 Exporting the cleaned dataset as csv file

```
[44]: df_airline.to_csv('Cleaned_airline.csv', index=False)
```

3 2. Apply machine learning algorithm

```
[45]: from sklearn.preprocessing import LabelEncoder, MinMaxScaler
      from sklearn.model_selection import train_test_split, GridSearchCV,␣
       ↪cross_val_score, RandomizedSearchCV
      from sklearn.linear_model import LinearRegression, ElasticNet, Lasso, Ridge
      from sklearn.metrics import mean_absolute_error, mean_squared_error
      from sklearn.ensemble import RandomForestRegressor, GradientBoostingRegressor


      import warnings
      warnings.filterwarnings('ignore')

      pd.set_option('display.max_columns', None)
```

```
[46]: df = pd.read_csv('Cleaned_airline.csv')
      df.head(2)
```

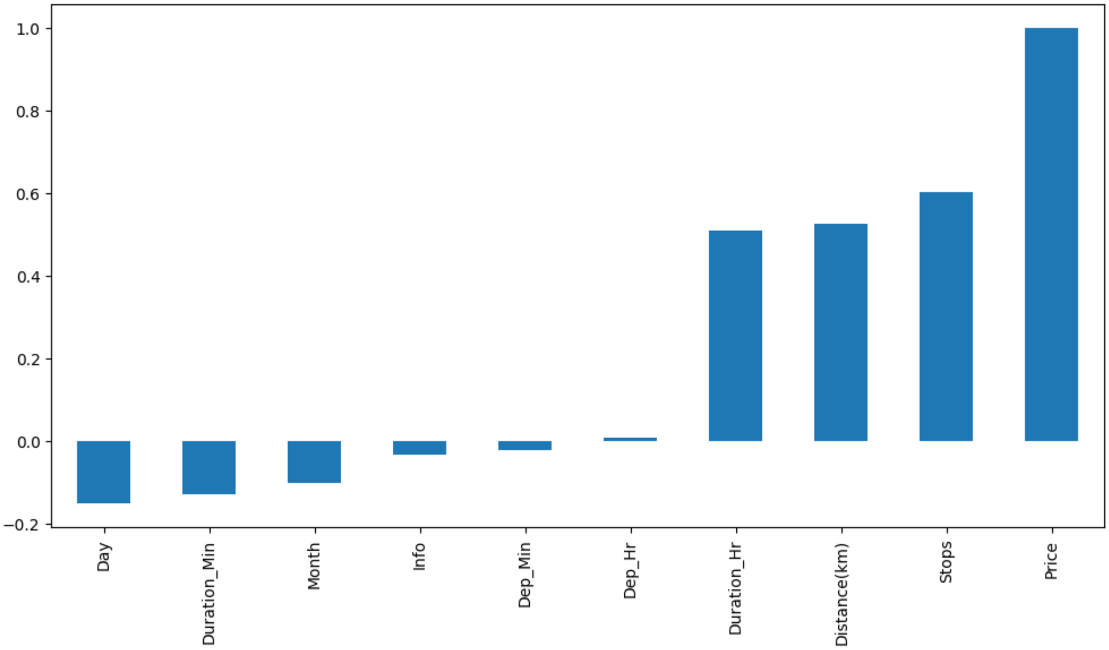
```
[46]:     Airline Source Dest              Route Map  Stops  Info  Price  Day  \
      0     IndiGo    BLR  DEL              BLR → DEL      0     0   3897   24
      1  Air India    CCU  BLR  CCU → IXR → BBI → BLR      2     0   7662    1

         Month  Distance(km)  Dep_Hr  Dep_Min  Duration_Hr  Duration_Min
      0      3       1709.71      22       20            2            50
```

```
1        5         1838.55         5         50               7                25
```

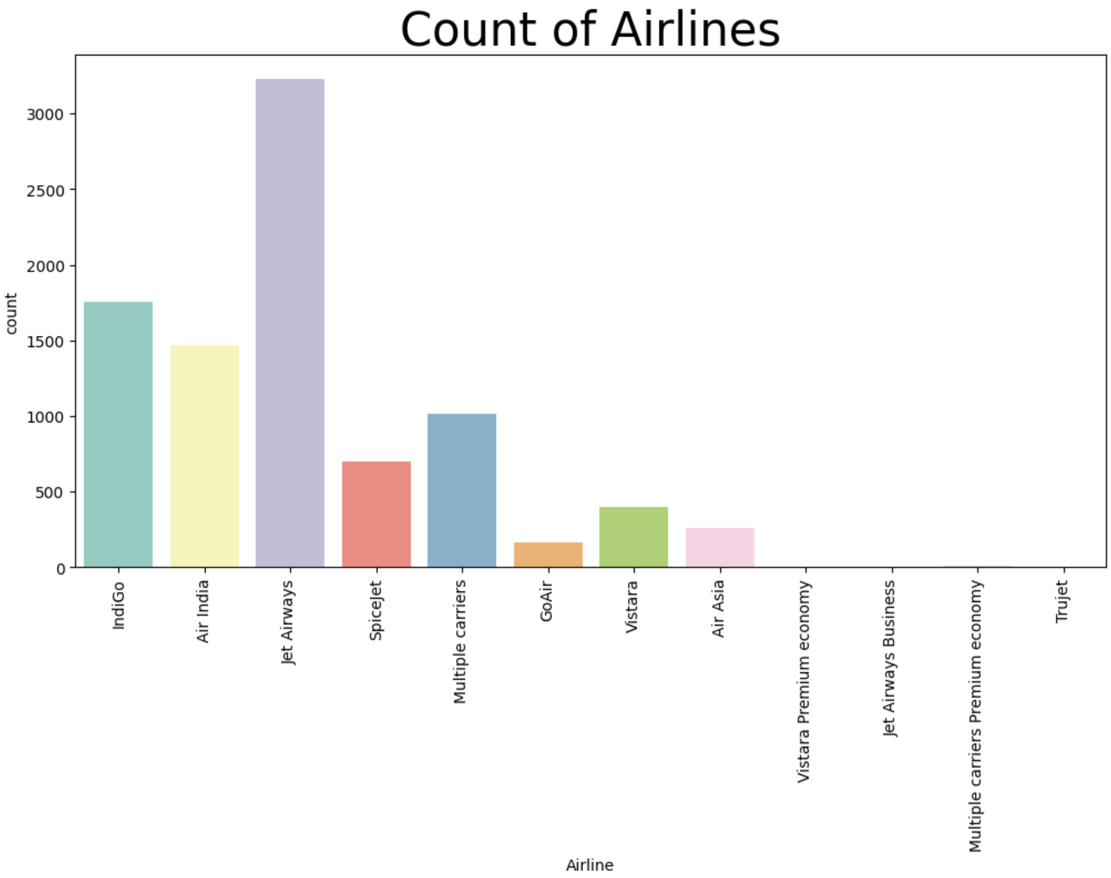
[47]:

```python
plt.figure(figsize=(12,6))
df.corr()['Price'].sort_values().plot(kind='bar');
```

