Capstone_Bike_Rental_Demand_Prediction

March 11, 2023

[5]:
```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns

from sklearn.model_selection import train_test_split
from sklearn.metrics import mean_squared_error,mean_absolute_error,r2_score
from sklearn.linear_model import LinearRegression
from sklearn.linear_model import Lasso
from sklearn.linear_model import Ridge
from sklearn.linear_model import ridge_regression
from sklearn.model_selection import GridSearchCV
from sklearn.preprocessing import PowerTransformer
from sklearn.preprocessing import OneHotEncoder

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

[6]:
```
bike_df = pd.read_csv('data/BikeRentalData.csv', encoding= 'unicode_escape',␣
↪parse_dates=[0])
```

0.1 Exploring Data Set

[3]:
```
bike_df.head()
```

[3]:
```
        Date  Rented Bike Count  Hour  Temperature(°C)  Humidity(%)  \
0 2017-01-12                254     0             -5.2           37
1 2017-01-12                204     1             -5.5           38
2 2017-01-12                173     2             -6.0           39
3 2017-01-12                107     3             -6.2           40
4 2017-01-12                 78     4             -6.0           36

   Wind speed (m/s)  Visibility (10m)  Dew point temperature(°C)  \
0               2.2              2000                      -17.6
1               0.8              2000                      -17.6
2               1.0              2000                      -17.7
3               0.9              2000                      -17.6
```

```
4              2.3            2000                     -18.6

   Solar Radiation (MJ/m2)  Rainfall(mm)  Snowfall (cm) Seasons     Holiday  \
0                      0.0           0.0            0.0  Winter  No Holiday
1                      0.0           0.0            0.0  Winter  No Holiday
2                      0.0           0.0            0.0  Winter  No Holiday
3                      0.0           0.0            0.0  Winter  No Holiday
4                      0.0           0.0            0.0  Winter  No Holiday

  Functioning Day
0             Yes
1             Yes
2             Yes
3             Yes
4             Yes
```

[11]:
```
bike_df.shape
```

[11]:
```
(8760, 14)
```

0.1.1 Total of 8760 records with 14 features found in dataset

[12]:
```
bike_df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 8760 entries, 0 to 8759
Data columns (total 14 columns):
 #   Column                     Non-Null Count  Dtype
---  ------                     --------------  -----
 0   Date                       8760 non-null   datetime64[ns]
 1   Rented Bike Count          8760 non-null   int64
 2   Hour                       8760 non-null   int64
 3   Temperature(°C)            8760 non-null   float64
 4   Humidity(%)                8760 non-null   int64
 5   Wind speed (m/s)           8760 non-null   float64
 6   Visibility (10m)           8760 non-null   int64
 7   Dew point temperature(°C)  8760 non-null   float64
 8   Solar Radiation (MJ/m2)    8760 non-null   float64
 9   Rainfall(mm)               8760 non-null   float64
 10  Snowfall (cm)              8760 non-null   float64
 11  Seasons                    8760 non-null   object
 12  Holiday                    8760 non-null   object
 13  Functioning Day            8760 non-null   object
dtypes: datetime64[ns](1), float64(6), int64(4), object(3)
memory usage: 958.2+ KB
```

date type understanding

one date time

four features of integer data type

six features of float data type

three features are in object data type

below are numerical features

Rented Bike Count, Hour , Temperatures, Humidity, Wind Speed, Visibility, Dew point Temperatures, solar radiation, rainfall, and snowfall.

below are Categorical features

Season, Holliday, Functioning day

Target Variable

Rented Bike Count

Input Variable

Date, Hour , Temperatures, Humidity, Wind Speed, Visibility, Dew point Temperatures, solar radiation, rainfall, snowfall, Season, Holliday, Functioning day.

[17]:
```python
# description of numerical variables and catagorical variables
bike_df.describe(include='all').T                    # T is for transpose
```

[17]:
```
                            count unique                  top  freq  \
Date                         8760    365  2017-01-12 00:00:00    24
Rented Bike Count          8760.0    NaN                  NaN   NaN
Hour                       8760.0    NaN                  NaN   NaN
Temperature(°C)            8760.0    NaN                  NaN   NaN
Humidity(%)                8760.0    NaN                  NaN   NaN
Wind speed (m/s)           8760.0    NaN                  NaN   NaN
Visibility (10m)           8760.0    NaN                  NaN   NaN
Dew point temperature(°C)  8760.0    NaN                  NaN   NaN
Solar Radiation (MJ/m2)    8760.0    NaN                  NaN   NaN
```

```
Rainfall(mm)                  8760.0    NaN                NaN   NaN
Snowfall (cm)                 8760.0    NaN                NaN   NaN
Seasons                         8760      4             Spring  2208
Holiday                         8760      2         No Holiday  8328
Functioning Day                 8760      2                Yes  8465

                                first       last         mean         std  \
Date                       2017-01-12 2018-12-11          NaN         NaN
Rented Bike Count                 NaT        NaT   704.602055  644.997468
Hour                              NaT        NaT         11.5    6.922582
Temperature(°C)                   NaT        NaT    12.882922   11.944825
Humidity(%)                       NaT        NaT    58.226256   20.362413
Wind speed (m/s)                  NaT        NaT     1.724909      1.0363
Visibility (10m)                  NaT        NaT  1436.825799  608.298712
Dew point temperature(°C)         NaT        NaT     4.073813   13.060369
Solar Radiation (MJ/m2)           NaT        NaT     0.569111    0.868746
Rainfall(mm)                      NaT        NaT     0.148687    1.128193
Snowfall (cm)                     NaT        NaT     0.075068    0.436746
Seasons                           NaT        NaT          NaN         NaN
Holiday                           NaT        NaT          NaN         NaN
Functioning Day                   NaT        NaT          NaN         NaN

                            min    25%     50%      75%     max
Date                        NaN    NaN     NaN      NaN     NaN
Rented Bike Count           0.0  191.0   504.5  1065.25  3556.0
Hour                        0.0   5.75    11.5    17.25    23.0
Temperature(°C)           -17.8    3.5    13.7     22.5    39.4
Humidity(%)                 0.0   42.0    57.0     74.0    98.0
Wind speed (m/s)            0.0    0.9     1.5      2.3     7.4
Visibility (10m)           27.0  940.0  1698.0   2000.0  2000.0
Dew point temperature(°C) -30.6   -4.7     5.1     14.8    27.2
Solar Radiation (MJ/m2)     0.0    0.0    0.01     0.93    3.52
Rainfall(mm)                0.0    0.0     0.0      0.0    35.0
Snowfall (cm)               0.0    0.0     0.0      0.0     8.8
Seasons                     NaN    NaN     NaN      NaN     NaN
Holiday                     NaN    NaN     NaN      NaN     NaN
Functioning Day             NaN    NaN     NaN      NaN     NaN
```

0.1.2 Preprocessing The Data

[18]:
```
bike_df.isnull().sum()
```

[18]:
```
Date                         0
Rented Bike Count            0
Hour                         0
Temperature(°C)              0
Humidity(%)                  0
```

```
Wind speed (m/s)            0
Visibility (10m)            0
Dew point temperature(°C)   0
Solar Radiation (MJ/m2)     0
Rainfall(mm)                0
Snowfall (cm)               0
Seasons                     0
Holiday                     0
Functioning Day             0
dtype: int64
```

No missing values found above

Check for any missing values

[20]:
```python
bike_df.duplicated().sum()
```

[20]:
```
0
```

[21]:
```python
bike_df.columns
```

[21]:
```
Index(['Date', 'Rented Bike Count', 'Hour', 'Temperature(°C)', 'Humidity(%)',
       'Wind speed (m/s)', 'Visibility (10m)', 'Dew point temperature(°C)',
       'Solar Radiation (MJ/m2)', 'Rainfall(mm)', 'Snowfall (cm)', 'Seasons',
       'Holiday', 'Functioning Day'],
      dtype='object')
```

0.1.3 Feature engineering on Date column

[22]:
```python
bike_df['year'] = bike_df['Date'].map(lambda x: x.year).astype('object')
bike_df['month'] = bike_df['Date'].dt.month_name()
bike_df['day'] = bike_df['Date'].dt.day_name()
```

0.1.4 date column can be dropped

[23]:
```python
bike_df.drop(columns=['Date'], inplace=True)
```

[24]:
```python
bike_df.head()
```

[24]:
```
   Rented Bike Count  Hour  Temperature(°C)  Humidity(%)  Wind speed (m/s)  \
0                254     0             -5.2           37               2.2
1                204     1             -5.5           38               0.8
2                173     2             -6.0           39               1.0
3                107     3             -6.2           40               0.9
4                 78     4             -6.0           36               2.3

   Visibility (10m)  Dew point temperature(°C)  Solar Radiation (MJ/m2)  \
```

```
0               2000                         -17.6                        0.0
1               2000                         -17.6                        0.0
2               2000                         -17.7                        0.0
3               2000                         -17.6                        0.0
4               2000                         -18.6                        0.0

   Rainfall(mm)  Snowfall (cm) Seasons     Holiday Functioning Day  year  \
0           0.0            0.0  Winter  No Holiday             Yes  2017
1           0.0            0.0  Winter  No Holiday             Yes  2017
2           0.0            0.0  Winter  No Holiday             Yes  2017
3           0.0            0.0  Winter  No Holiday             Yes  2017
4           0.0            0.0  Winter  No Holiday             Yes  2017

     month       day
0  January  Thursday
1  January  Thursday
2  January  Thursday
3  January  Thursday
4  January  Thursday
```

[25]:
```
bike_df.shape
```

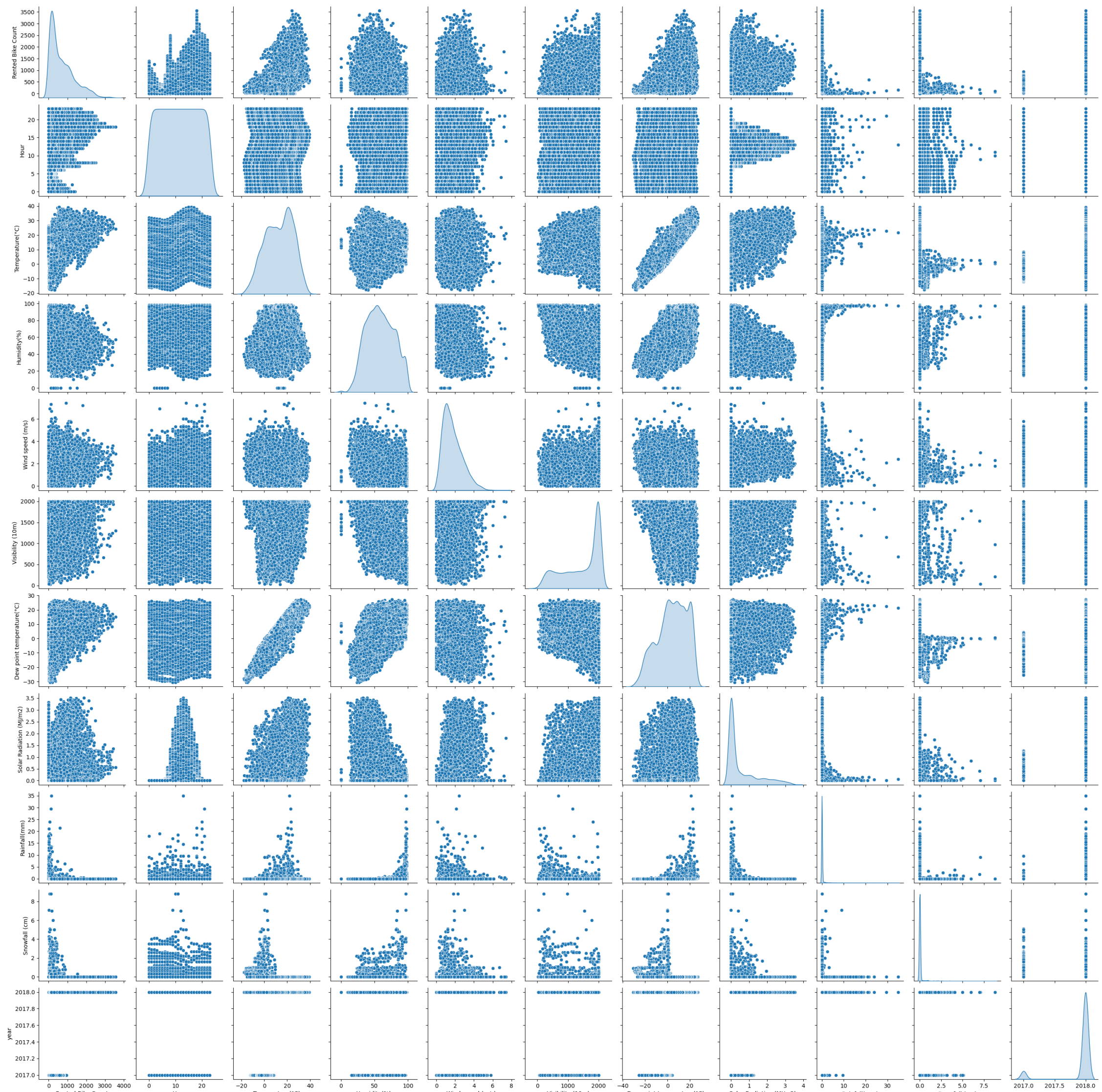
[25]: (8760, 16)

0.1.5 Data Visualization

how the features are related with each other

[26]:
```
sns.pairplot(bike_df, diag_kind= 'kde')
```

[26]: <seaborn.axisgrid.PairGrid at 0x7f78d2231c70>



[27]:
```
bike_df['Hour']= bike_df['Hour'].astype('object')     # converting numerical␣
↪Hour column datatype into categorical column
```

[28]:
```
bike_df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 8760 entries, 0 to 8759
Data columns (total 16 columns):
 #   Column                     Non-Null Count  Dtype
---  ------                     --------------  -----
 0   Rented Bike Count          8760 non-null   int64
 1   Hour                       8760 non-null   object
 2   Temperature(°C)            8760 non-null   float64
```

```
 3   Humidity(%)                8760 non-null   int64
 4   Wind speed (m/s)           8760 non-null   float64
 5   Visibility (10m)           8760 non-null   int64
 6   Dew point temperature(°C)  8760 non-null   float64
 7   Solar Radiation (MJ/m2)    8760 non-null   float64
 8   Rainfall(mm)               8760 non-null   float64
 9   Snowfall (cm)              8760 non-null   float64
 10  Seasons                    8760 non-null   object
 11  Holiday                    8760 non-null   object
 12  Functioning Day            8760 non-null   object
 13  year                       8760 non-null   object
 14  month                      8760 non-null   object
 15  day                        8760 non-null   object
dtypes: float64(6), int64(3), object(7)
memory usage: 1.1+ MB
```

identify how many Numerical Features && Categorical Features

[30]:
```
numeric_features = bike_df.describe().columns
categorical_features = bike_df.describe(include=['object','category']).columns
```

[31]:
```
numeric_features
```

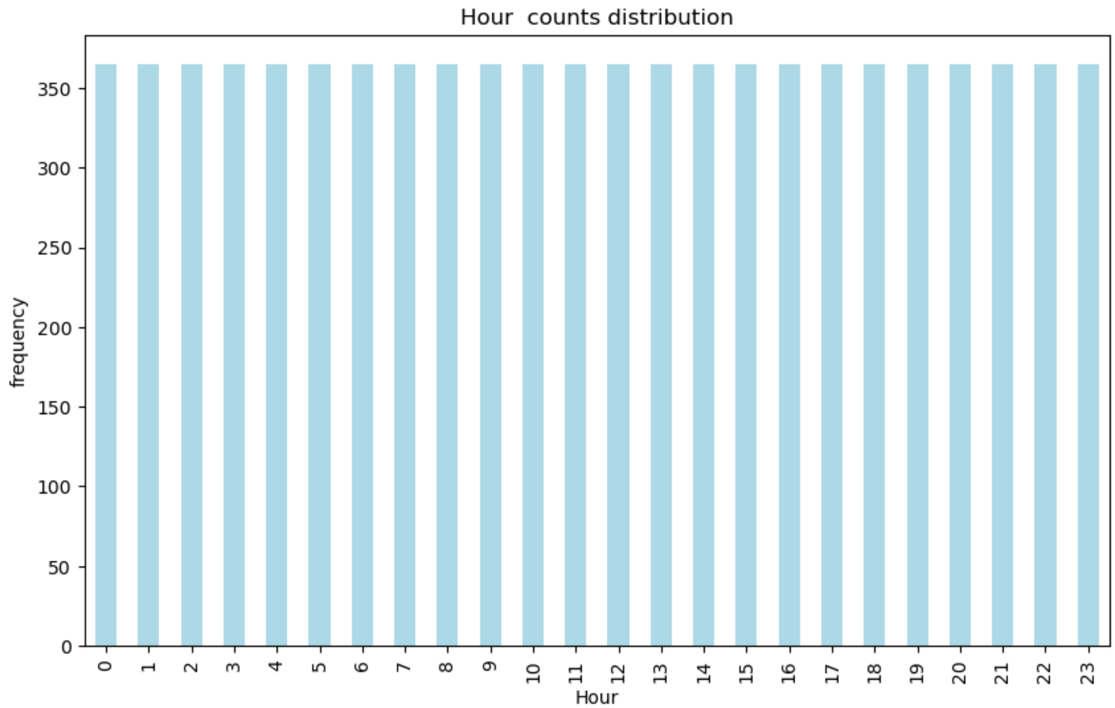
[31]:
```
Index(['Rented Bike Count', 'Temperature(°C)', 'Humidity(%)',
       'Wind speed (m/s)', 'Visibility (10m)', 'Dew point temperature(°C)',
       'Solar Radiation (MJ/m2)', 'Rainfall(mm)', 'Snowfall (cm)'],
      dtype='object')
```

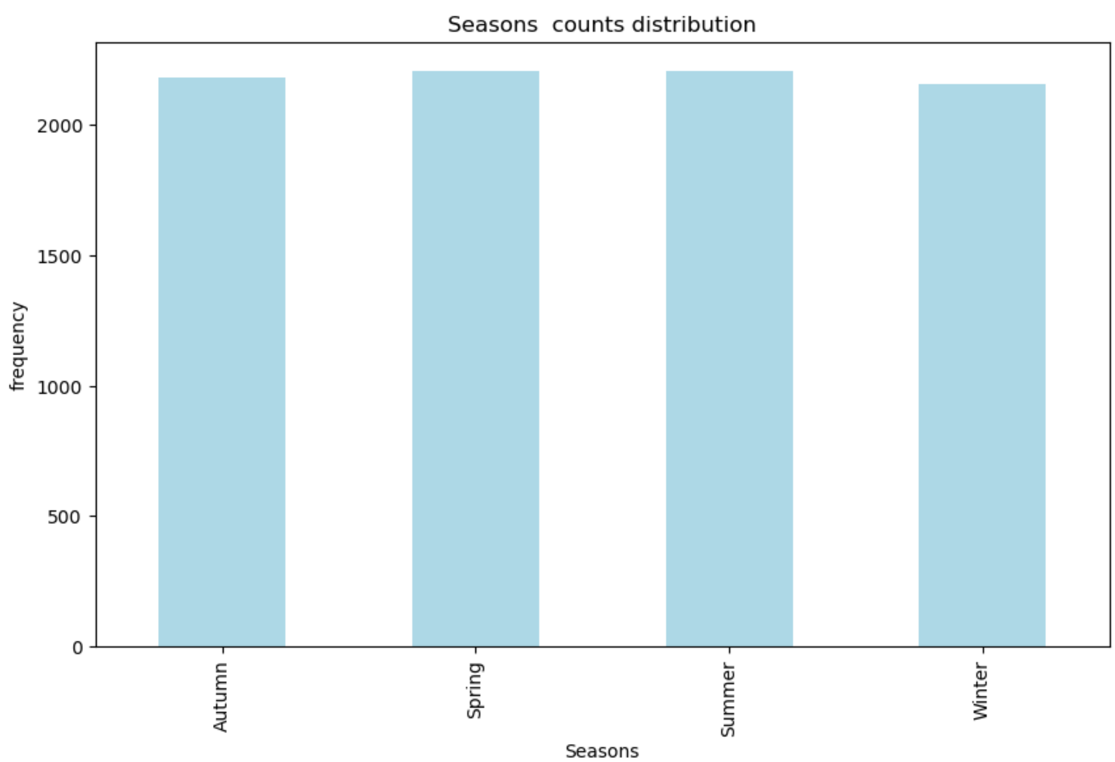
[32]:
```
categorical_features
```

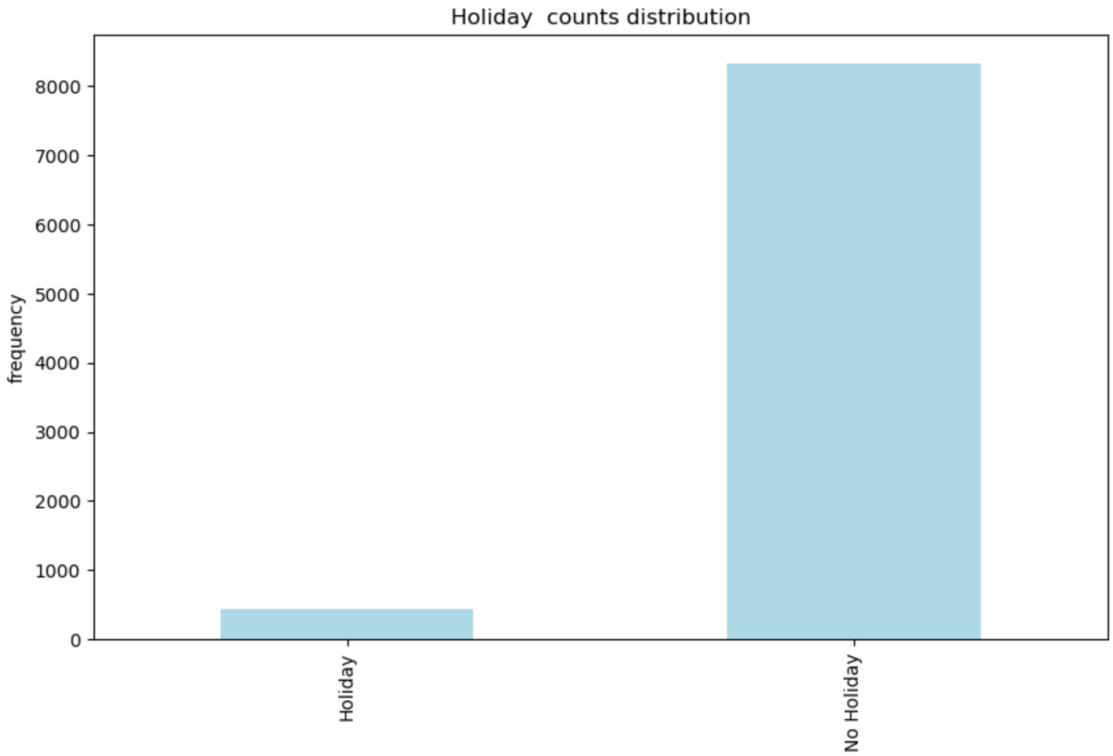
[32]:
```
Index(['Hour', 'Seasons', 'Holiday', 'Functioning Day', 'year', 'month',
       'day'],
      dtype='object')
```

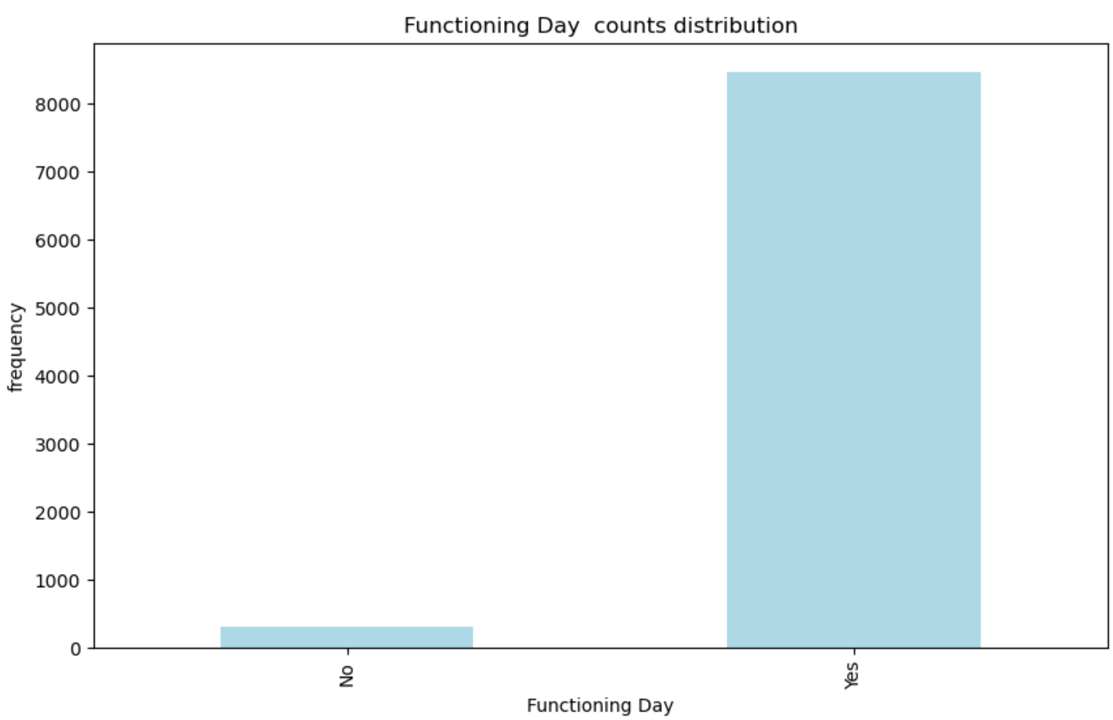
Analtze Categorical features

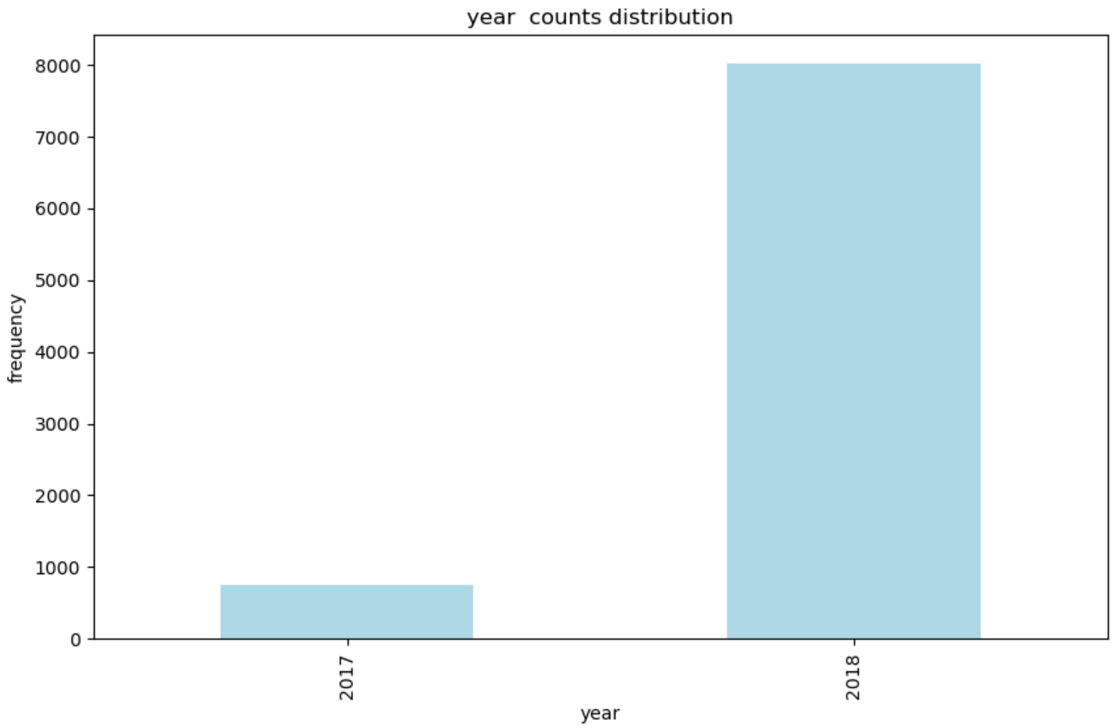
[35]:
```
# Ploting count plot for categorical features

for col in categorical_features:
  counts = bike_df[col].value_counts().sort_index()
  fig = plt.figure(figsize=(10,6))
  ax = fig.gca()
  counts.plot.bar(ax=ax,color='lightblue')
  ax.set_title(col+'  counts distribution')
  ax.set_xlabel(col)
  ax.set_ylabel('frequency')

plt.show()
```

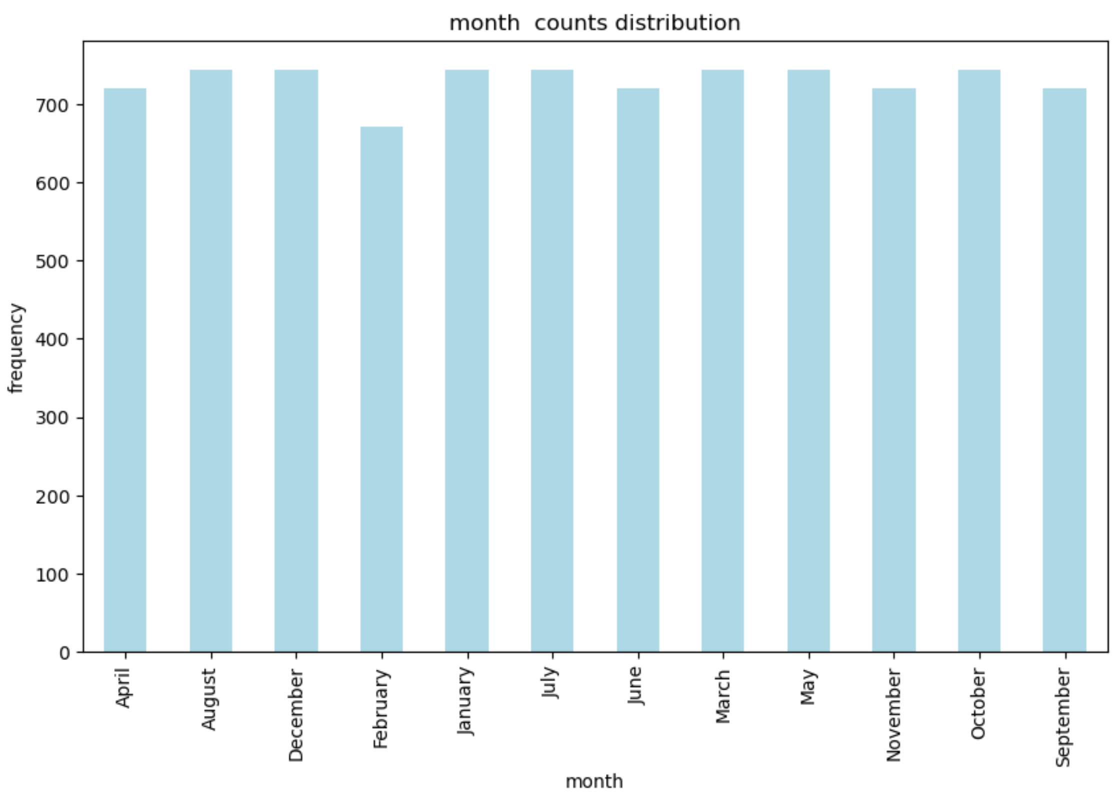

Hour counts distribution
frequency
0
50
100
150
200
250
300
350
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
Hour

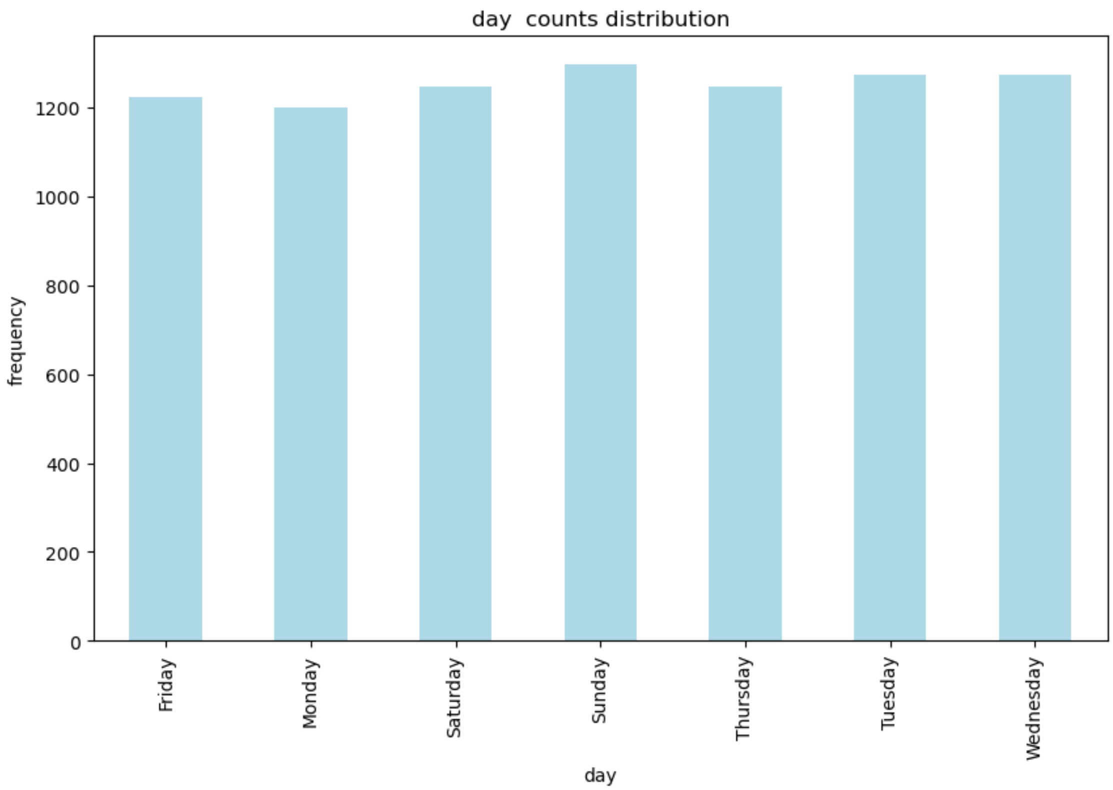

Seasons counts distribution
frequency
0
500
1000
1500
2000
Autumn
Spring
Summer
Winter
Seasons


Holiday counts distribution
frequency
0
1000
2000
3000
4000
5000
6000
7000
8000
Holiday
No Holiday
Holiday


Functioning Day counts distribution
frequency
0
1000
2000
3000
4000
5000
6000
7000
8000
No
Yes
Functioning Day


year counts distribution
frequency
0
1000
2000
3000
4000
5000
6000
7000
8000
2017
2018
year


month counts distribution
frequency
0
100
200
300
400
500
600
700
April
August
December
February
January
July
June
March
May
November
October
September
month



Year column reveals that 80% data is for year 2018.

functioning day column we can say 90% data present is for when functioning day is present.

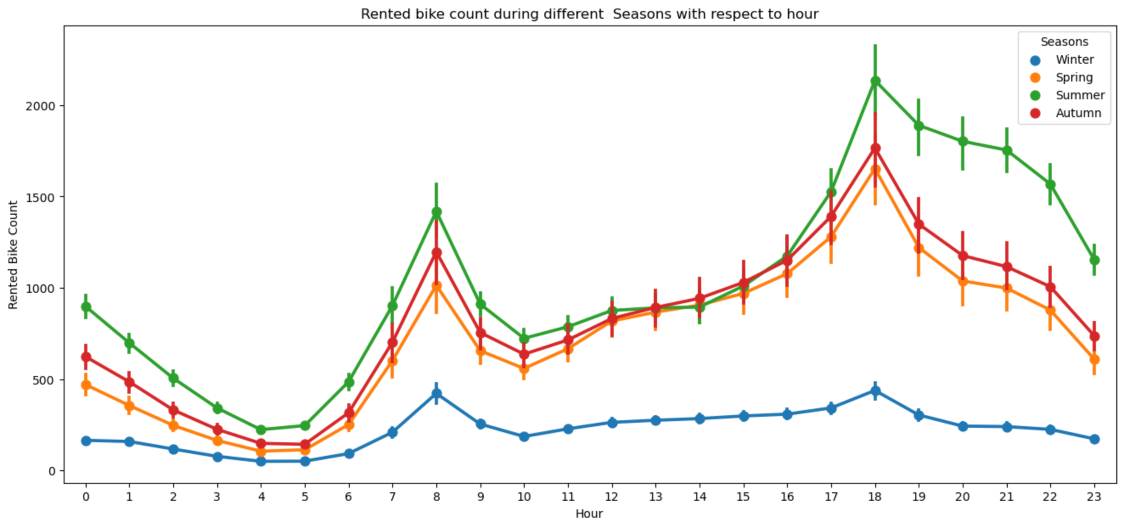
Holiday column feature we can predict that most of the Data is present for Non holiday.

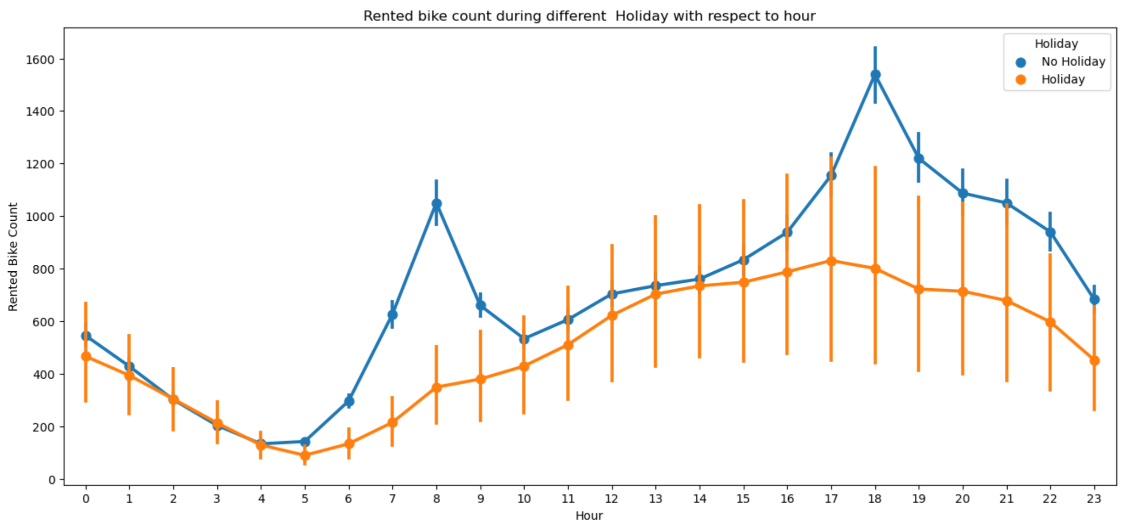
Data distribution frequency is evenly distributed in (Autumn(Fall), Spring, Summer, Winter)

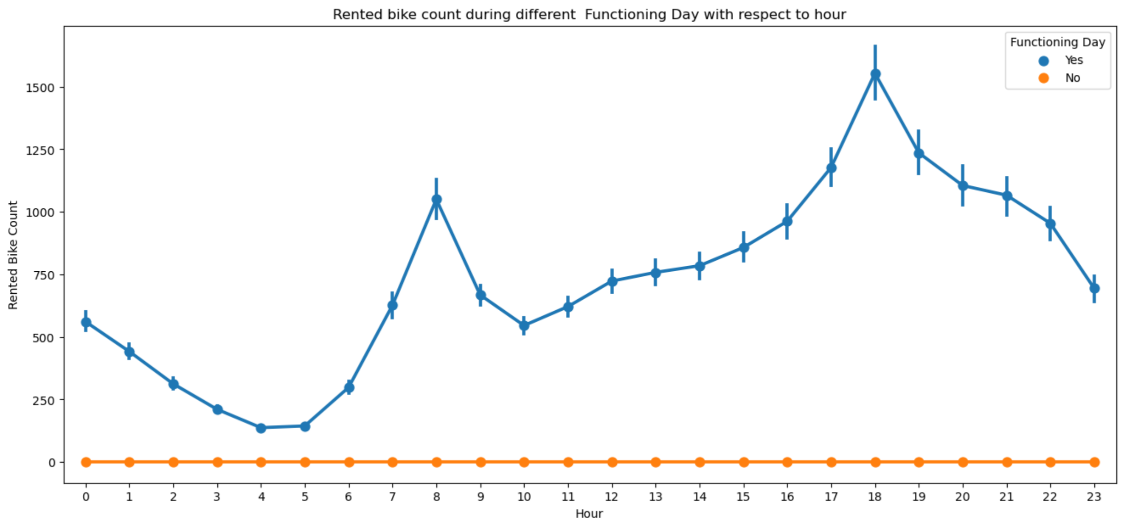
0.1.6 How the categorical features are distributed with respect to dependent feature for different hours in a day.

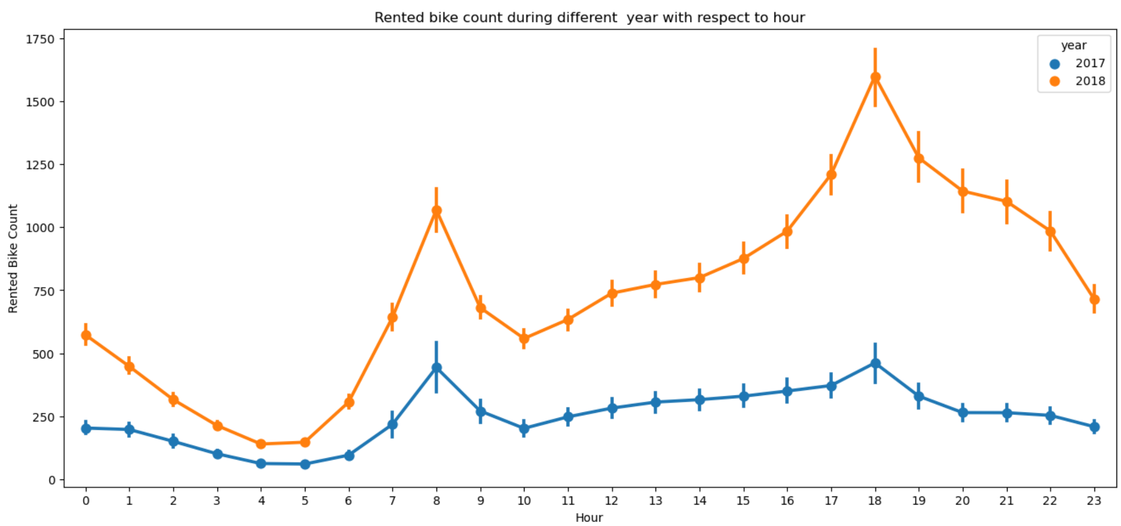
[36]:
```
for col in categorical_features:
  if col == 'Hour':
    pass