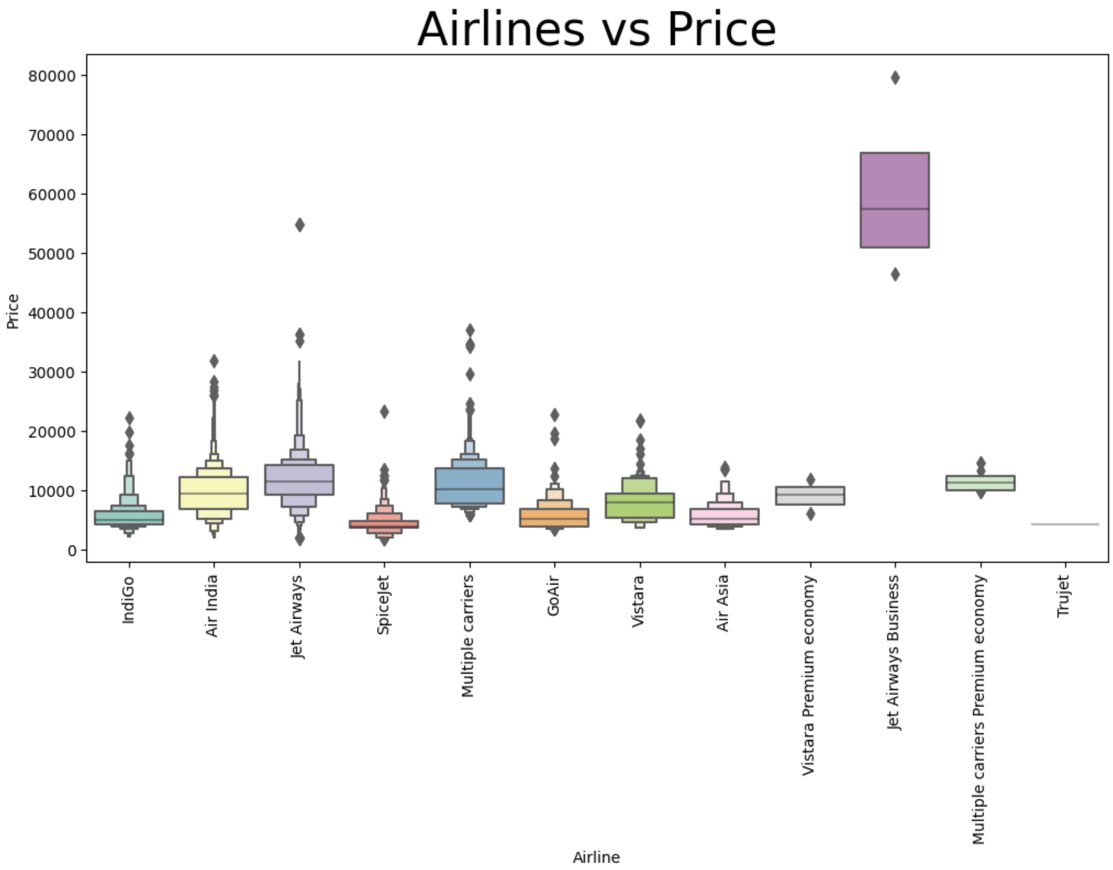


[48]:

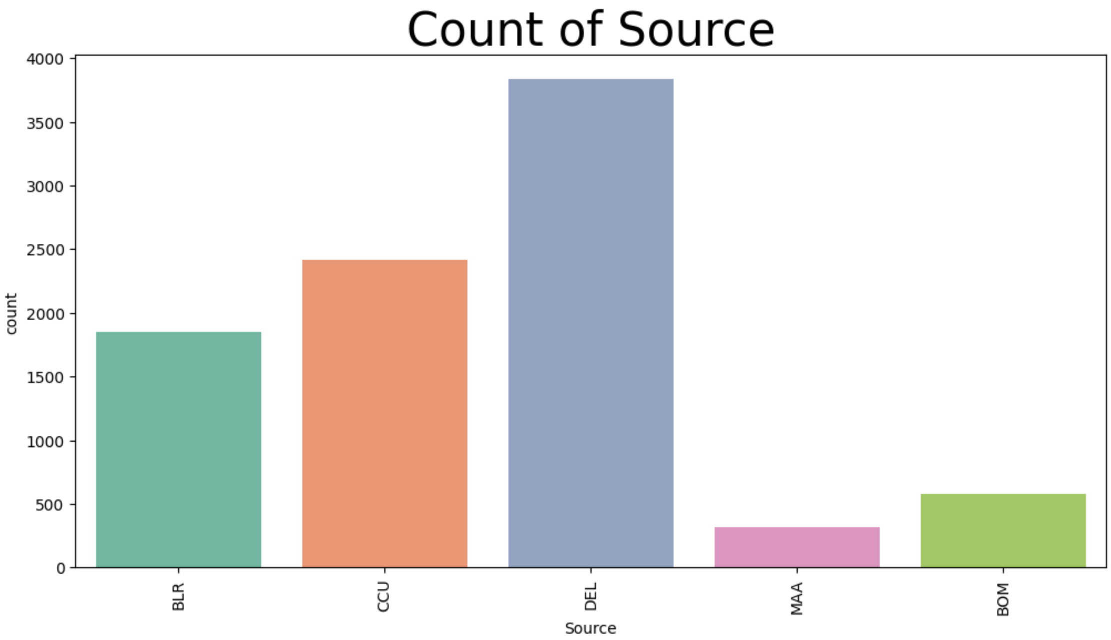
```python
plt.figure(figsize=(12,6))
sns.countplot(x="Airline", data = df, palette='Set3')
plt.title('Count of Airlines', size=30)
plt.xticks(rotation=90)
plt.show()
```



[49]:
```
plt.figure(figsize=(12,6))
sns.boxenplot(x = 'Airline', y= 'Price', data=df, palette='Set3')
plt.title('Airlines vs Price', size=30)
plt.xticks(rotation=90)
plt.show()
```

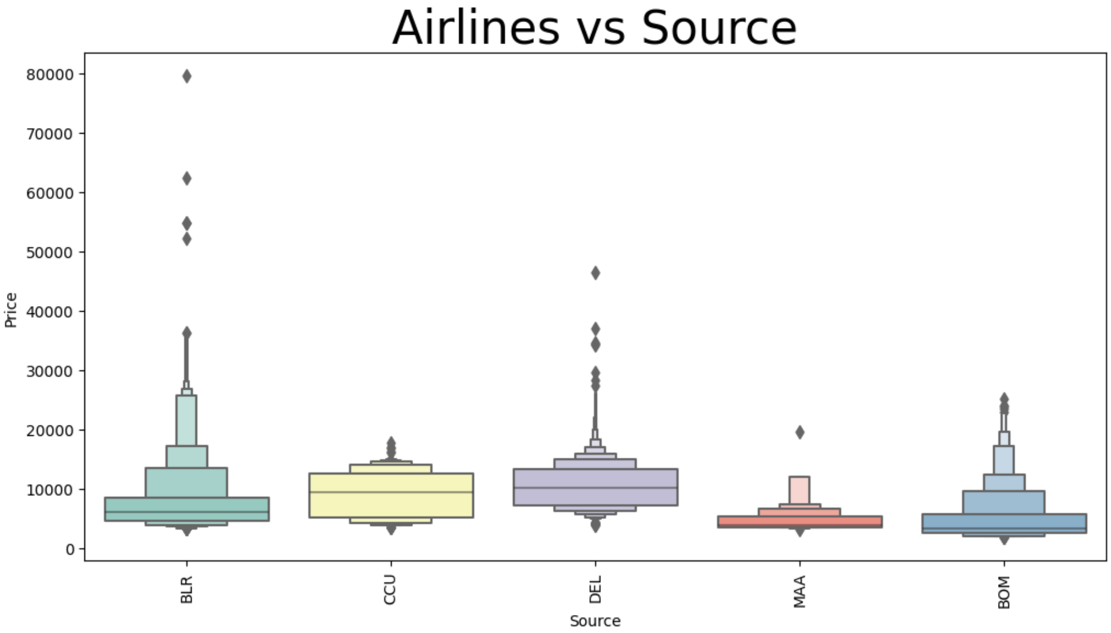


```
[50]: plt.figure(figsize=(12,6))
      sns.countplot(x='Source', data = df, palette='Set2')
      plt.title('Count of Source', size=30)
      plt.xticks(rotation=90)
      plt.show()
```