  else :
    plt.figure(figsize=(16,7))
```

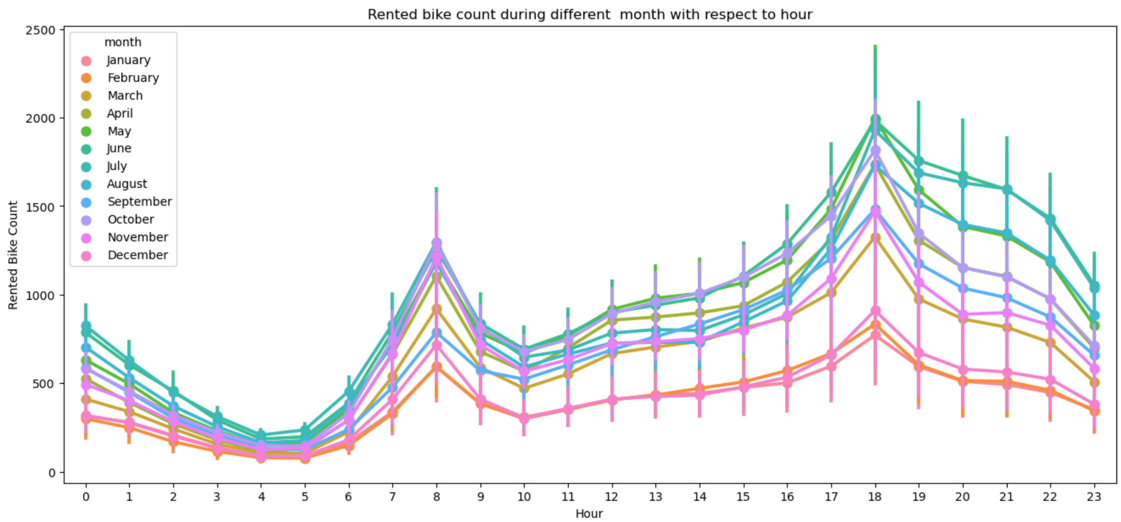
```
    sns.pointplot(x=bike_df['Hour'], y= bike_df['Rented Bike Count'],␣
↪hue=bike_df[col])
    plt.title(f'Rented bike count during different  {col} with respect to hour')

plt.show()
```

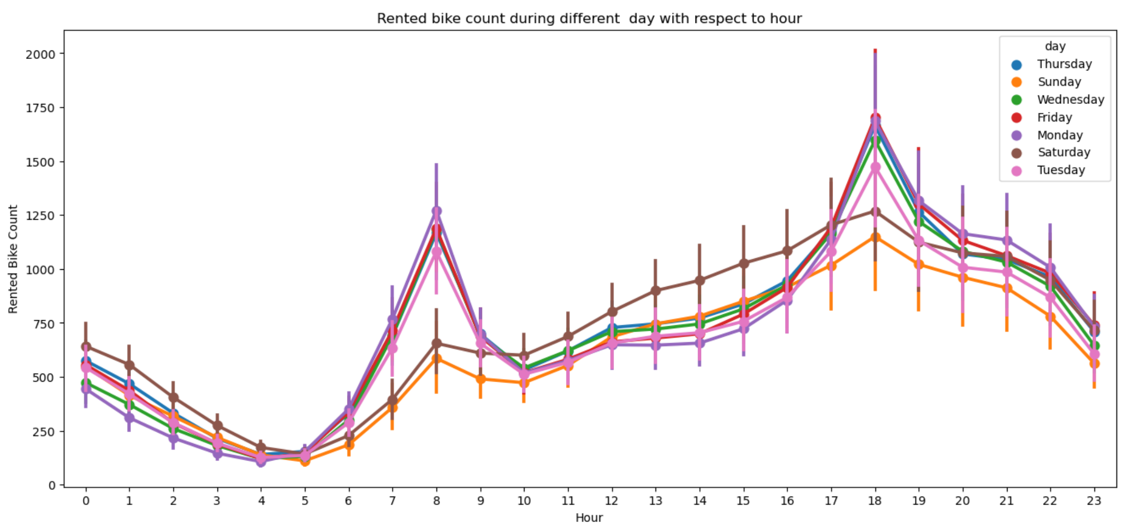





Rented bike count during different Functioning Day with respect to hour
Functioning Day
Yes
No
Rented Bike Count
Hour


Rented bike count during different year with respect to hour
year
2017
2018
Rented Bike Count
Hour





Seasonal demand for bikes is lower during winter and higher during summer, as evident from the Season column.

Demand during holidays is lower compared to non-holidays, possibly due to people using bikes for commuting to work, as stated in the Holiday column.

No demand exists on days when there is no Functioning Day, as mentioned in the Functioning Day column.

Demand for rented bikes increased in 2018 as compared to 2017, which could be attributed to increased awareness about rented bike facilities in 2017.

The Days of week column indicates a different demand pattern on weekdays and weekends. Afternoon demand on weekends is higher, while office hours show higher demand during weekdays.

Demand is lower in December, January, and February as these months are cold and the Season column already established low demand during winters. This information is clearly visible in the Month column.

0.1.7 Feature Engineering

[38]:
```
def hour(h):

  if h >= 7 and h <=10:
    return 'Morning'

  elif h>=11 and h<=16:
    return 'Afternoon'

  elif h>=17 and h<=22:
    return 'Evening'

  else:
    return 'Night'
```

[39]:
```
bike_df['Hour'] = bike_df['Hour'].apply(hour)
```

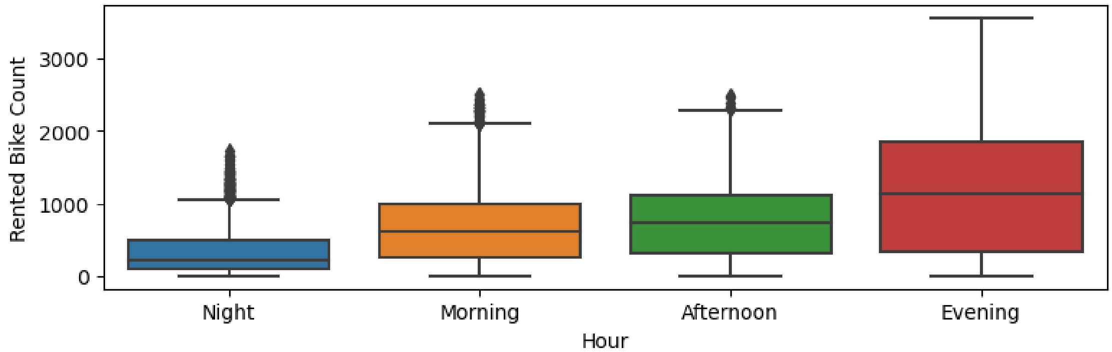
[40]:
```
bike_df['Hour'].value_counts()
```

[40]:
```
Night        2920
Afternoon    2190
Evening      2190
Morning      1460
Name: Hour, dtype: int64
```

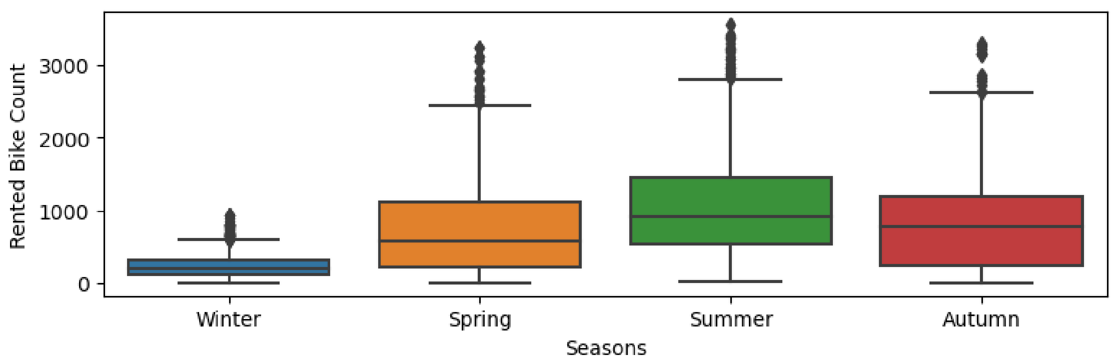
Checking if some outliers present in categroical features as wrt dependent variable.

[42]:
```
n=1
for i in categorical_features:
  plt.figure(figsize=(15,15))
  plt.subplot(6,2,n)
  n+=1
  print('\n')
  print('='*70,i,'='*70)
  print('\n')
  sns.boxplot(x=bike_df[i],y=bike_df["Rented Bike Count"])
  plt.tight_layout()
  plt.show()
```

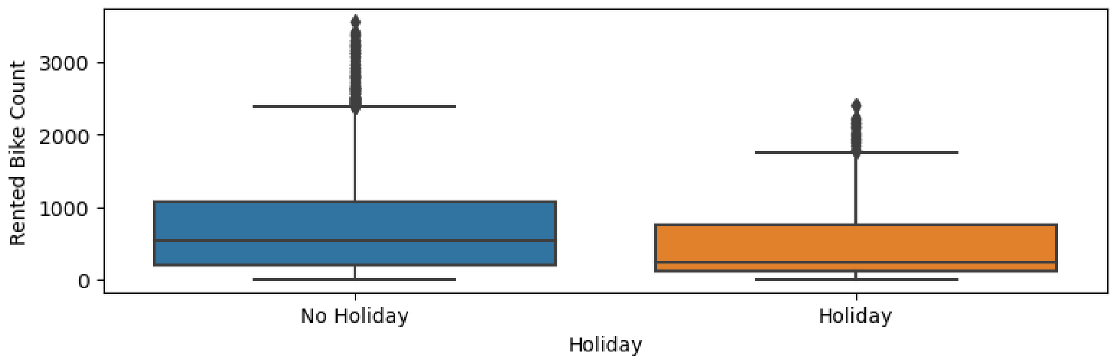
== Hour
==



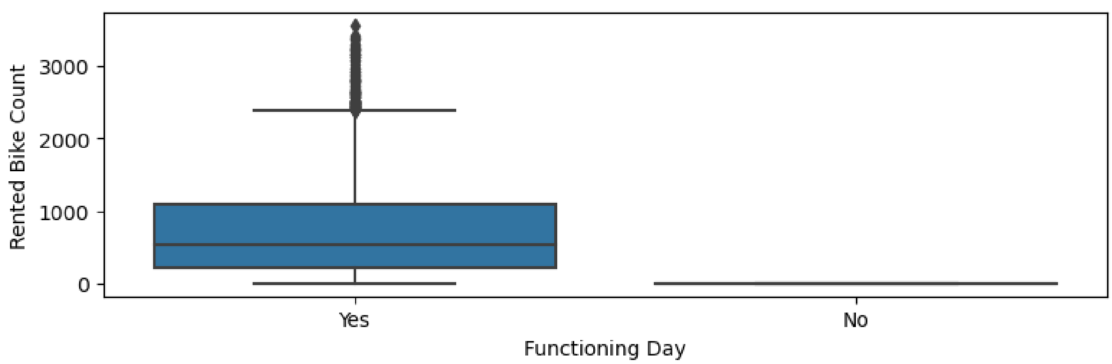
== Seasons
==



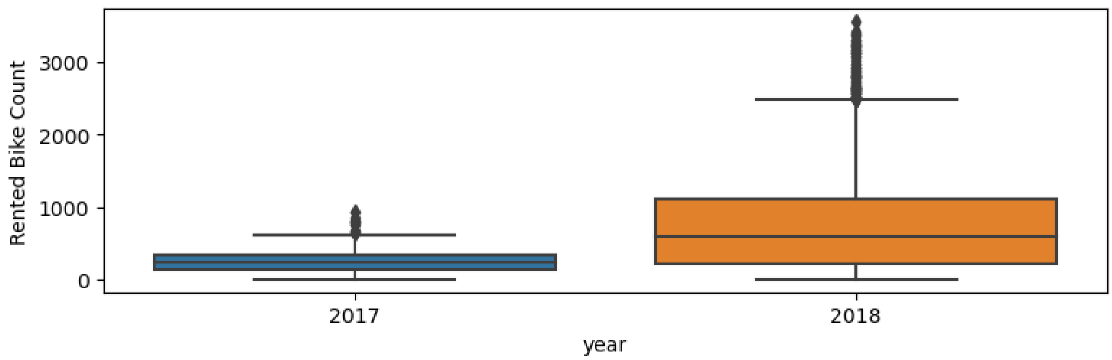
== Holiday
==



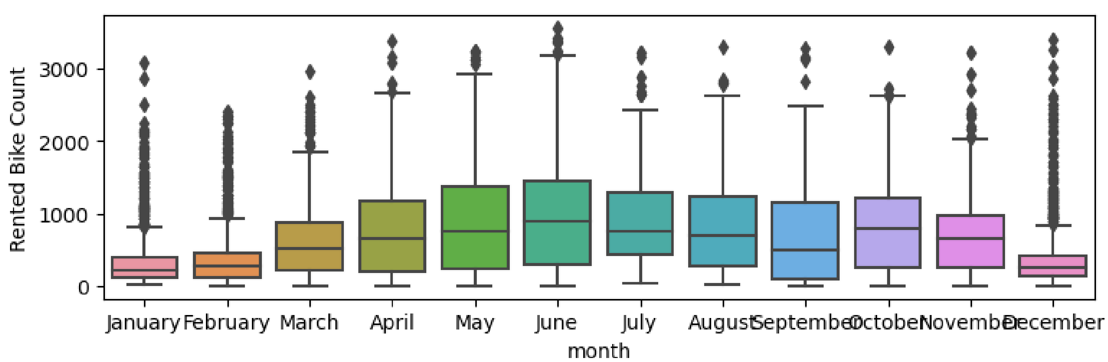

```
======================================================================
Functioning Day
======================================================================
```



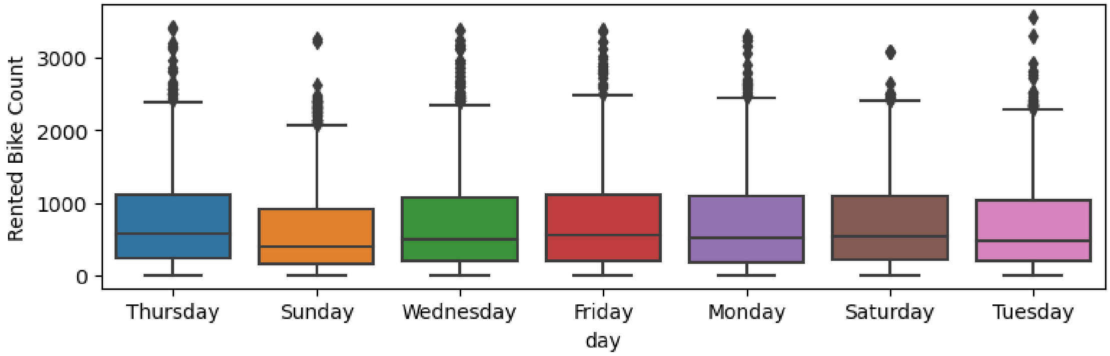

```
====================================================================== year
======================================================================
```


Rented Bike Count
3000
2000
1000
0
2017
2018
year

```
======================================================================= month
=======================================================================
```


Rented Bike Count
3000
2000
1000
0
January
February
March
April
May
June
July
August
September
October
November
December
month

```
======================================================================= day
=======================================================================
```



It is recommended to update the day columns to differentiate between weekdays and weekends for better observation, based on the pattern of higher demand for rented bikes in the afternoon on weekends and during office hours on weekdays.

[43]:
```
bike_df['week'] = bike_df['day'].apply(lambda x:'Weekend'  if x=='Saturday' or ␣
↪x== 'Sunday' else 'Weekdays')
```

[44]:
```
bike_df.head(2)
```

[44]:
```
   Rented Bike Count   Hour  Temperature(°C)  Humidity(%)  Wind speed (m/s)  \
0                254  Night             -5.2           37               2.2
1                204  Night             -5.5           38               0.8

   Visibility (10m)  Dew point temperature(°C)  Solar Radiation (MJ/m2)  \
0              2000                      -17.6                      0.0
1              2000                      -17.6                      0.0

   Rainfall(mm)  Snowfall (cm) Seasons     Holiday Functioning Day  year  \
0           0.0            0.0  Winter  No Holiday             Yes  2017
1           0.0            0.0  Winter  No Holiday             Yes  2017

     month       day      week
0  January  Thursday  Weekdays
1  January  Thursday  Weekdays
```

Now no need of day column in datframe so we can remove it.

[46]:
```
bike_df.drop(columns=['day'], inplace=True)
```

[47]:
```
bike_df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 8760 entries, 0 to 8759
Data columns (total 16 columns):
 #   Column                     Non-Null Count  Dtype
```

```
 ---  ------                         --------------  -----
  0   Rented Bike Count              8760 non-null   int64
  1   Hour                           8760 non-null   object
  2   Temperature(°C)                8760 non-null   float64
  3   Humidity(%)                    8760 non-null   int64
  4   Wind speed (m/s)               8760 non-null   float64
  5   Visibility (10m)               8760 non-null   int64
  6   Dew point temperature(°C)      8760 non-null   float64
  7   Solar Radiation (MJ/m2)        8760 non-null   float64
  8   Rainfall(mm)                   8760 non-null   float64
  9   Snowfall (cm)                  8760 non-null   float64
  10  Seasons                        8760 non-null   object
  11  Holiday                        8760 non-null   object
  12  Functioning Day                8760 non-null   object
  13  year                           8760 non-null   object
  14  month                          8760 non-null   object
  15  week                           8760 non-null   object
 dtypes: float64(6), int64(3), object(7)
 memory usage: 1.1+ MB
```

[48]:
```
categorical_features
```

[48]:
```
Index(['Hour', 'Seasons', 'Holiday', 'Functioning Day', 'year', 'month',
       'day'],
      dtype='object')
```

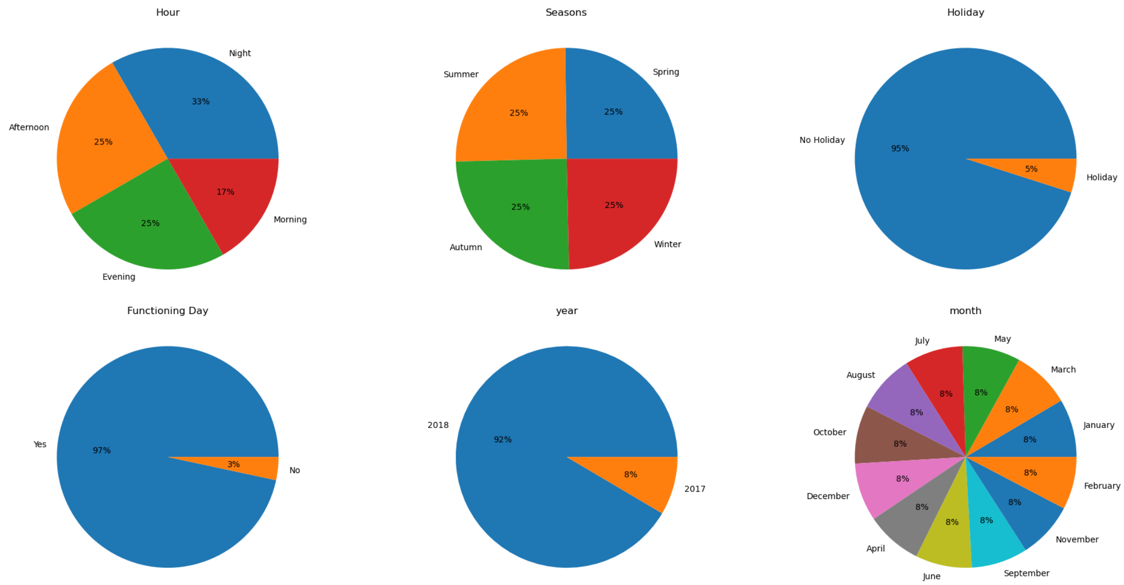
[49]:
```
#dropping day column
categorical_features = categorical_features.drop('day')
```

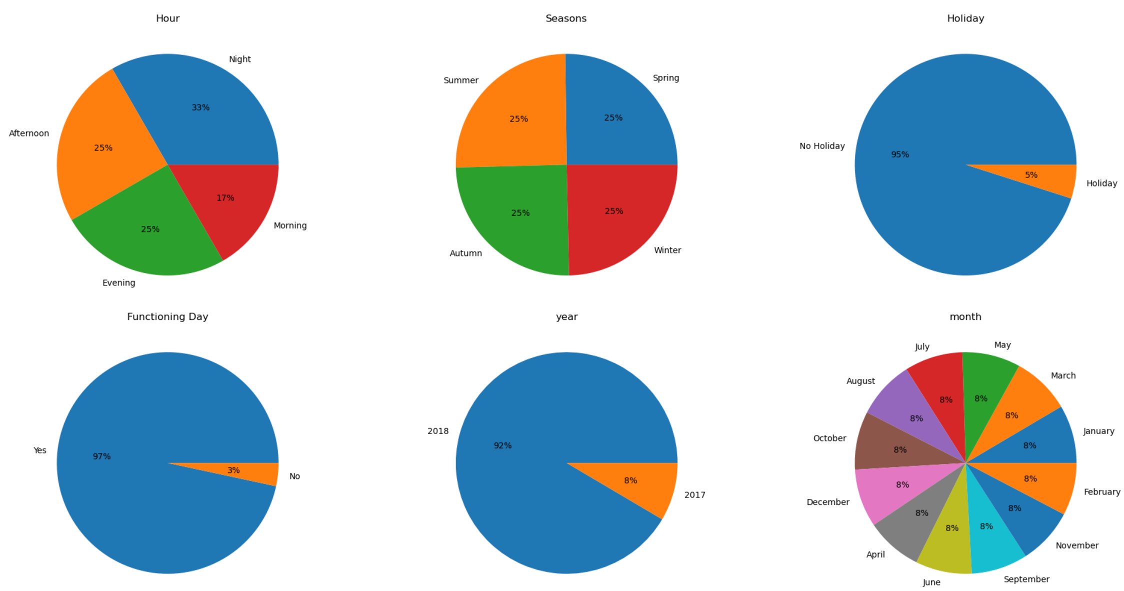
[50]:
```
categorical_features
```

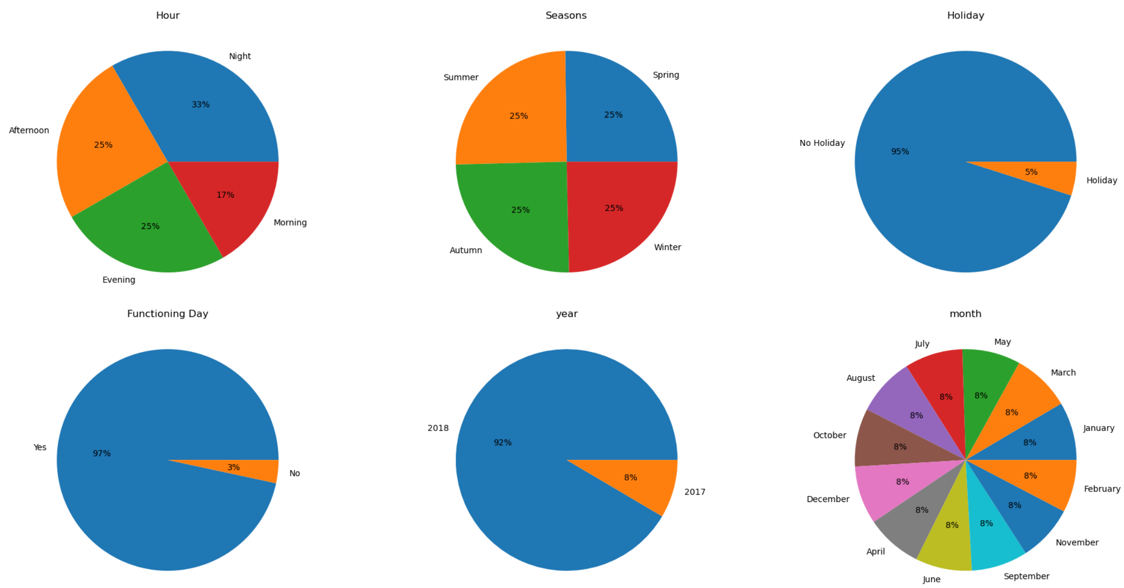
[50]:
```
Index(['Hour', 'Seasons', 'Holiday', 'Functioning Day', 'year', 'month'],
dtype='object')
```

0.1.8 Checking how much percentage of features present in dataset

[54]:
```
n=1
plt.figure(figsize=(20,15))
for i in categorical_features:
  plt.subplot(3,3,n)
  n=n+1
  plt.pie(bike_df[i].value_counts(),labels = bike_df[i].value_counts().keys().
 ↪tolist(),autopct='%.0f%%')
  plt.title(i)
  plt.tight_layout()
plt.show()
```


Hour
Night
33%
Afternoon
25%
17%
Morning
25%
Evening
Seasons
Summer
Spring
25%
25%
25%
25%
Autumn
Winter
Holiday
No Holiday
95%
5%
Holiday
Functioning Day
Yes
97%
3%
No
year
2018
92%
8%
2017
month
July
May
August
March
October
January
February
December
November
April
June
September
8%


Hour
Night
33%
Afternoon
25%
17%
Morning
25%
Evening
Seasons
Summer
Spring
25%
25%
25%
25%
Autumn
Winter
Holiday
No Holiday
95%
5%
Holiday
Functioning Day
Yes
97%
3%
No
year
2018
92%
8%
2017
month
July
May
August
March
October
January
February
December
November
April
June
September
8%

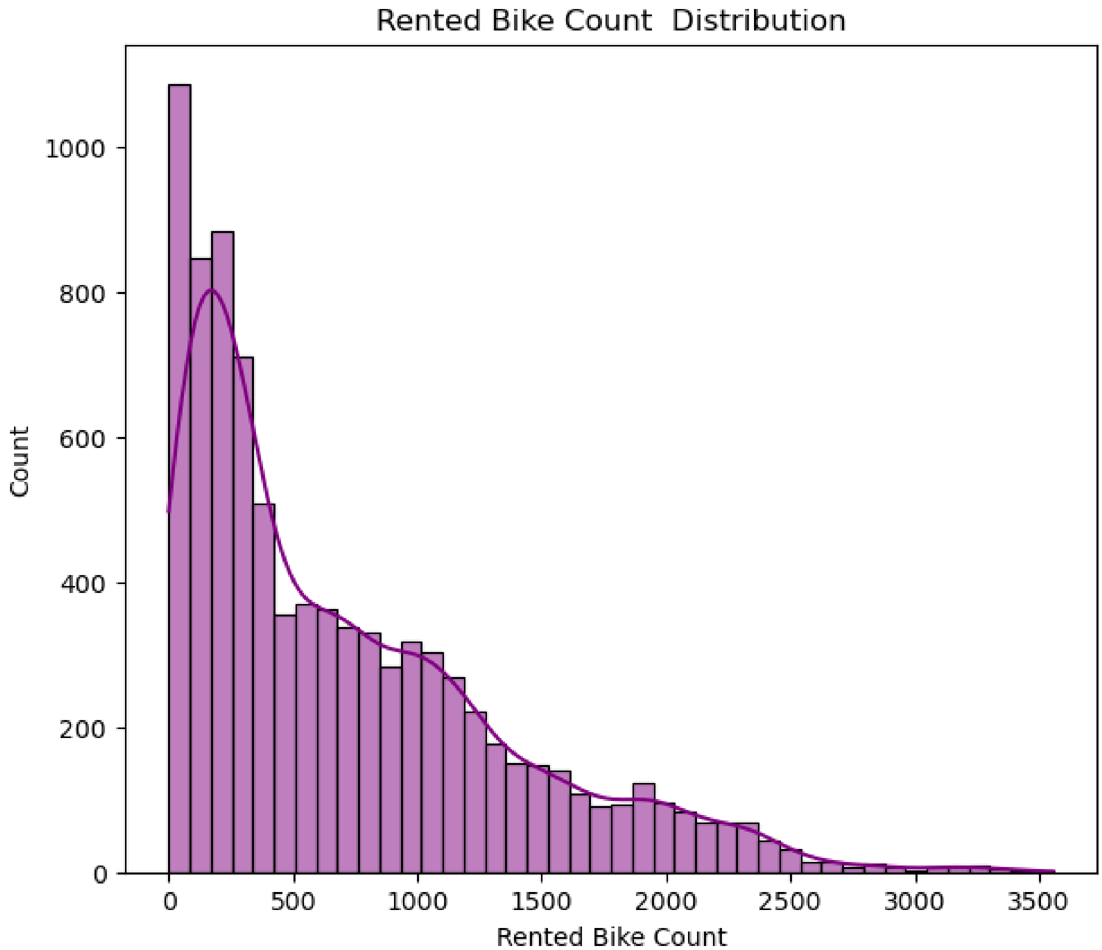


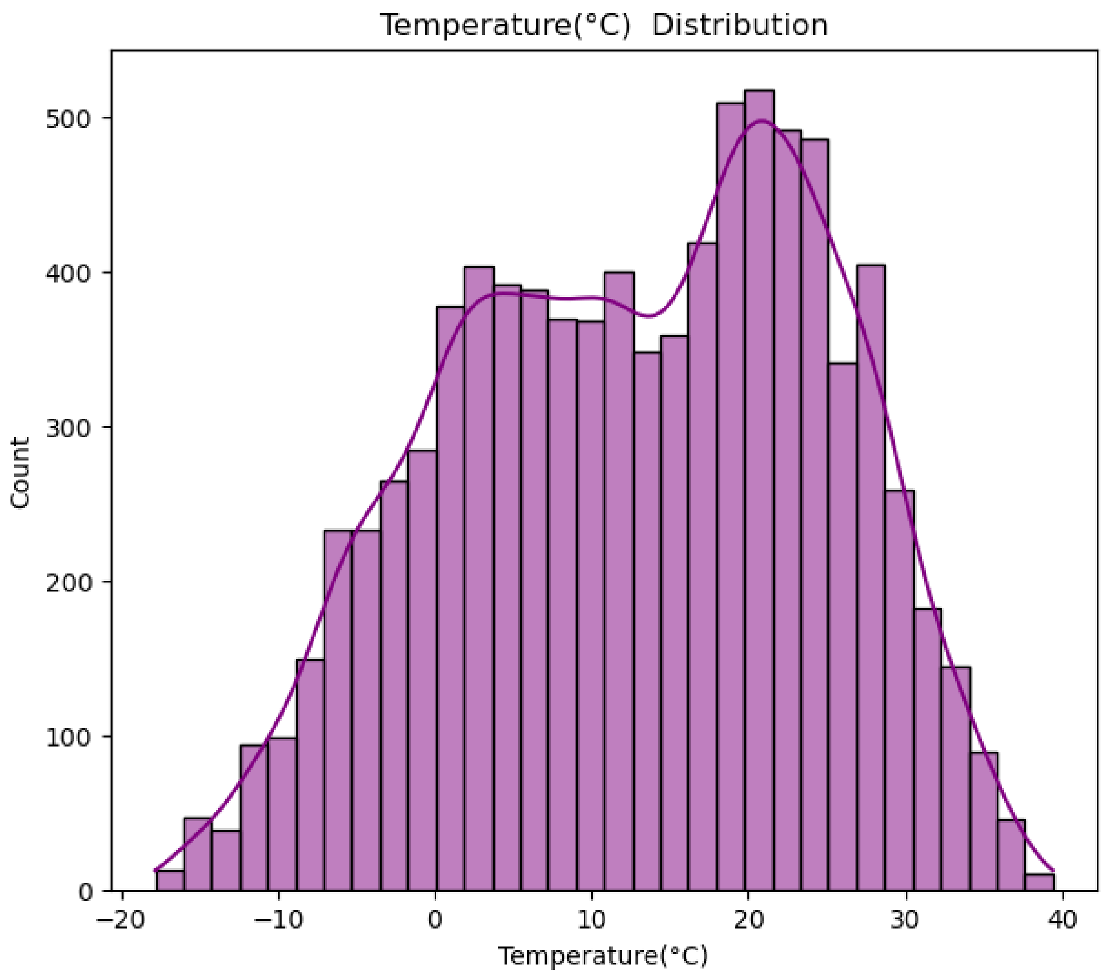
The “Holiday” feature contains 95% data for non-holidays, which is crucial for predicting bike rental counts.

The year 2018 accounts for 92% of the data in the year feature, indicating a significant increase in the use of rented bikes in that year.

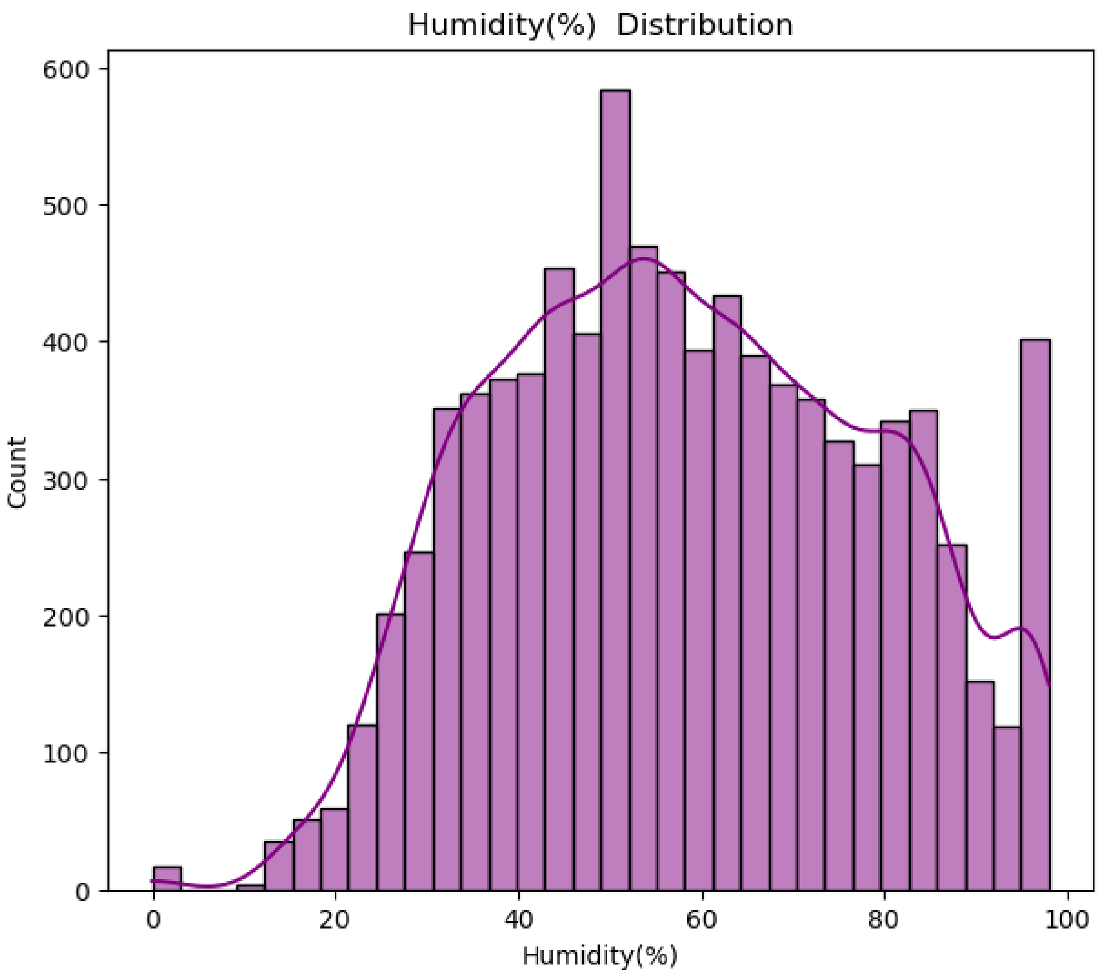
0.1.9 Analysing Numerical Features

[55]:
```
for col in numeric_features:
    fig = plt.figure(figsize=(7, 6))
    ax = fig.gca()
    feature = bike_df[col]
    sns.histplot(data=bike_df,x=col ,ax = ax,color='purple', kde=True)
    plt.title(col + '  Distribution')