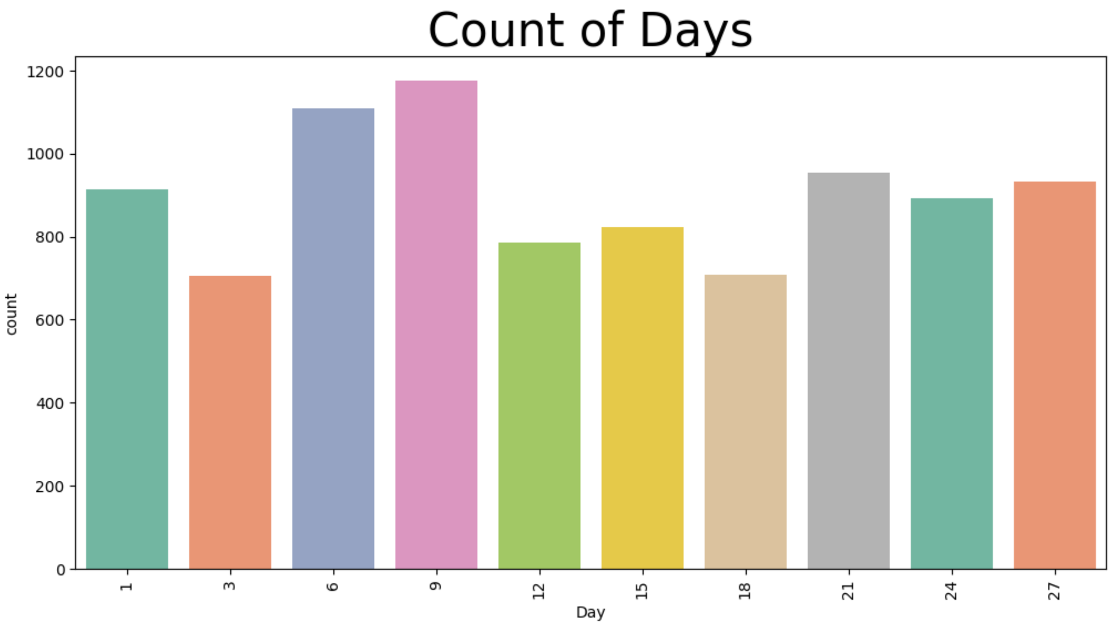
[51]:

```
plt.figure(figsize=(12,6))
sns.boxenplot(x= 'Source', y= 'Price', data=df, palette='Set3')
plt.title('Airlines vs Source', size=30)
plt.xticks(rotation=90)
plt.show()
```



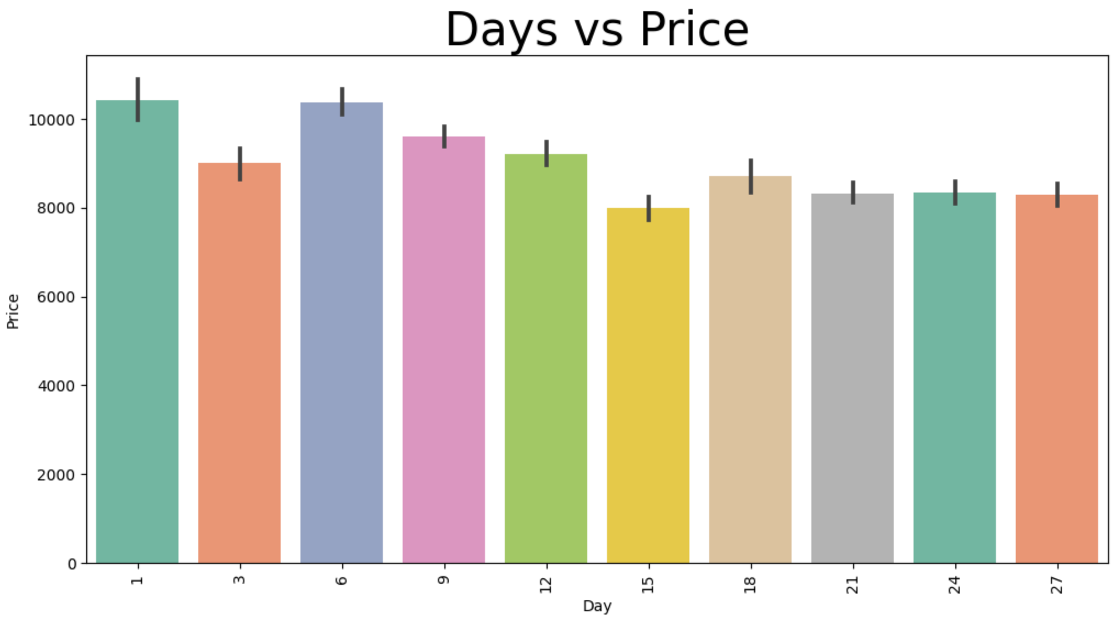
[52]:

```
plt.figure(figsize=(12,6))
sns.countplot(x='Day', data= df, palette='Set2')
plt.title('Count of Days', size=30)
plt.xticks(rotation=90)
plt.show()
```



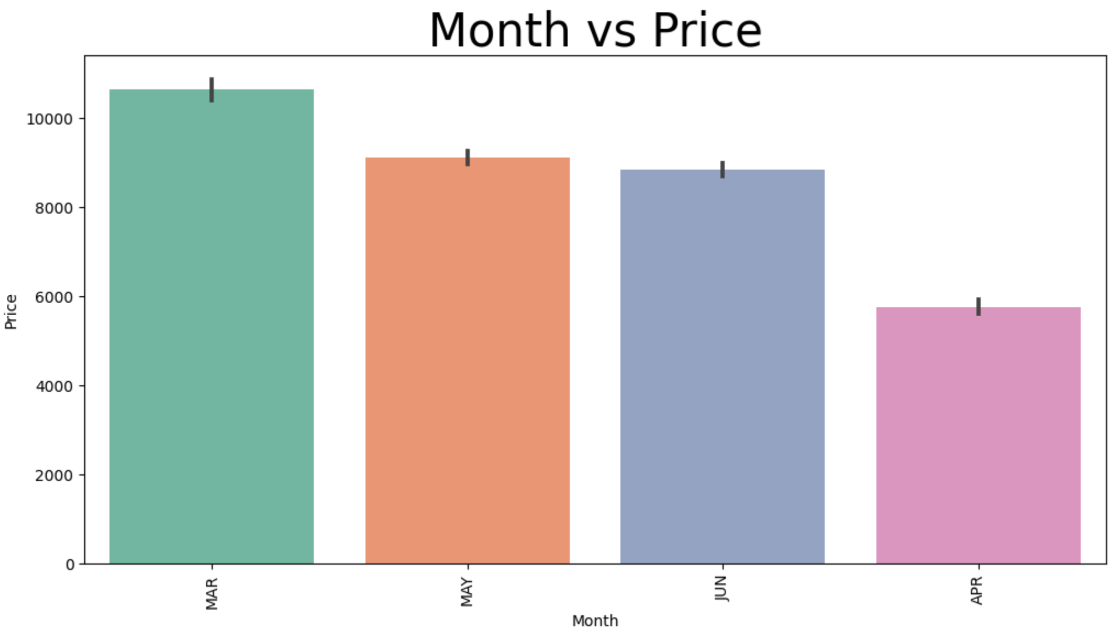
[53]:

```
plt.figure(figsize=(12,6))
sns.barplot(x='Day', y='Price', data=df, palette='Set2')
plt.title('Days vs Price', size=30)
plt.xticks(rotation=90)
plt.show()
```

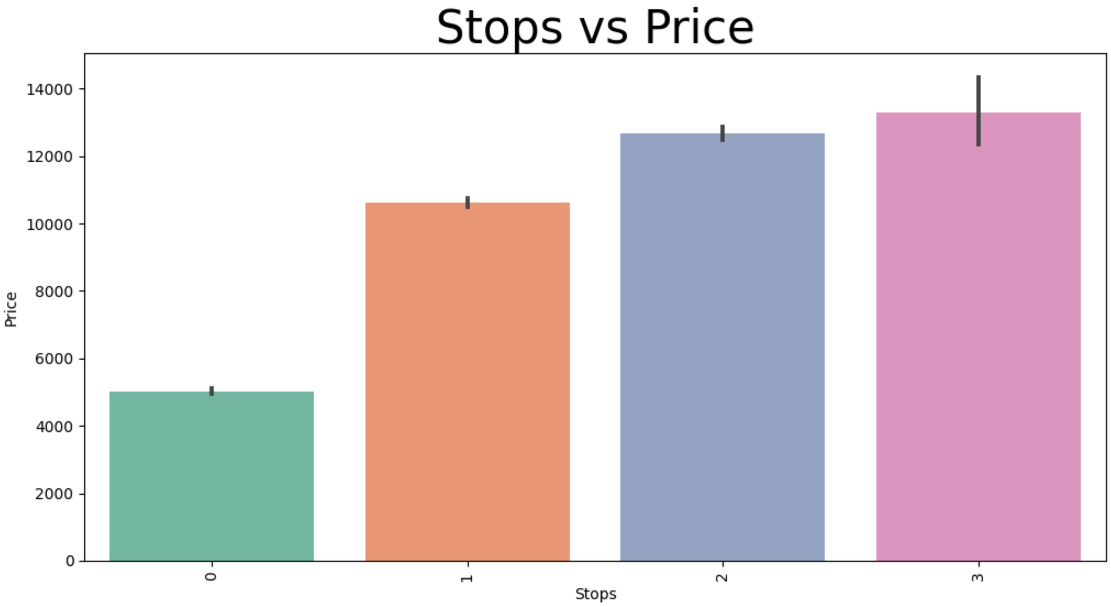


[54]:
```
df['Month'] = df['Month'].map({
    1:'JAN',
    2:'FEB',
    3:'MAR',
    4:'APR',
    5:'MAY',
    6:'JUN',
    7:'JUL',
    8:'AUG',
    9:'SEP',
    10:'OCT',
    11:'NOV',
    12:'DEC'
})
```

[55]:
```
plt.figure(figsize=(12,6))
sns.barplot(x='Month', y='Price', data=df, palette='Set2')
plt.title('Month vs Price', size=30)
plt.xticks(rotation=90)
plt.show()
```

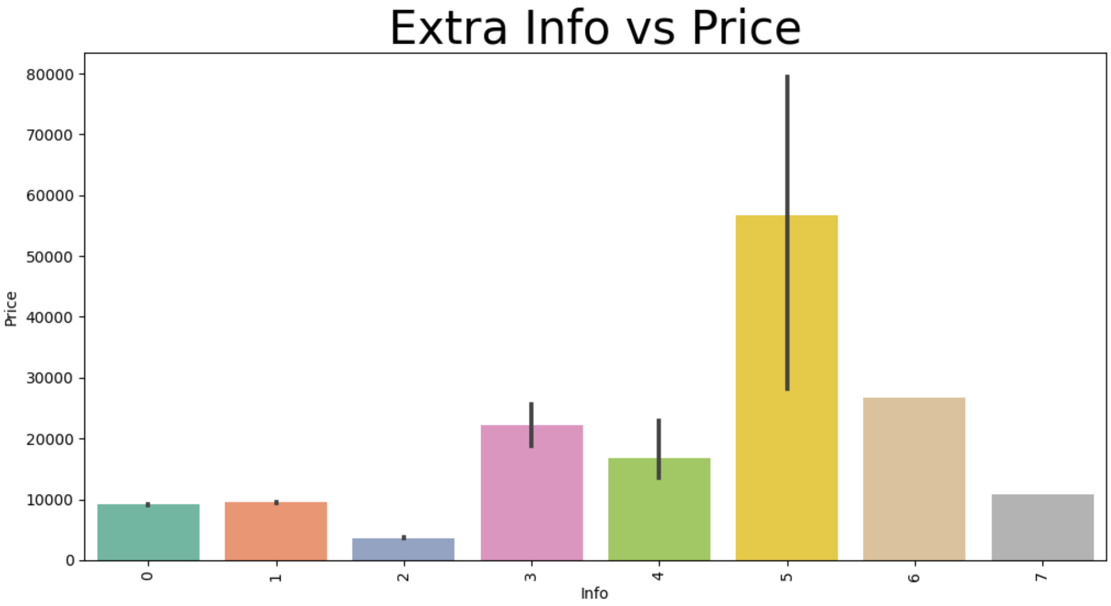


[56]:
```
plt.figure(figsize=(12,6))
sns.barplot(x='Stops', y='Price', data=df, palette='Set2')
plt.title('Stops vs Price', size=30)
plt.xticks(rotation=90)
plt.show()
```