plt.show()
```

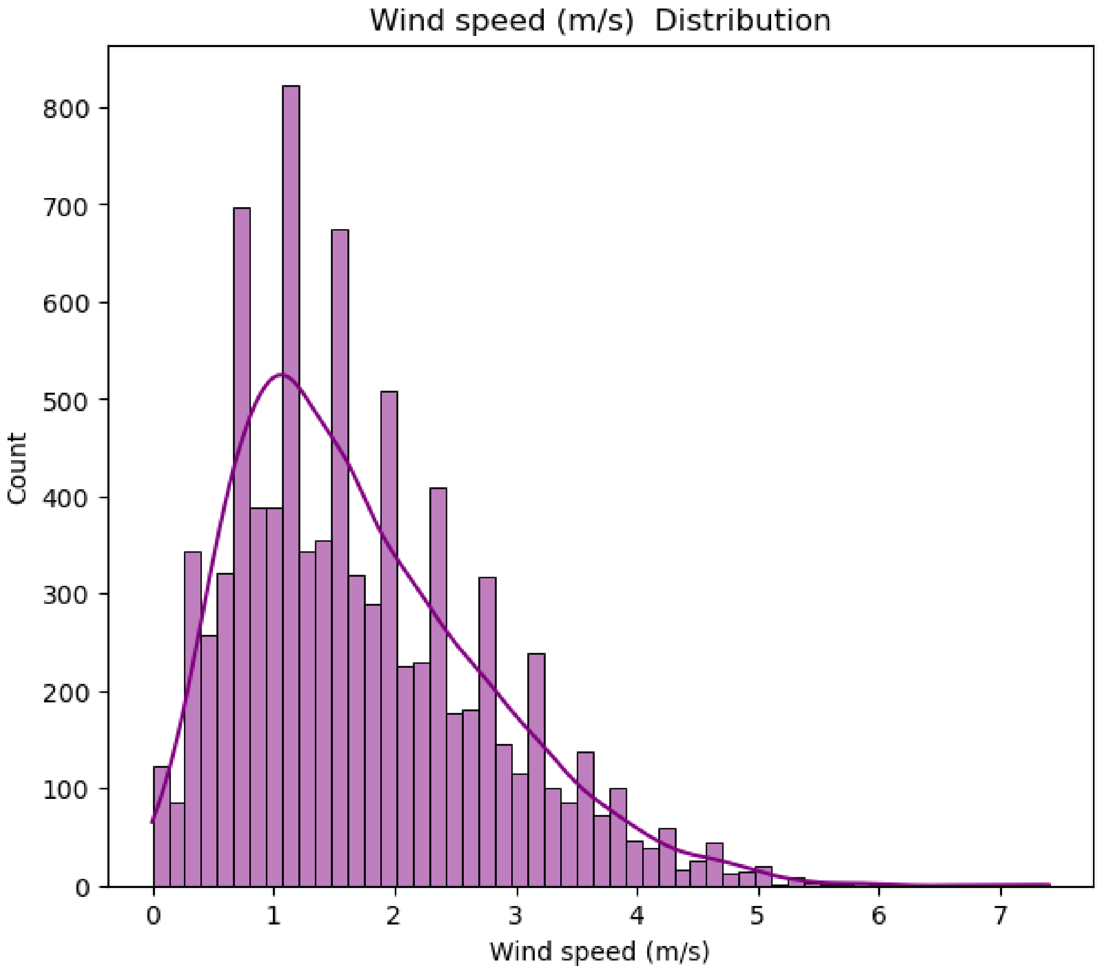

Rented Bike Count Distribution
Count
1000
800
600
400
200
0
0
500
1000
1500
2000
2500
3000
3500
Rented Bike Count

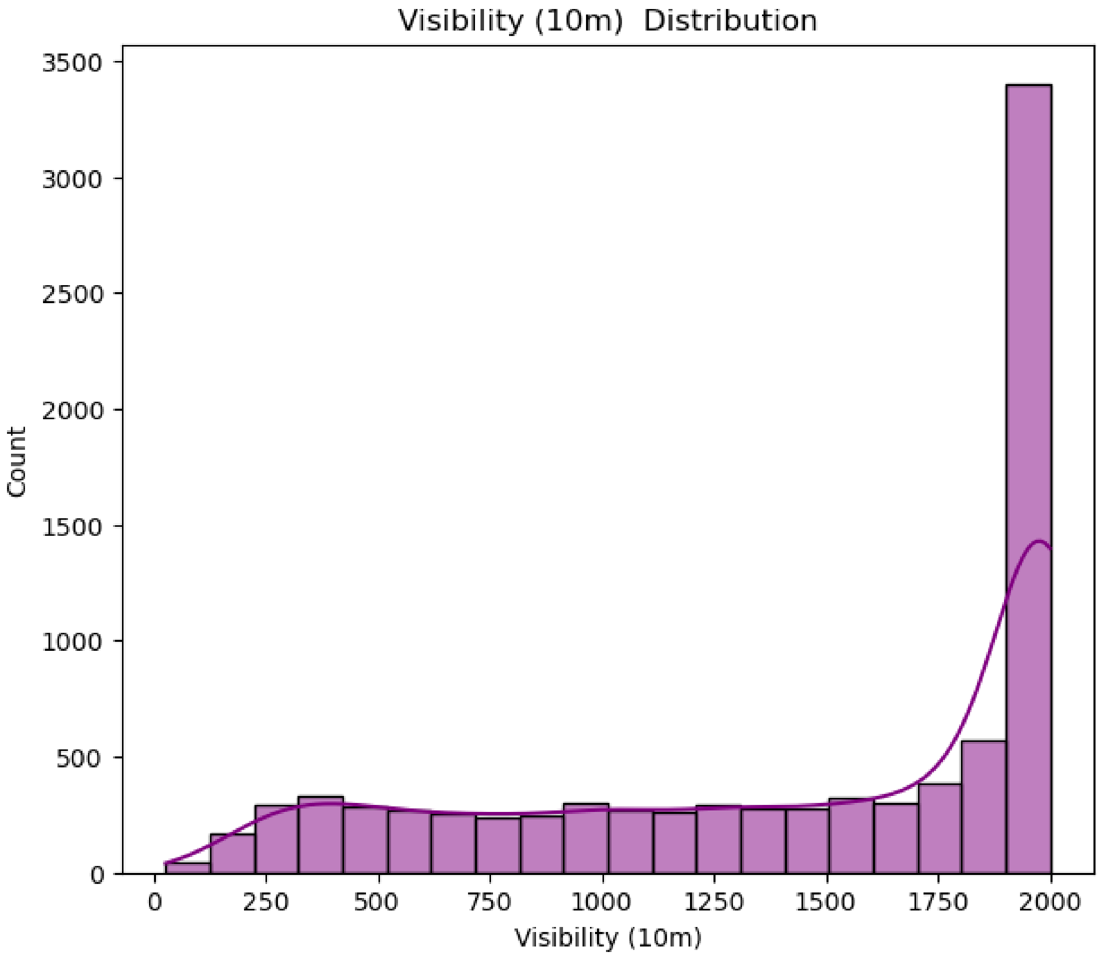


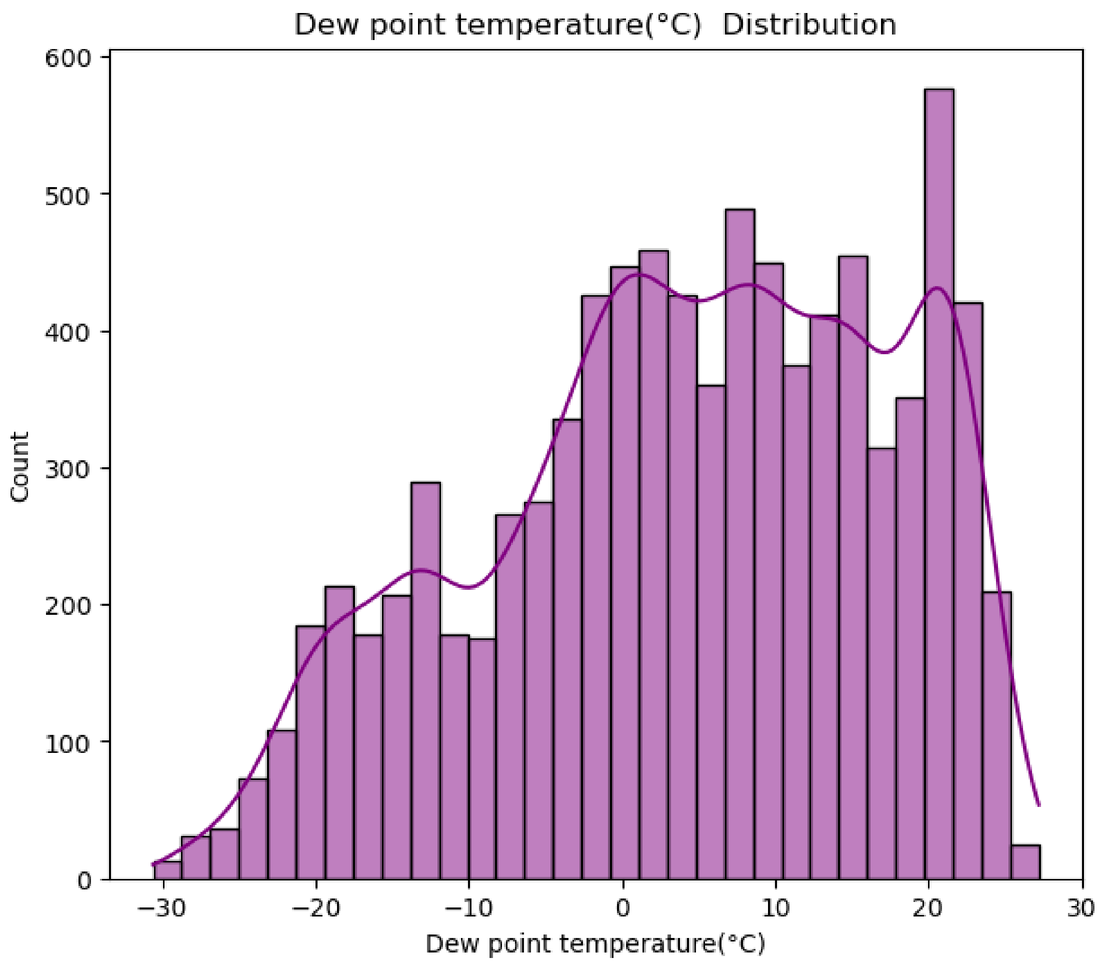
Temperature(°C) Distribution
Count
Temperature(°C)
500
400
300
200
100
0
−20
−10
0
10
20
30
40

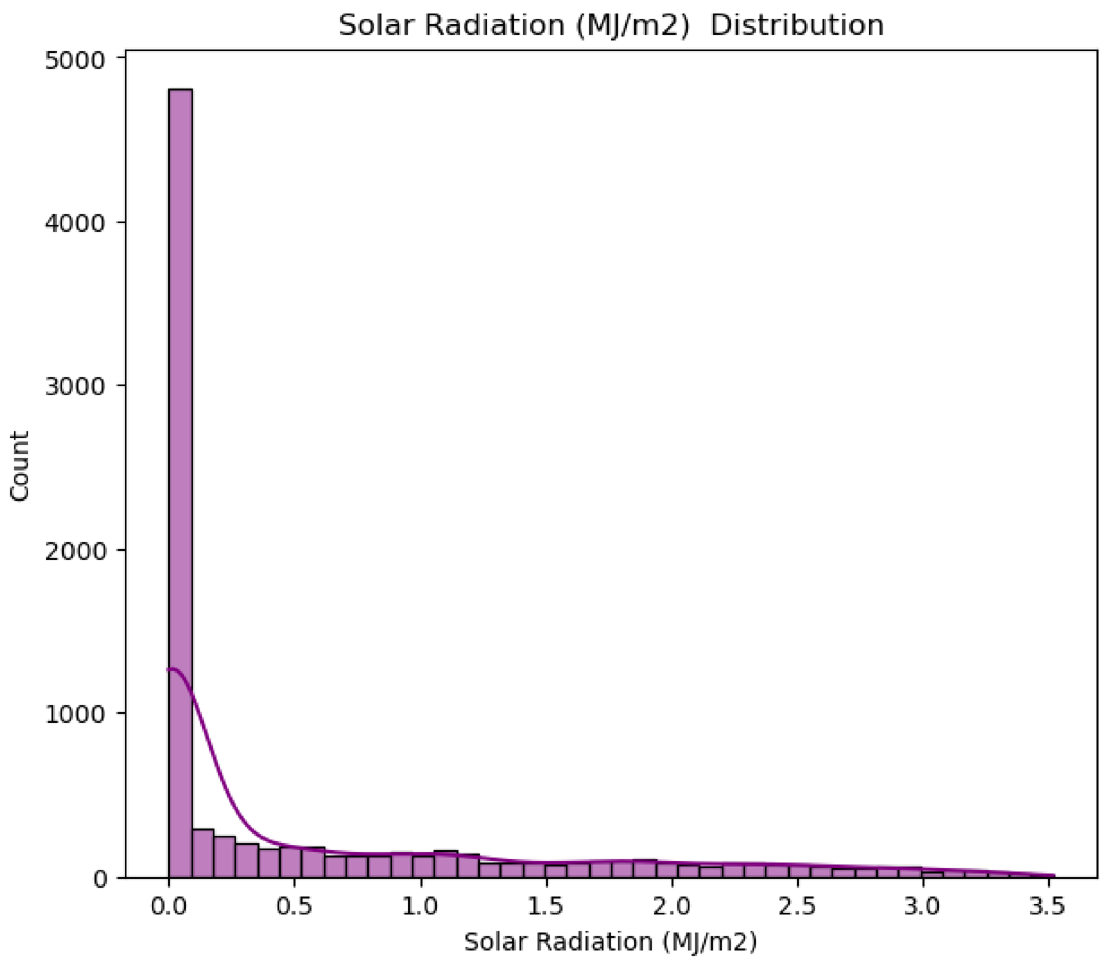


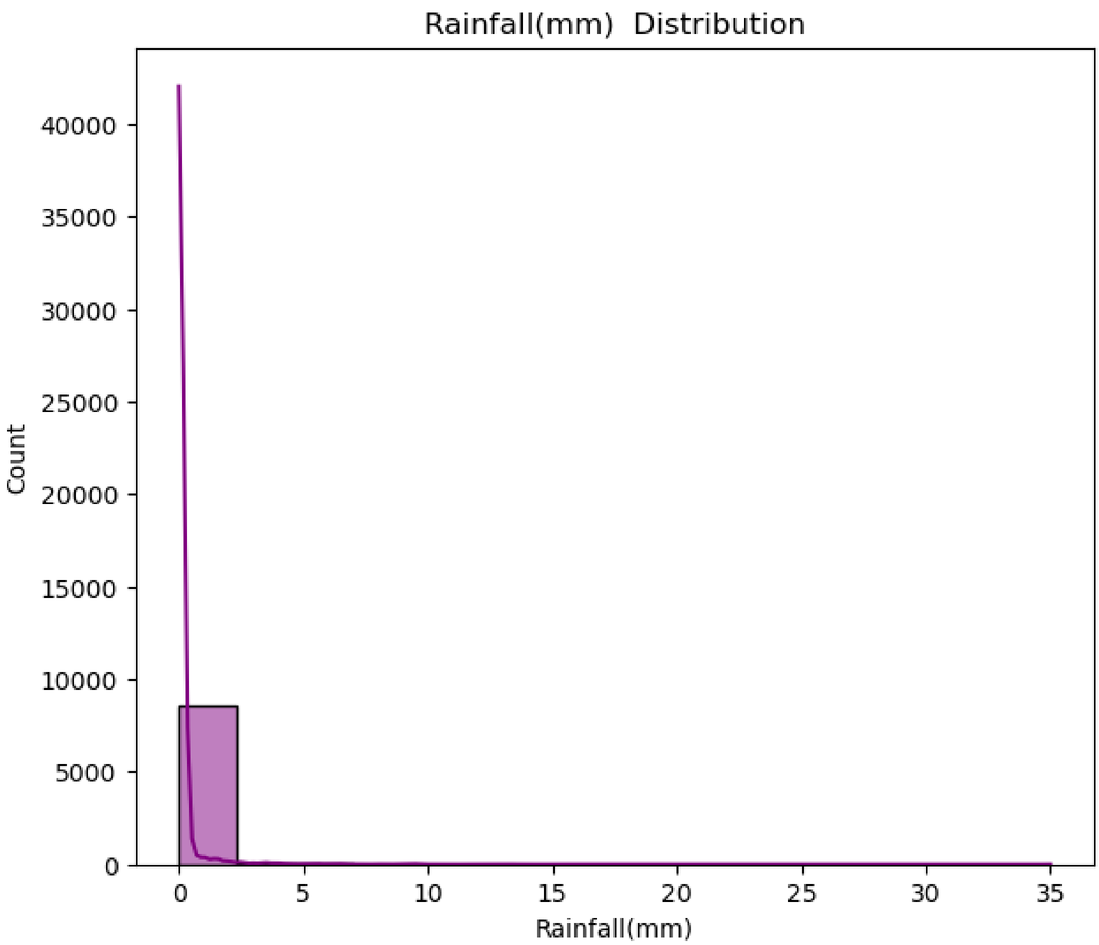
Humidity(%) Distribution
Count
Humidity(%)
0
100
200
300
400
500
600
0
20
40
60
80
100


Wind speed (m/s) Distribution
Count
Wind speed (m/s)
0
100
200
300
400
500
600
700
800
0
1
2
3
4
5
6
7

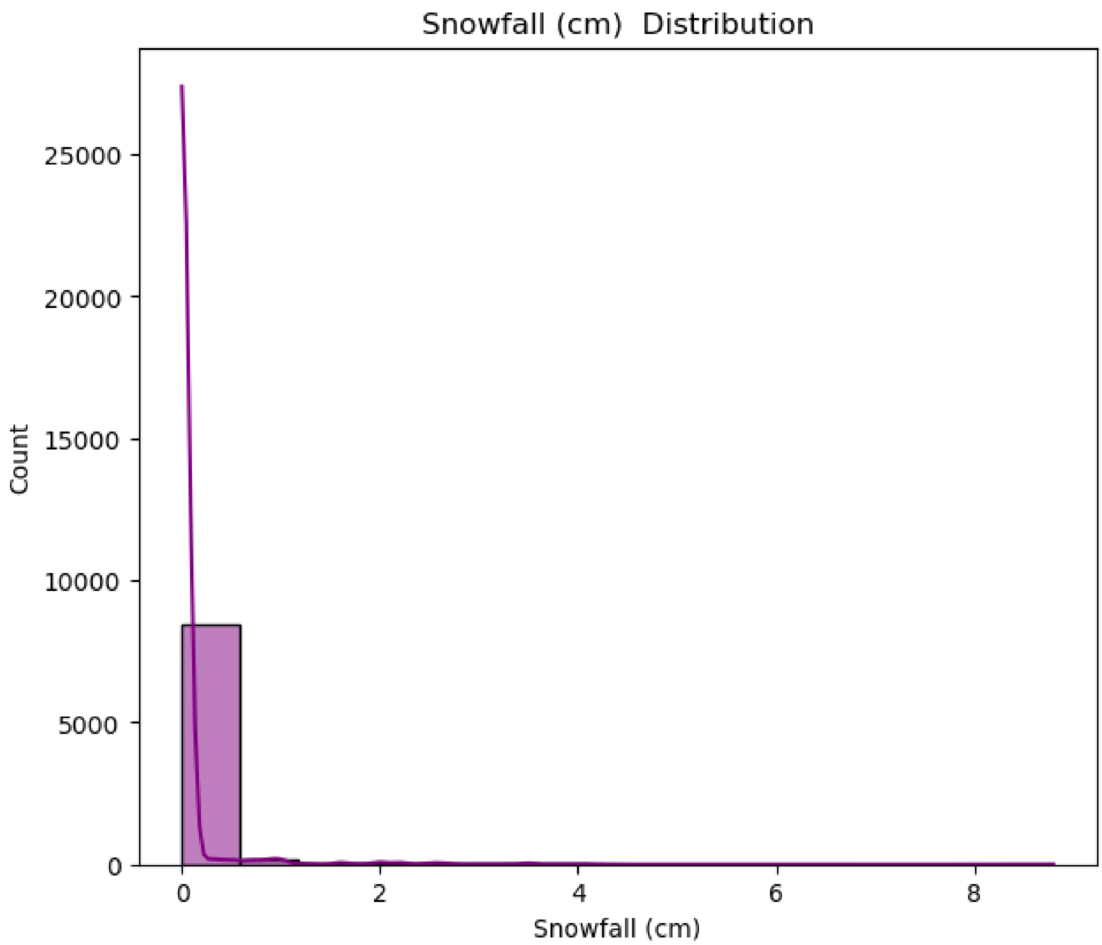

Visibility (10m) Distribution
Count
Visibility (10m)
0
500
1000
1500
2000
2500
3000
3500
0
250
500
750
1000
1250
1500
1750
2000


Dew point temperature(°C) Distribution
Count
Dew point temperature(°C)
0
100
200
300
400
500
600
−30
−20
−10
0
10
20
30


Solar Radiation (MJ/m2) Distribution
5000
4000
3000
2000
1000
0
Count
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
Solar Radiation (MJ/m2)



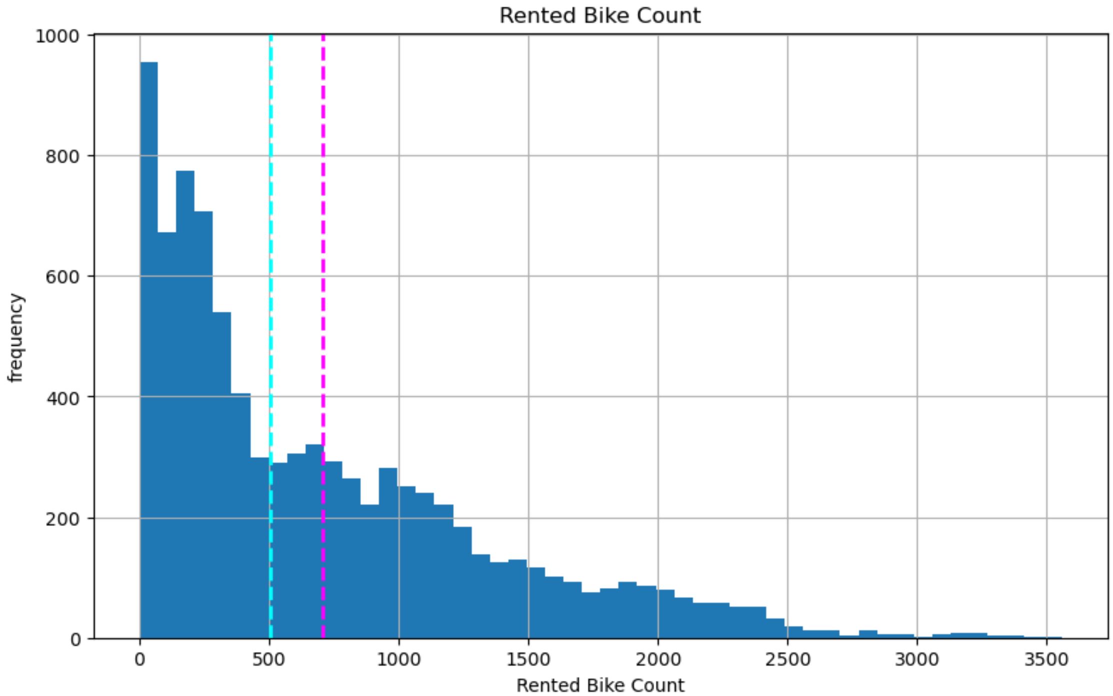
Rainfall(mm) Distribution
Count
40000
35000
30000
25000
20000
15000
10000
5000
0
0
5
10
15
20
25
30
35
Rainfall(mm)



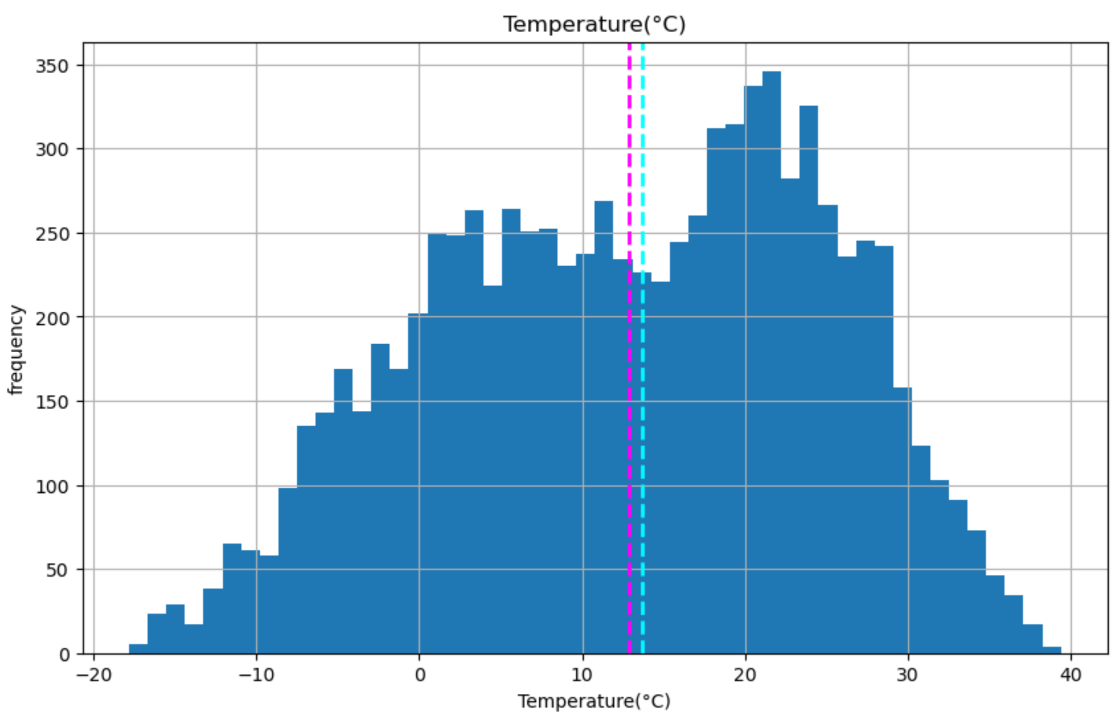
0.1.10 check features distribution with their mean and median so we can get better analysis of features values.

[56]:
```
for col in numeric_features[:]:
  fig = plt.figure(figsize=(10,6))