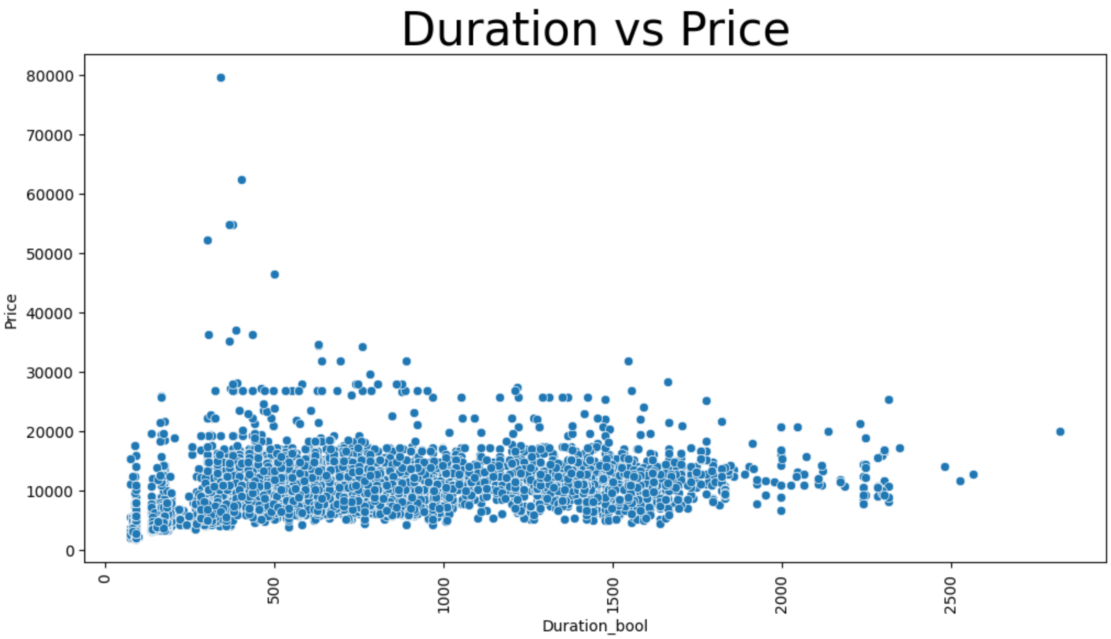
[57]:

```
plt.figure(figsize=(12,6))
sns.barplot(x='Info', y='Price', data=df, palette='Set2')
plt.title('Extra Info vs Price', size=30)
plt.xticks(rotation=90)
plt.show()
```



[58]:

```
df['Duration_bool'] = (df['Duration_Hr']*60)+df['Duration_Min']
plt.figure(figsize=(12,6))
sns.scatterplot(x= 'Duration_bool', y ='Price', data=df, palette='Set2')
plt.title('Duration vs Price', size=30)
plt.xticks(rotation=90)
plt.show()
```



[59]:

```
ncol=["Duration_bool"]
for i in ncol:
    q75, q25 = np.percentile(df.loc[:,i], [75 ,25])
    iqr = q75 - q25
    min = q25 - (iqr*1.5)
    max = q75 + (iqr*1.5)
    df = df.drop(df[df.loc[:,i] <= min].index)
    df = df.drop(df[df.loc[:,i] >= max].index)


df = df.dropna()
df1 = df[['Airline', 'Source', 'Dest', 'Stops',
         'Info', 'Price', 'Day', 'Month', 'Distance(km)', 'Duration_bool']]
df1 = df1.rename(columns={'Duration_bool': 'Duration'})
df1['Month'] = df1['Month'].map({
    'JAN':1,
    'FEB':2,
    'MAR':3,
    'APR':4,
    'MAY':5,
    'JUN':6,
    'JUL':7,
    'AUG':8,
    'SEP':9,
    'OCT':10,
    'NOV':11,
    'DEC':12
})
df.head(2)
```

[59]:

```
      Airline Source Dest                  Route Map  Stops  Info  Price  Day  \
0      IndiGo    BLR  DEL                  BLR → DEL      0     0   3897   24
1   Air India    CCU  BLR  CCU → IXR → BBI → BLR      2     0   7662    1

  Month  Distance(km)  Dep_Hr  Dep_Min  Duration_Hr  Duration_Min  \
0   MAR       1709.71      22       20            2            50
1   MAY       1838.55       5       50            7            25

   Duration_bool
0            170
1            445
```

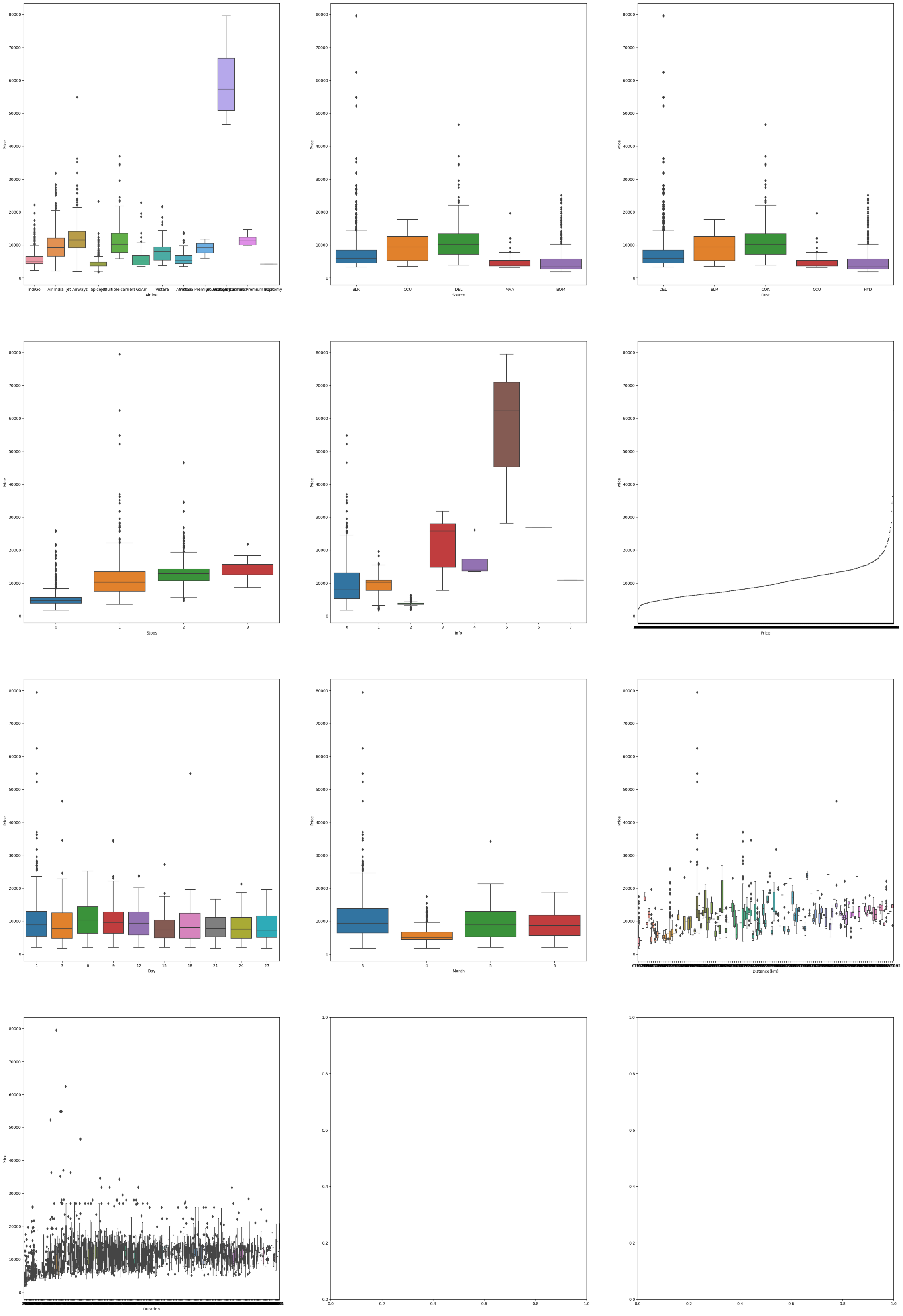
[60]:

```
X = df1.drop('Price', axis=1)
y = df1['Price']
```

[61]:

```
# set figure size
fig, ax = plt.subplots(4, 3, figsize=(40, 60))

# create box plot for categorical variables
for var, subplot in zip(df1.columns, ax.flatten()):
    sns.boxplot(x=var, y='Price', data=df1, ax=subplot)
```


Price
0
10000
20000
30000
40000
50000
60000
70000
80000
IndiGo
Air India
Jet Airways
SpiceJet
Multiple carriers
GoAir
Vistara
Air Asia
Vistara Premium economy
Jet Airways Business
Multiple carriers Premium economy
Trujet
Airline
BLR
CCU
DEL
MAA
BOM
Source
DEL
BLR
COK
CCU
HYD
Dest
0
1
2
3
Stops
0
1
2
3
4
5
6
7
Info
Price
1
3
6
9
12
15
18
21
24
27
Day
3
4
5
6
Month
Distance(km)
Duration
0.0
0.2
0.4
0.6
0.8
1.0

[62]:

```python
df1.to_csv('final_airfare.csv', index=False)
```

[63]:

```python
# display all columns of the dataframe
pd.options.display.max_columns = None

# display all rows of the dataframe
pd.options.display.max_rows = None

# to display the float values upto 6 decimal places
pd.options.display.float_format = '{:.6f}'.format

# import train-test split
from sklearn.model_selection import train_test_split

# import various functions from statsmodels
import statsmodels
import statsmodels.api as sm

# import 'stats'
from scipy import stats

# 'metrics' from sklearn is used for evaluating the model performance
from sklearn.metrics import mean_squared_error
from sklearn.metrics import mean_absolute_error


# import function to perform linear regression
from sklearn.linear_model import LinearRegression

# import StandardScaler to perform scaling
from sklearn.preprocessing import StandardScaler

# import SGDRegressor from sklearn to perform linear regression with stochastic gradient descent
from sklearn.linear_model import SGDRegressor

# import function for ridge regression
from sklearn.linear_model import Ridge

# import function for lasso regression
from sklearn.linear_model import Lasso

# import function for elastic net regression
from sklearn.linear_model import ElasticNet

# import function to perform GridSearchCV
from sklearn.model_selection import GridSearchCV
from sklearn.ensemble import GradientBoostingRegressor

# import functions to perform cross validation
from sklearn.model_selection import LeaveOneOut
from sklearn.model_selection import cross_val_score
from sklearn.model_selection import KFold
```

[64]:

```
df = pd.read_csv('./final_airfare.csv')

# display first two observations using head()
df.head(2)
```

[64]:

```
      Airline Source Dest  Stops  Info  Price  Day  Month  Distance(km)  \
0      IndiGo    BLR  DEL      0     0   3897   24      3   1709.710000
1   Air India    CCU  BLR      2     0   7662    1      5   1838.550000

   Duration
0       170
1       445
```

[65]:

```
# store the target variable 'PRICE' in a dataframe 'df_target'
df_target = df['Price']
df_feature = df.drop('Price', axis = 1)

df_num = df_feature.select_dtypes(include = [np.number])

# display numerical features
print("display numerical features:\n",df_num.columns)


df_cat = df_feature.select_dtypes(include = [np.object])

# display categorical features
print("display categorical features:\n",df_cat.columns)

# use 'get_dummies' from pandas to create dummy variables
# use 'drop_first' to create (n-1) dummy variables
dummy_var = pd.get_dummies(data = df_cat, drop_first = True)
```

```
display numerical features:
 Index(['Stops', 'Info', 'Day', 'Month', 'Distance(km)', 'Duration'],
dtype='object')
display categorical features:
 Index(['Airline', 'Source', 'Dest'], dtype='object')
```

[66]:

```
# initialize the standard scalar
X_scaler = StandardScaler()
```

```python
# scale all the numeric variables
# standardize all the columns of the dataframe 'df_num'
num_scaled = X_scaler.fit_transform(df_num)

# create a dataframe of scaled numerical variables
# pass the required column names to the parameter 'columns'
df_num_scaled = pd.DataFrame(num_scaled, columns = df_num.columns)

# standardize the target variable explicitly and store it in a new variable 'y'
y = (df_target - df_target.mean()) / df_target.std()
```

[67]:

```python
# concat the dummy variables with numeric features to create a dataframe of all␣
 ↪independent variables
# 'axis=1' concats the dataframes along columns
X = pd.concat([df_num_scaled, dummy_var], axis = 1)

# display first five observations
X.head(2)
```

[67]:

```
      Stops      Info       Day     Month  Distance(km)  Duration  \
0 -1.221463 -0.479818  1.240175 -1.470566     -0.614115 -0.939403
1  1.789648 -0.479818 -1.474359  0.249940     -0.391266 -0.374705

   Airline_Air India  Airline_GoAir  Airline_IndiGo  Airline_Jet Airways  \
0                  0              0               1                    0
1                  1              0               0                    0

   Airline_Jet Airways Business  Airline_Multiple carriers  \
0                             0                          0
1                             0                          0

   Airline_Multiple carriers Premium economy  Airline_SpiceJet  \
0                                          0                 0
1                                          0                 0

   Airline_Trujet  Airline_Vistara  Airline_Vistara Premium economy  \
0               0                0                                0
1               0                0                                0

   Source_BOM  Source_CCU  Source_DEL  Source_MAA  Dest_CCU  Dest_COK  \
0           0           0           0           0         0         0
1           0           1           0           0         0         0

   Dest_DEL  Dest_HYD
0         1         0
1         0         0
```

3.1 Train-test split

[68]:

```
# split data into train subset and test subset
# set 'random_state' to generate the same dataset each time you run the code
# 'test_size' returns the proportion of data to be included in the testing set
X_train, X_test, y_train, y_test = train_test_split(X, y, random_state = 10,␣
 ↪test_size = 0.3)

# check the dimensions of the train & test subset using 'shape'
# print dimension of train set
print('X_train', X_train.shape)
print('y_train', y_train.shape)

# print dimension of test set
print('X_test', X_test.shape)
print('y_test', y_test.shape)
```

```
X_train (6254, 25)
y_train (6254,)
X_test (2681, 25)
y_test (2681,)
```

3.2 Creating RMSE values for train set

[69]:

```
# create a generalized function to calculate the RMSE values for train set
def get_train_rmse(model):

    # For training set:
    # train_pred: prediction made by the model on the training dataset 'X_train'
    # y_train: actual values ofthe target variable for the train dataset

    # predict the output of the target variable from the train data
    train_pred = model.predict(X_train)

    # calculate the MSE using the "mean_squared_error" function

    # MSE for the train data
    mse_train = mean_squared_error(y_train, train_pred)

    # take the square root of the MSE to calculate the RMSE
    # round the value upto 4 digits using 'round()'
    rmse_train = round(np.sqrt(mse_train), 4)

    # return the training RMSE
    return(rmse_train)
```

3.3 Creating RMSE values for test data

[70]:

```python
# create a generalized function to calculate the RMSE values test set
def get_test_rmse(model):

    # For testing set:
    # test_pred: prediction made by the model on the test dataset 'X_test'
    # y_test: actual values of the target variable for the test dataset

    # predict the output of the target variable from the test data
    test_pred = model.predict(X_test)

    # MSE for the test data
    mse_test = mean_squared_error(y_test, test_pred)

    # take the square root of the MSE to calculate the RMSE
    # round the value upto 4 digits using 'round()'
    rmse_test = round(np.sqrt(mse_test), 4)

    # return the test RMSE
    return(rmse_test)
```