  ax = fig.gca()                          # gca() ---> get current axis
  feature = bike_df[col]       # to transform features into normal distribution␣
↪we used log10 transformation
  feature.hist(bins=50, ax=ax)            # ploting histogram
  ax.axvline(feature.mean(),color='magenta',linestyle='dashed',linewidth=2)
  ax.axvline(feature.median(),color='cyan',linestyle='dashed',linewidth=2)

  ax.set_title(col)
  ax.set_ylabel('frequency')
  ax.set_xlabel(col)
```

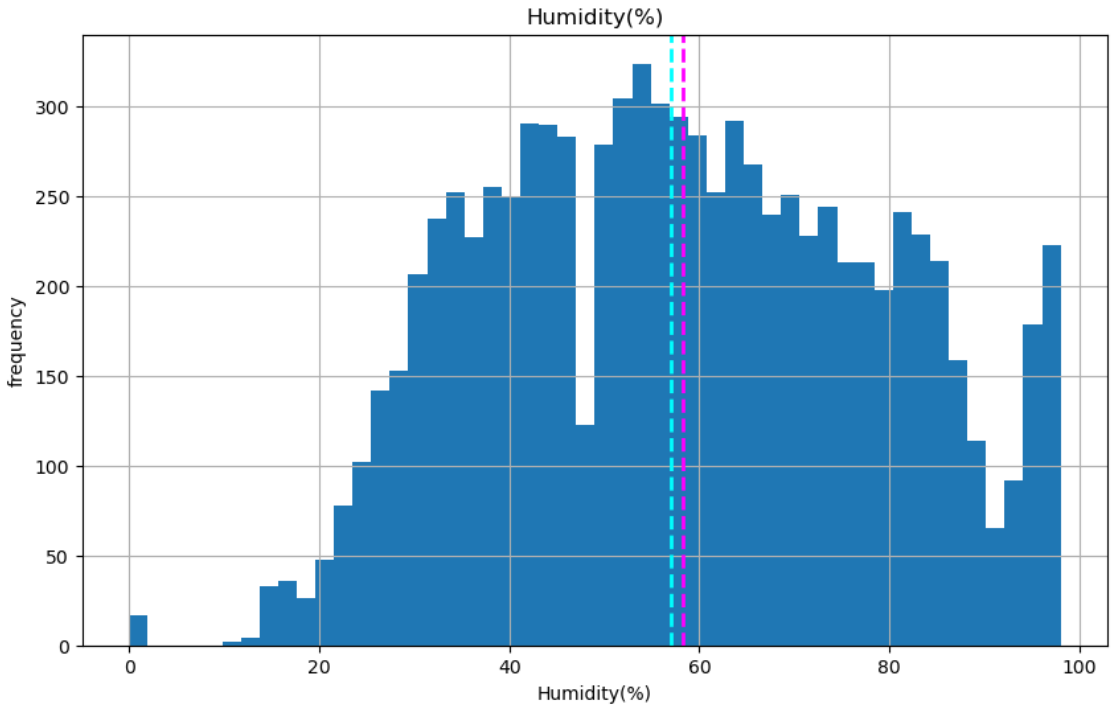
```
plt.show()
```

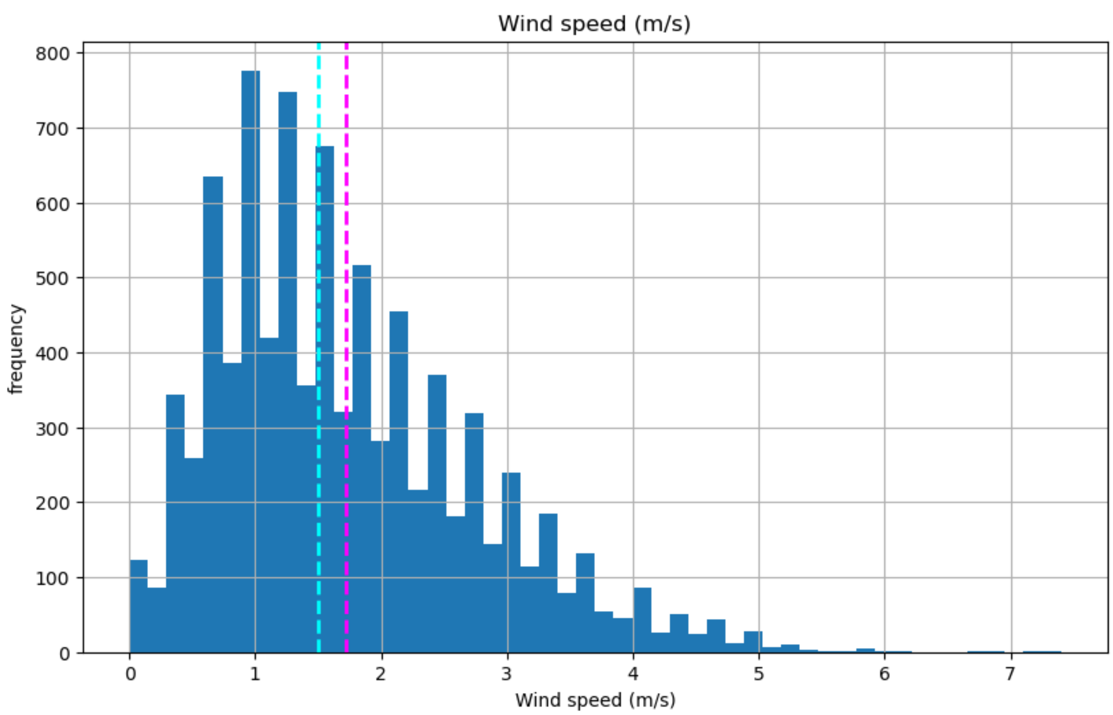


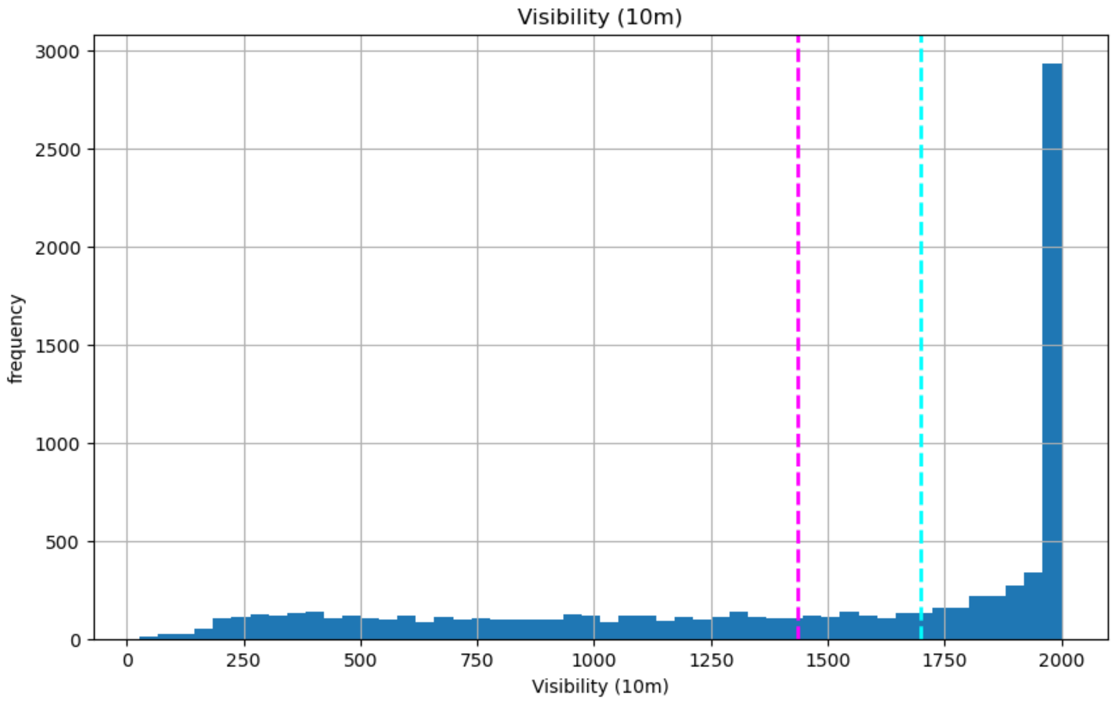
Rented Bike Count
frequency
Rented Bike Count

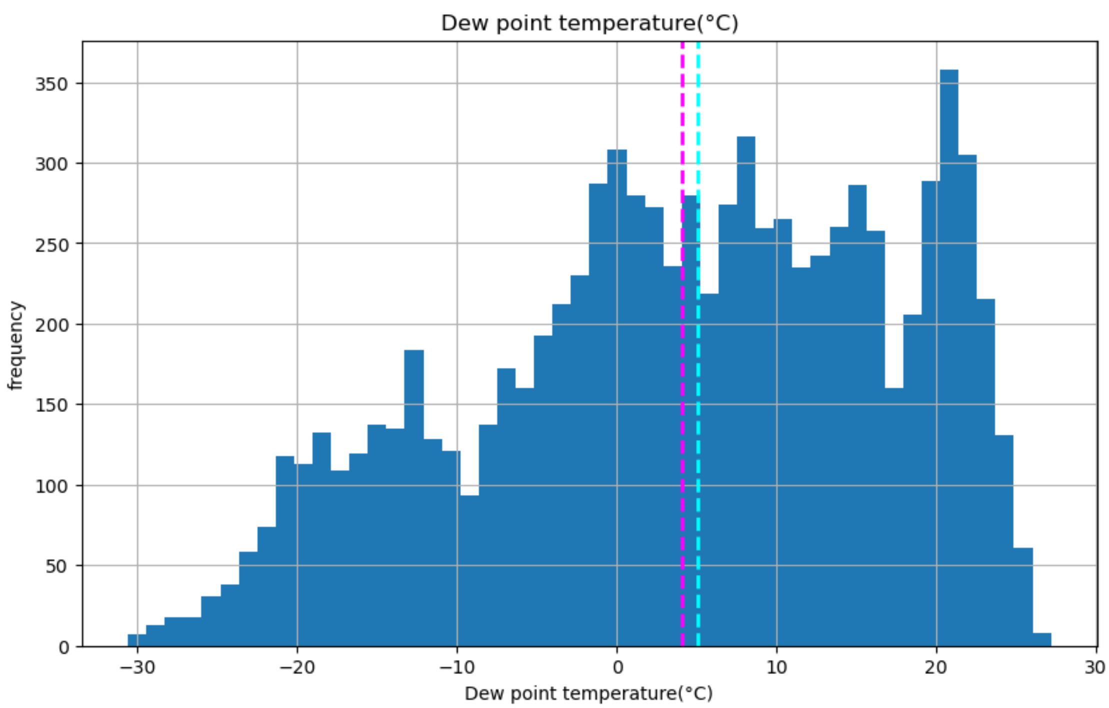


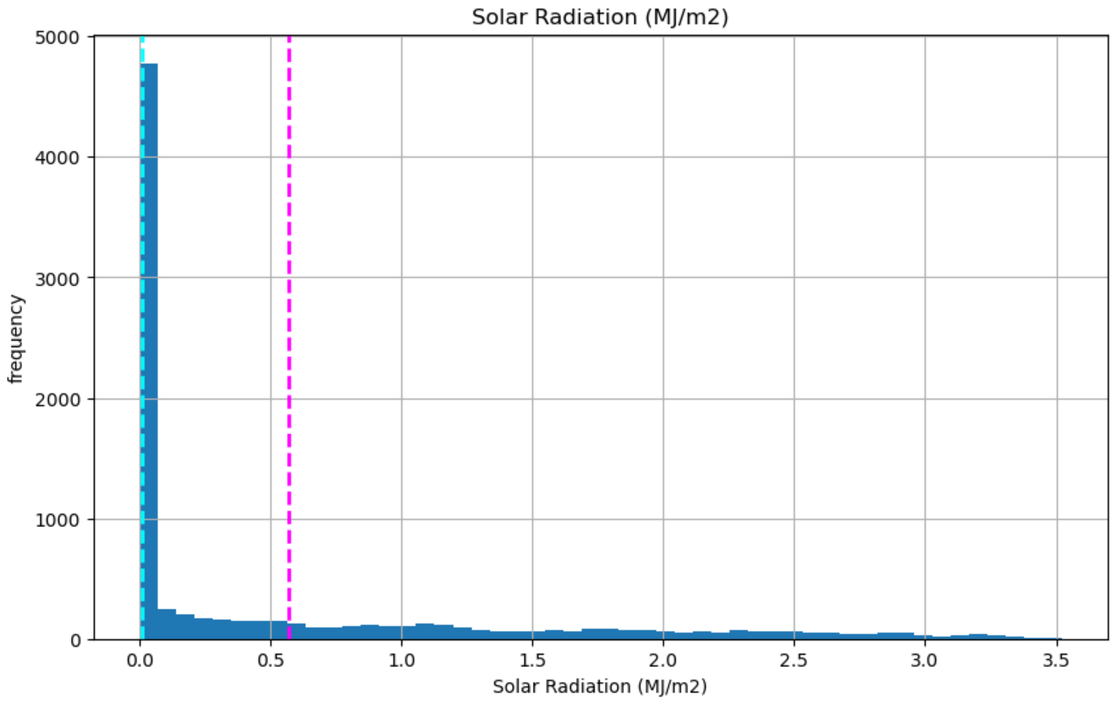
Temperature(°C)
frequency
Temperature(°C)

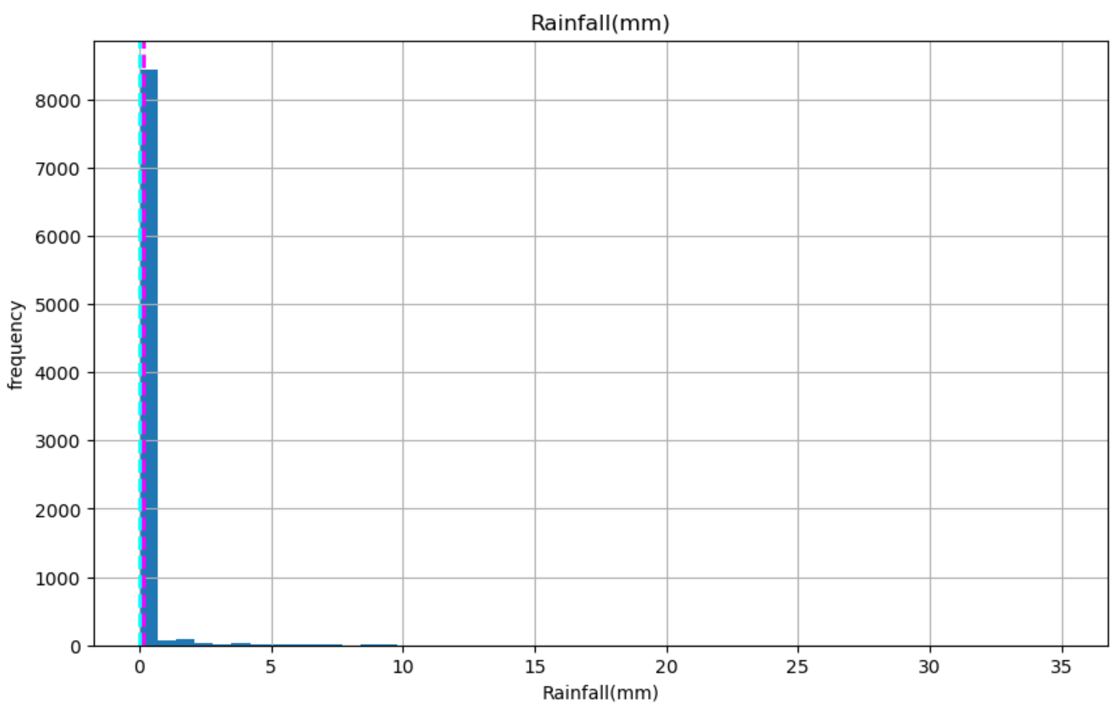

Humidity(%)
300
250
200
150
100
50
0
frequency
0
20
40
60
80
100
Humidity(%)

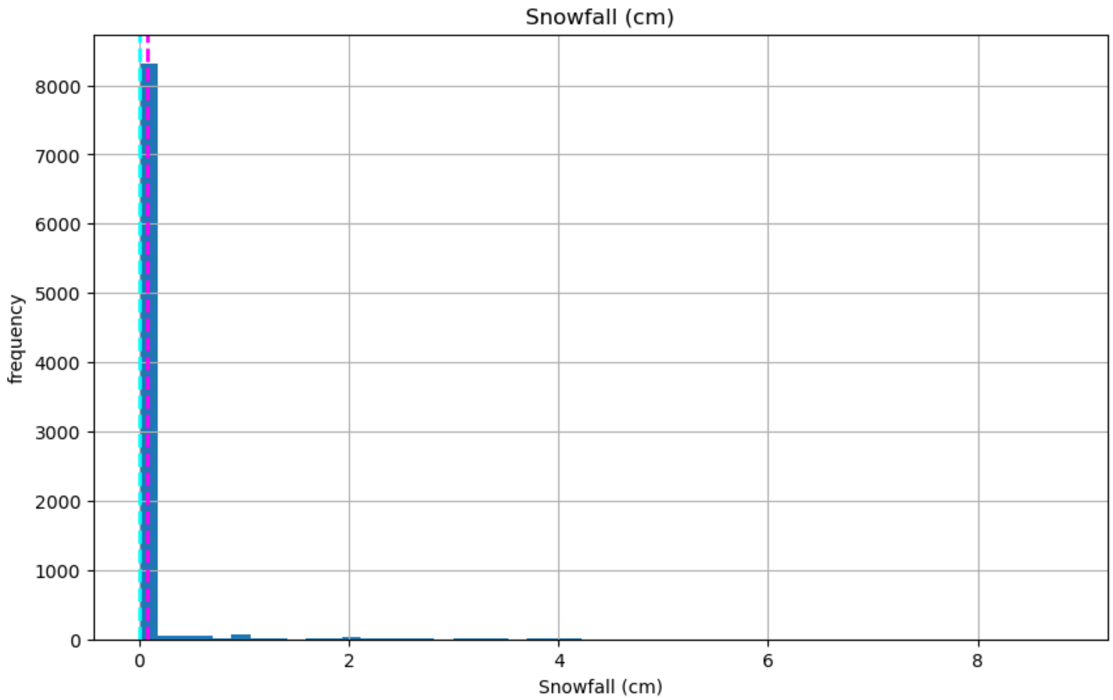

Wind speed (m/s)
800
700
600
500
400
300
200
100
0
frequency
0
1
2
3
4
5
6
7
Wind speed (m/s)


Visibility (10m)
frequency
3000
2500
2000
1500
1000
500
0
0
250
500
750
1000
1250
1500
1750
2000
Visibility (10m)


Dew point temperature(°C)