3.4 MAPE Calculation

[71]:

```python
# define a function to calculate MAPE
# pass the actual and predicted values as input to the function
# return the calculated MAPE
def mape(actual, predicted):
    return (np.mean(np.abs((actual - predicted) / actual)) * 100)

def get_test_mape(model):

    # For testing set:
    # test_pred: prediction made by the model on the test dataset 'X_test'
    # y_test: actual values of the target variable for the test dataset

    # predict the output of the target variable from the test data
    test_pred = model.predict(X_test)

    # calculate the mape using the "mape()" function created above
    # calculate the MAPE for the test data
    mape_test = mape(y_test, test_pred)

    # return the MAPE for the test set
    return(mape_test)
```

[ ]:

3.5 Creating a function to update scorecard

[72]:

```
# create a function to update the score card for comparision of the scores from␣
 ↪different algorithms
# pass the model name, model build, alpha and l1_ration as input parameters
# if 'alpha' and/or 'l1_ratio' is not specified, the function assigns '-'
def update_score_card(algorithm_name, model, alpha = '-', l1_ratio = '-'):

    # assign 'score_card' as global variable
    global score_card

    # append the results to the dataframe 'score_card'
    # 'ignore_index = True' do not consider the index labels
    score_card = score_card.append({'Model_Name': algorithm_name,
                       'Alpha (Wherever Required)': alpha,
                       'l1-ratio': l1_ratio,
                       'Test_MAPE': get_test_mape(model),
                       'Test_RMSE': get_test_rmse(model),
                       'R-Squared': get_score(model)[0],
                       'Adj. R-Squared': get_score(model)[1]}, ignore_index =␣
 ↪True)
```

3.6 Function to plot barplot

[73]:

```
# define a function to plot a barplot
# pass the model
def plot_coefficients(model, algorithm_name):
    # create a dataframe of variable names and their corresponding value of␣
 ↪coefficients obtained from model
    # 'columns' returns the column names of the dataframe 'X'
    # 'coef_' returns the coefficient of each variable
    df_coeff = pd.DataFrame({'Variable': X.columns, 'Coefficient': model.coef_})

    # sort the dataframe in descending order
    # 'sort_values' sorts the column based on the values
    # 'ascending = False' sorts the values in the descending order
    sorted_coeff = df_coeff.sort_values('Coefficient', ascending = False)

    # plot a bar plot with Coefficient on the x-axis and Variable names on␣
 ↪y-axis
    # pass the data to the parameter, 'sorted_coeff' to plot the barplot
    sns.barplot(x = "Coefficient", y = "Variable", data = sorted_coeff)

    # add x-axis label
    # set the size of the text using 'fontsize'
    plt.xlabel("Coefficients from {}".format(algorithm_name), fontsize = 15)
    # add y-axis label
    # set the size of the text using 'fontsize'
    plt.ylabel('Features', fontsize = 15)
```

3.7 Function to generated R-squared and Adj R-squared

[74]:
```
# define a function to get R-squared and adjusted R-squared value
def get_score(model):

    # score() returns the R-squared value
    r_sq = model.score(X_train, y_train)

    # calculate adjusted R-squared value
    # 'n' denotes number of observations in train set
    # 'shape[0]' returns number of rows
    n = X_train.shape[0]

    # 'k' denotes number of variables in train set
    # 'shape[1]' returns number of columns
    k = X_train.shape[1]

    # calculate adjusted R-squared using the formula
    r_sq_adj = 1 - ((1-r_sq)*(n-1)/(n-k-1))

    # return the R-squared and adjusted R-squared value
    return ([r_sq, r_sq_adj])
```

[75]:
```
# n_splits: specify the number of k folds
kf = KFold(n_splits = 5)
```

[76]:
```
# create a function 'get_score' that returns the R-squared score for the␣
 ↪training set
# 'get_score' takes 5 input parameters
def Get_score(model, X_train_k, X_test_k, y_train_k, y_test_k):
    model.fit(X_train_k, y_train_k)                                  # fit the␣
 ↪model
    return model.score(X_test_k, y_test_k)
```

[77]:
```
# create an empty list to store the scores
scores = []

# kf.split() splits the indices of X_train into train_index and test_index
# further dividing the X_train and y_train sets into train and test sets for␣
 ↪cross validation
# Remember: Cross validation works on training set not on test set
# use '\' for stacking the code
```

```
for train_index, test_index in kf.split(X_train):
    X_train_k, X_test_k, y_train_k, y_test_k = X_train.iloc[train_index],␣
 ↪X_train.iloc[test_index], \
                                                y_train.iloc[train_index],␣
 ↪y_train.iloc[test_index]

    # call the function 'get_scores()' and append the scores in the list␣
 ↪'scores'
    scores.append(Get_score(LinearRegression(), X_train_k, X_test_k, y_train_k,␣
 ↪y_test_k))

# print all scores
print('All scores: ', scores)

# print the minimum score from the list
# use 'round()' to round-off the minimum score upto 4 digits
# min() returns minimum score
print("\nMinimum score obtained: ", np.min(scores))

# print the maximum score from the list
# use 'round()' to round-off the maximum score upto 4 digits
# max() returns maximum score
print("Maximum score obtained: ", np.max(scores))

# print the average score from the list
# use 'round()' to round-off the average score upto 4 digits
# np.mean() returns average score
print("Average score obtained: ", np.mean(scores))
```

```
All scores:  [0.583402449363021, 0.6215639618731148, 0.5779648965672155,
0.6145383837471873, -1.1033139815909515e+17]

Minimum score obtained:  -1.1033139815909515e+17
Maximum score obtained:  0.6215639618731148
Average score obtained:  -2.206627963181903e+16
```

[78]:

```
# using cross_val_score() for k-fold cross validation
# estimator: pass the machine learning function. Here we are performing linear␣
 ↪regression
# pass the X_train and y_train sets
# cv: stands for number of folds. Similar to k in KFold
# scoring: pass the scoring parameter e.g. 'r2' for r-squared,␣
 ↪'neg_mean_squared_error' for mean squared error (negative)
scores = cross_val_score(estimator = LinearRegression(),
                         X = X_train,
                         y = y_train,
                         cv = 5,
                                    scoring = 'r2')
```

[79]:

```
# print all scores
print('All scores: ', scores)

# print the minimum score from the list
# use 'round()' to round-off the minimum score upto 4 digits
# min() returns minimum score
print("\nMinimum score obtained: ", round(np.min(scores), 4))

# print the maximum score from the list
# use 'round()' to round-off the maximum score upto 4 digits
# max() returns maximum score
print("Maximum score obtained: ", round(np.max(scores), 4))

# print the average score from the list
# use 'round()' to round-off the average score upto 4 digits
# np.mean() returns average score
print("Average score obtained: ", round(np.mean(scores), 4))
```

```
All scores:  [ 5.83402449e-01  6.21563962e-01  5.77964897e-01  6.14538384e-01
 -1.10331398e+17]

Minimum score obtained:  -1.1033139815909515e+17
Maximum score obtained:  0.6216
Average score obtained:  -2.206627963181903e+16
```