frequency
350
300
250
200
150
100
50
0
−30
−20
−10
0
10
20
30
Dew point temperature(°C)

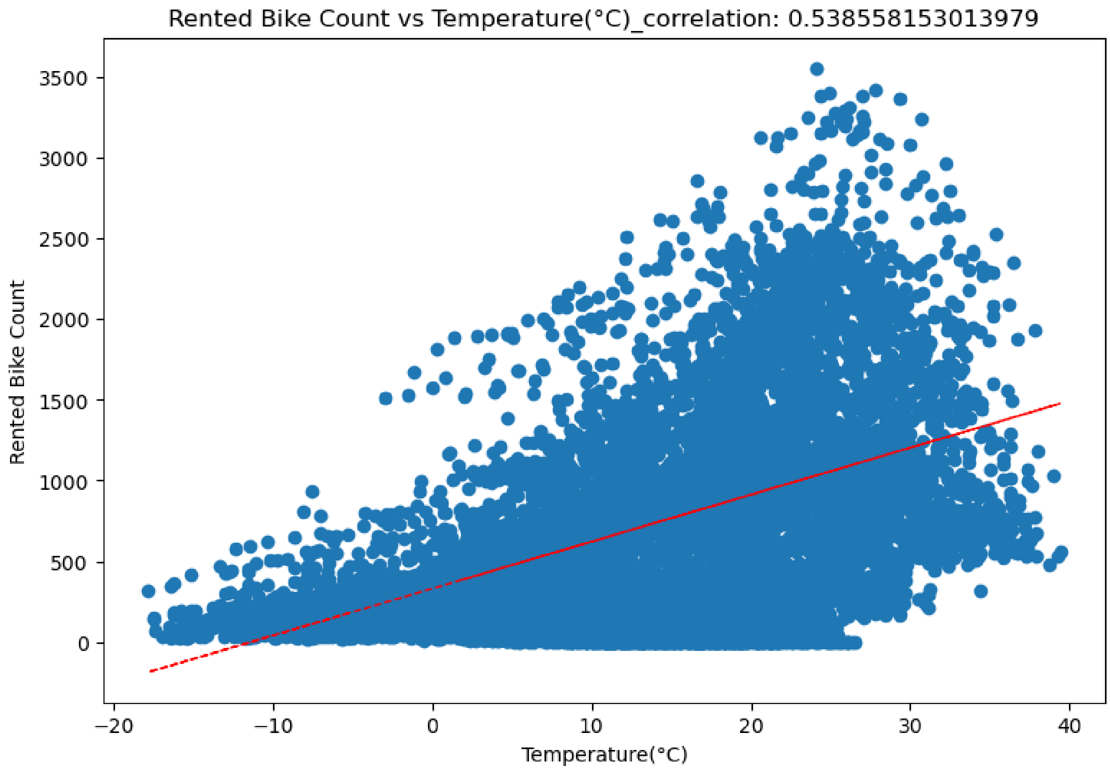

Solar Radiation (MJ/m2)
5000
4000
3000
2000
1000
0
frequency
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
Solar Radiation (MJ/m2)

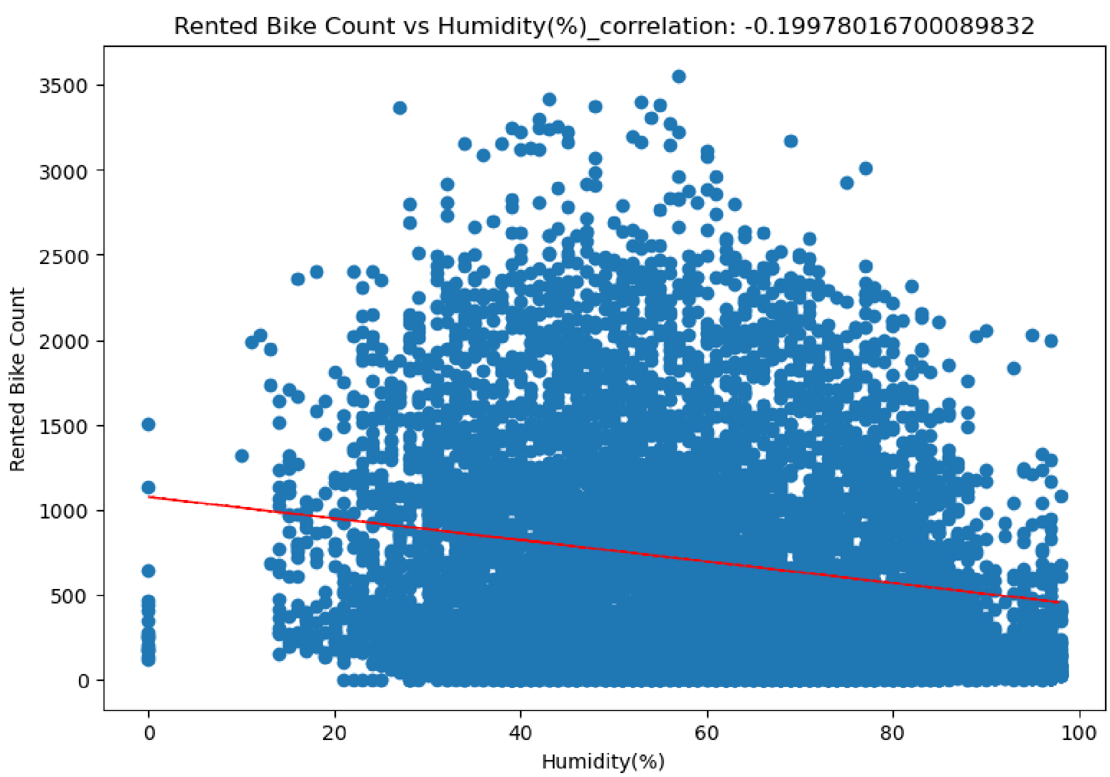

Rainfall(mm)
8000
7000
6000
5000
4000
3000
2000
1000
0
frequency
0
5
10
15
20
25
30
35
Rainfall(mm)

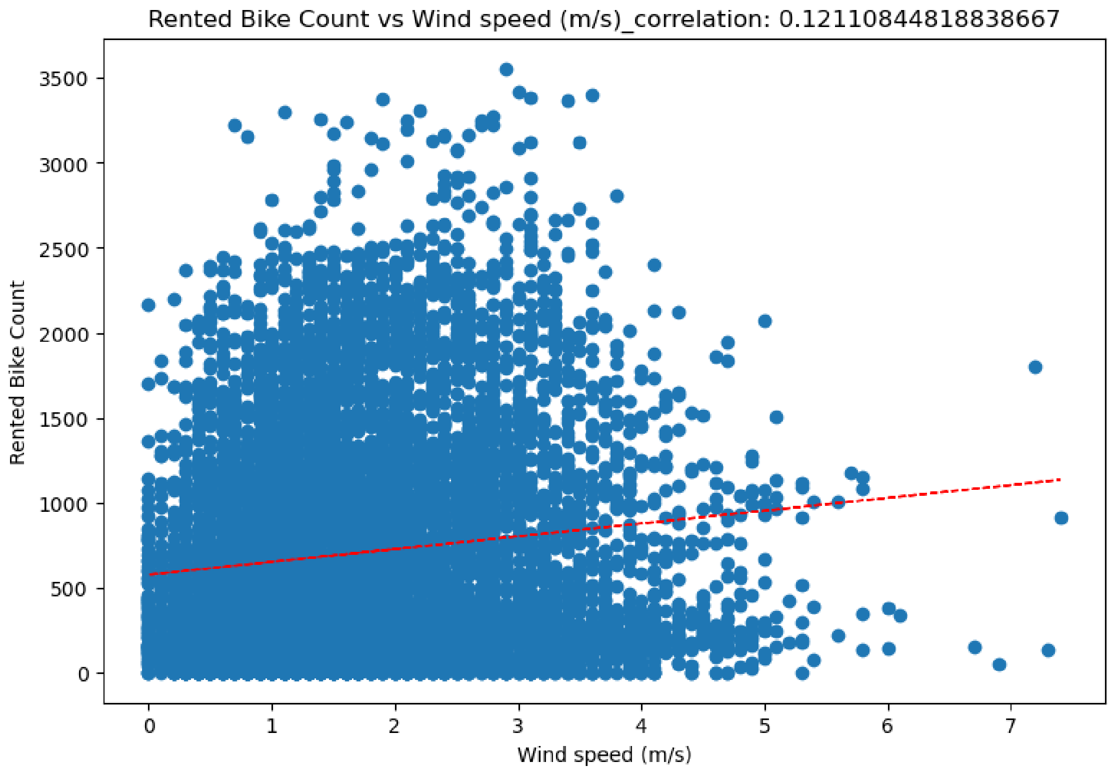


0.1.11 Now to find how is the relation of numerical features with our dependent variable. we use scatter plot.

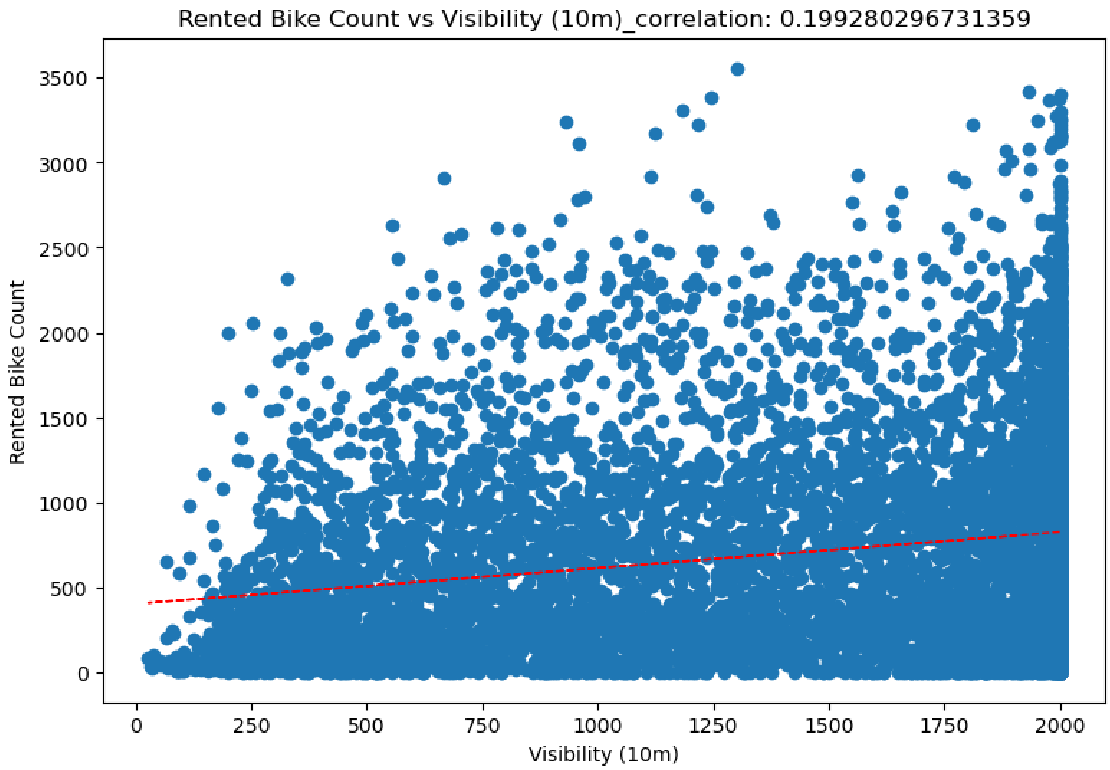
[57]:
```
for col in numeric_features[1:]:    # since rented bike count column is not␣
↪included in this for loop
  fig = plt.figure(figsize=(9,6))
  ax = fig.gca()
  feature = bike_df[col]
  correlation = feature.corr(bike_df['Rented Bike Count'])
  plt.scatter(x=feature, y= bike_df['Rented Bike Count'])
  plt.xlabel(col)
  plt.ylabel('Rented Bike Count')
  ax.set_title('Rented Bike Count vs '+col+ '_correlation: '+str(correlation))
  z= np.polyfit(bike_df[col],bike_df['Rented Bike Count'],1)
  y_hat = np.poly1d(z)(bike_df[col])
  plt.plot(bike_df[col],y_hat,'r--',lw=1)