[80]:

```
# create an empty to store the MSE for each model
loocv_rmse = []

# instantiate the LOOCV method
loocv = LeaveOneOut()

# use the for loop to build the regression model for each cross validation
# use split() to split the dataset into two subsets; one with (n-1) data points␣
 ↪and another with 1 data point
# where, n = total number of observations

for train_index, test_index in loocv.split(X_train):
    # create the train dataset, use iloc[] to retrieve the corresponding␣
 ↪observations in train data
    # create the test dataset, use iloc[] to retrieve the corresponding␣
 ↪observations in test data
    # # use '\' for stacking the code
    X_train_l, X_test_l, y_train_l, y_test_l = X_train.iloc[train_index],␣
 ↪X_train.iloc[test_index], \
                                                  y_train.iloc[train_index],␣
↪y_train.iloc[test_index]

    # instantiate the regression model
    linreg = LinearRegression()

    # fit the model on training dataset
    linreg.fit(X_train_l, y_train_l)

    # calculate MSE using test dataset
    # use predict() to predict the values of target variable
    mse = mean_squared_error(y_test_l, linreg.predict(X_test_l))

    # calculate the RMSE
    rmse = np.sqrt(mse)

    # use append() to add each RMSE to the list 'loocv_rmse'
    loocv_rmse.append(rmse)
```

[81]:

```
# print the minimum rmse from the list
# use 'round()' to round-off the minimum rmse upto 4 digits
# min() returns minimum rmse
print("\nMinimum rmse obtained: ", round(np.min(loocv_rmse), 4))

# print the maximum rmse from the list
# use 'round()' to round-off the maximum rmse upto 4 digits
# max() returns maximum rmse
print("Maximum rmse obtained: ", round(np.max(loocv_rmse), 4))

# print the average rmse from the list
# use 'round()' to round-off the average rmse upto 4 digits
# np.mean() returns average rmse
print("Average rmse obtained: ", round(np.mean(loocv_rmse), 4))
```

```

Minimum rmse obtained:  0.0001
Maximum rmse obtained:  3952236962.6924
Average rmse obtained:  631953.8728
```

[82]:

```
models = [['LinearRegression', LinearRegression(),'na'],
          ['ElasticNet', ElasticNet(), [{'alpha':[0.0001, 0.001, 0.01, 0.1, 1,␣
↪5, 10, 20, 40, 60],
                      'l1_ratio':[0.0001, 0.0002, 0.001, 0.01, 0.1, 0.2]}]],
          ['Lasso', Lasso(), [{'alpha':[0.0001, 0.001, 0.01, 0.1, 1, 5, 10,␣
↪20]}]],
          ['Ridge', Ridge(), [{'alpha':[1e-4,1e-3, 1e-2, 0.1, 1, 5, 10, 20, 40,␣
↪60, 80, 100]}]],
          ['GradientBoostingRegressor', GradientBoostingRegressor(), 'na'],
         ['SGDRegressor', SGDRegressor(), 'na']]
```

[83]:

```
# create an empty dataframe to store the scores for various algorithms
score_card = pd.DataFrame(columns=['Model_Name', 'Alpha (Wherever Required)',␣
 ↪'l1-ratio', 'R-Squared',
                                       'Adj. R-Squared', 'Test_RMSE',␣
 ↪'Test_MAPE'])

for name, model, grid in models:
    model=model
    if grid == 'na':
        model.fit(X_train, y_train)
        update_score_card(algorithm_name = name, model = model)
    else:
        model = GridSearchCV(estimator = model,
                          param_grid = grid,
                          cv = 10)
        model.fit(X_train, y_train)
        update_score_card(algorithm_name = name, model = model, alpha = model.
 ↪best_params_.get('alpha'),
                         l1_ratio = model.best_params_.get('l1_ratio'))
# sort the dataframe 'score_card' on 'Test_RMSE' in an ascending order using␣
 ↪'sort_values'
# 'reset_index' resets the index of the dataframe
# 'drop = True' drops the previous index
score_card = score_card.sort_values('Test_RMSE').reset_index(drop = True)

# color the cell in the column 'Test_RMSE' having minimum RMSE value
# 'style.highlight_min' assigns color to the minimum value
# pass specified color to the parameter, 'color'
# pass the data to limit the color assignment to the parameter, 'subset'
score_card.style.highlight_min(color = 'lightblue', subset = 'Test_RMSE')
```

[83]:

```
<pandas.io.formats.style.Styler at 0x2a4038ecf70>
```

3.8 2. Module Creation

[84]:

```
gradBoost = GradientBoostingRegressor()
gradBoost.fit(X_train, y_train)
prediction = gradBoost.predict(X_test)
print('RMSE : {}'.format(np.sqrt(mean_squared_error(y_test, prediction))))
```

```
RMSE : 0.3876990229902486
```

[85]:

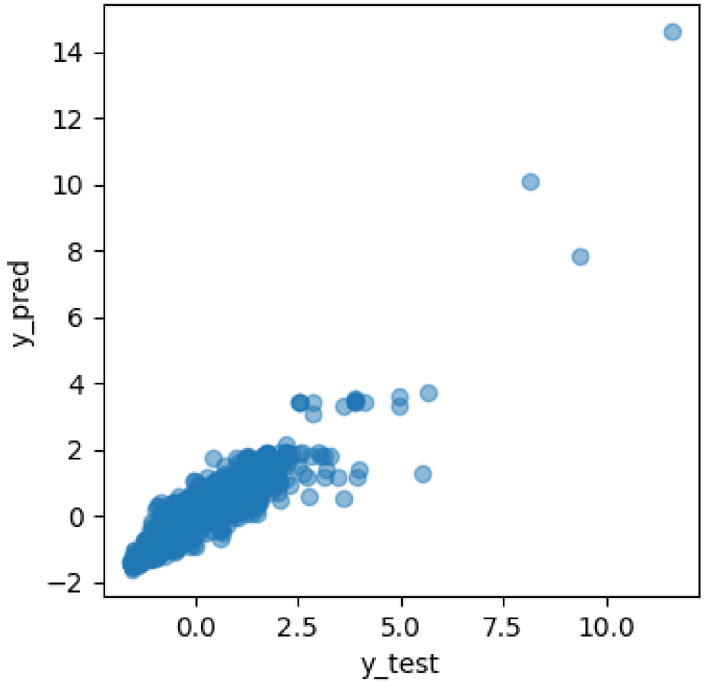
```
gradBoost.score(X_train, y_train), gradBoost.score(X_test, y_test)
```

```
[85]: (0.8340958488952346, 0.8513860966526166)
```

```
[86]: print('MAE:', mean_absolute_error(y_test, prediction))
      print('MSE:', mean_squared_error(y_test, prediction))
      print('RMSE:', np.sqrt(mean_squared_error(y_test, prediction)))
```

```
MAE: 0.2612347663124806
MSE: 0.15031053242759332
RMSE: 0.3876990229902486
```

```
[87]: plt.figure(figsize = (4,4))
      plt.scatter(y_test, prediction, alpha = 0.5)
      plt.xlabel("y_test")
      plt.ylabel("y_pred")
      plt.show()
```



4 Create a Pipeline and Save Predictive Model:

```
[88]: import pickle
      file = open('final_model.pkl', 'wb')
      pickle.dump(gradBoost, file)
```

[89]:

```
model = open("final_model.pkl", "rb")
gradBoost = pickle.load(model)
```

[90]:

```
from sklearn import metrics
predictions2=gradBoost.predict(X_test)
metrics.r2_score(y_test,predictions2)
```

[90]:

```
0.8513860966526166
```

So we have created predictive model and permanently saved in hard-drive with all the required pre-processing steps and whenever the new data to be tested

[ ]:

```

```