plt.show()
```

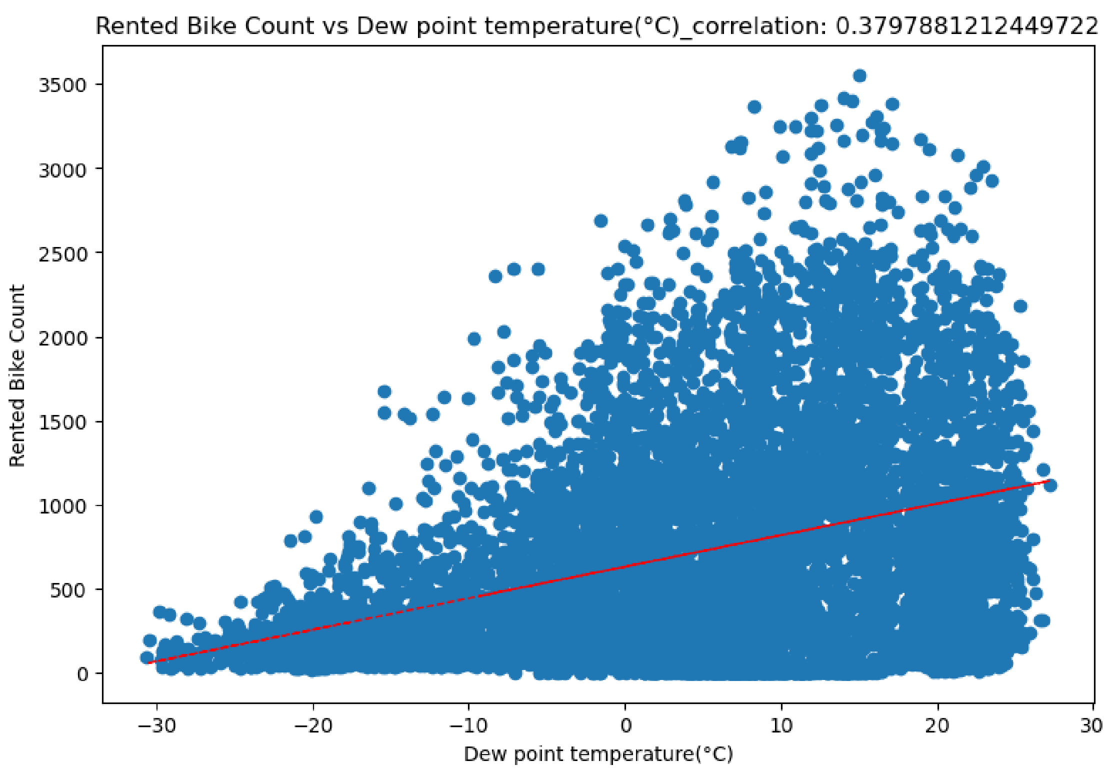

Rented Bike Count vs Temperature(°C)_correlation: 0.538558153013979
Rented Bike Count
Temperature(°C)
3500
3000
2500
2000
1500
1000
500
0
−20
−10
0
10
20
30
40

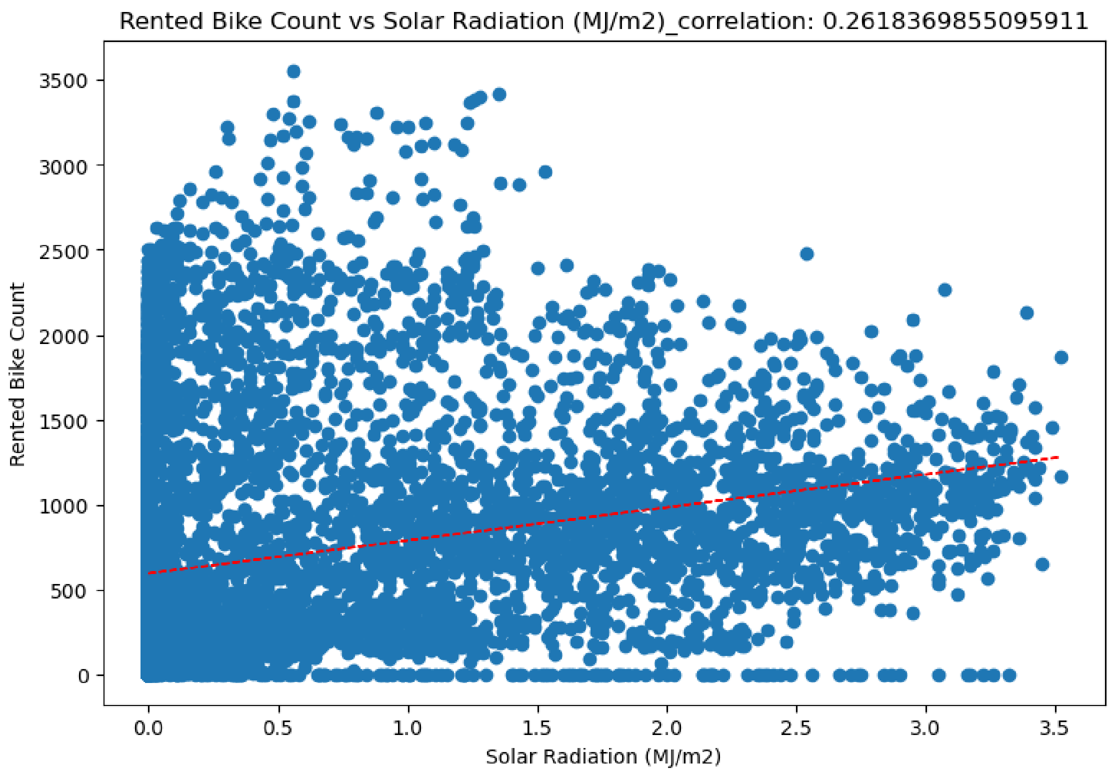

Rented Bike Count vs Humidity(%)_correlation: -0.19978016700089832
Rented Bike Count
Humidity(%)
3500
3000
2500
2000
1500
1000
500
0
0
20
40
60
80
100

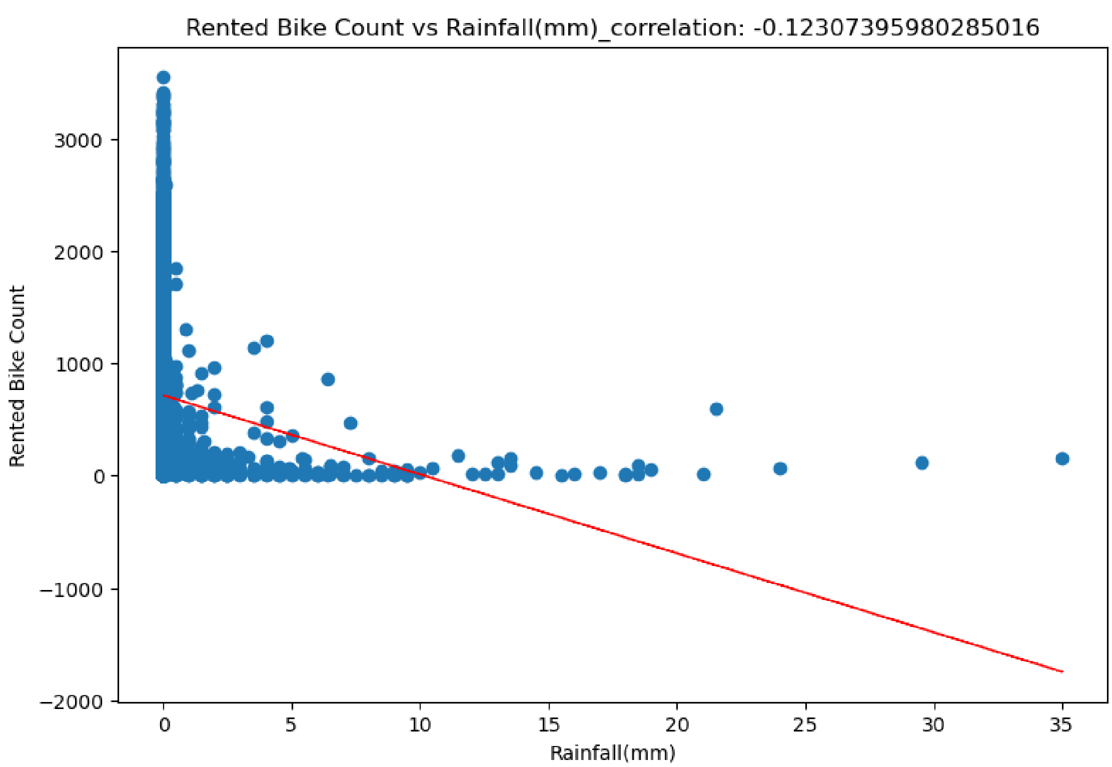


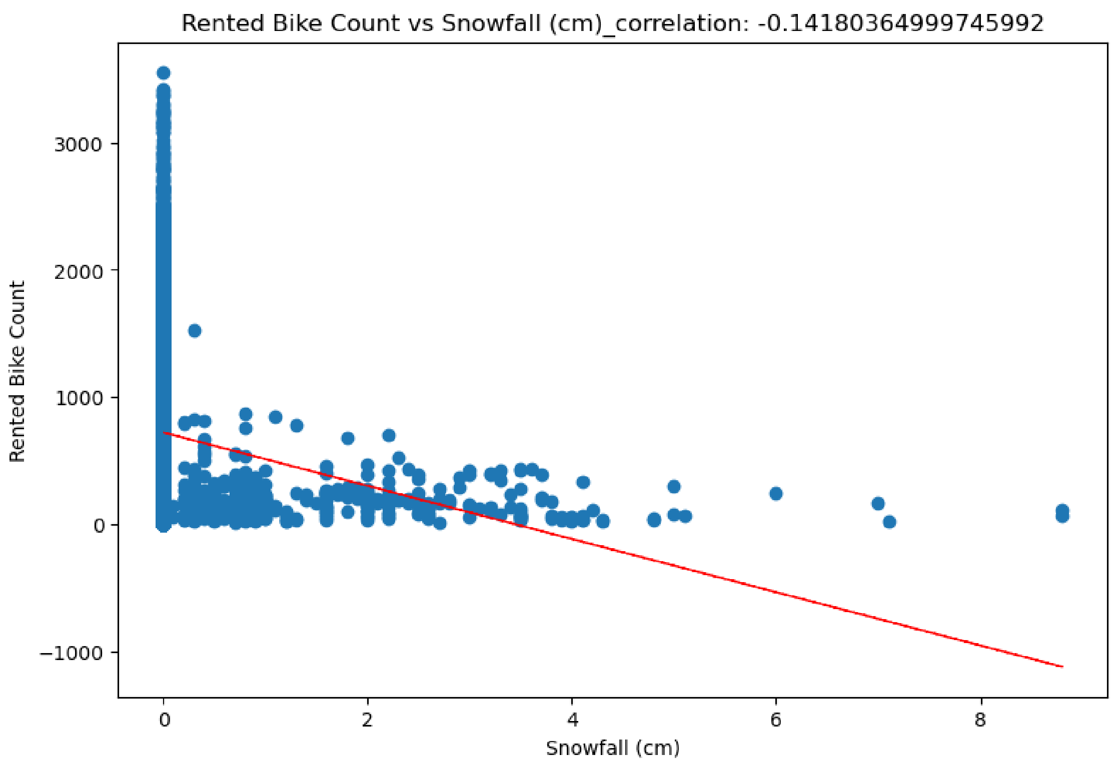
Rented Bike Count vs Wind speed (m/s)_correlation: 0.12110844818838667
Rented Bike Count
Wind speed (m/s)
0
500
1000
1500
2000
2500
3000
3500
0
1
2
3
4
5
6
7


Rented Bike Count vs Visibility (10m)_correlation: 0.199280296731359
Rented Bike Count
Visibility (10m)
0
500
1000
1500
2000
2500
3000
3500
0
250
500
750
1000
1250
1500
1750
2000


Rented Bike Count vs Dew point temperature(°C)_correlation: 0.3797881212449722
Rented Bike Count
Dew point temperature(°C)
0
500
1000
1500
2000
2500
3000
3500
−30
−20
−10
0
10
20
30


Rented Bike Count vs Solar Radiation (MJ/m2)_correlation: 0.2618369855095911
Rented Bike Count
Solar Radiation (MJ/m2)
0
500
1000
1500
2000
2500
3000
3500
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5


Rented Bike Count vs Rainfall(mm)_correlation: -0.12307395980285016
Rented Bike Count
Rainfall(mm)
−2000
−1000
0
1000
2000
3000
0
5
10
15
20
25
30
35



The scatter plot or regression plot indicates that certain numeric features have a positive correlation with the dependent variable, while others have a negative correlation.

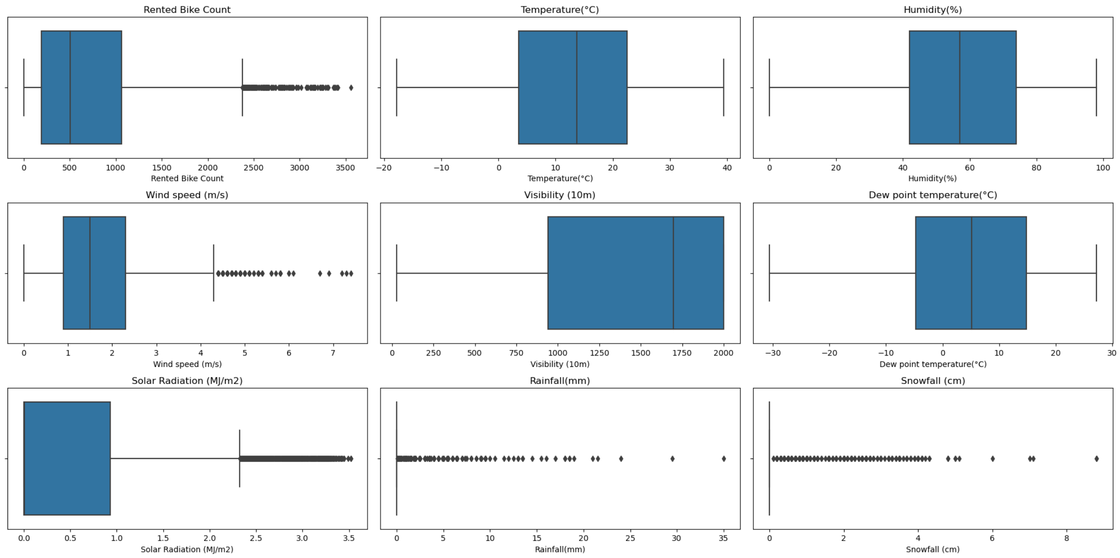
The correlation of the features with the dependent feature is as follows:

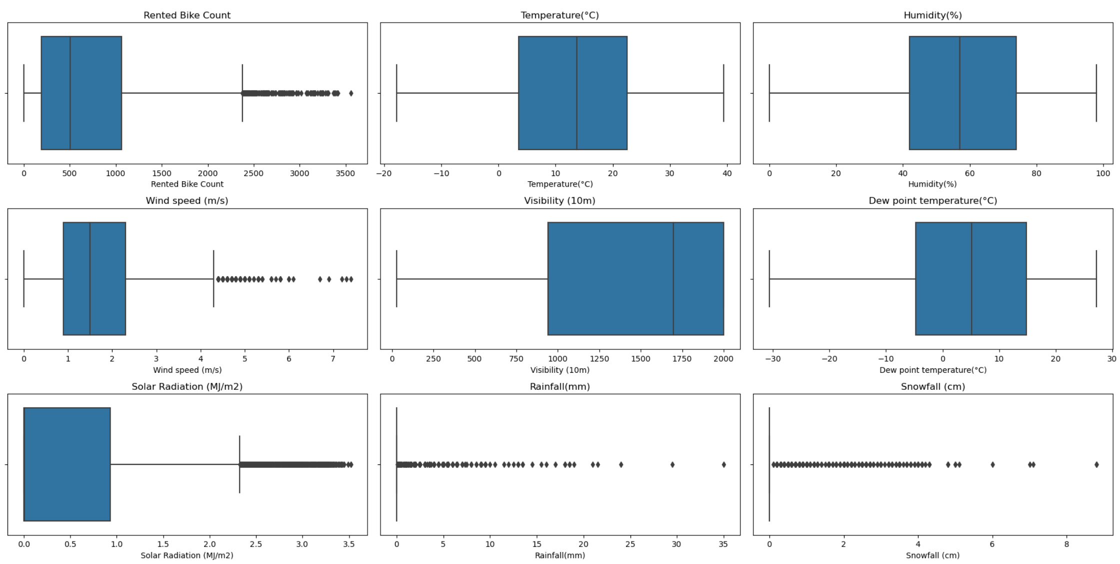
Positive correlation: Temperature, wind speed, visibility, dew point temperature, and solar radiation.

Negative correlation: Humidity, rainfall, and snowfall.

treating Outliers of features by using Boxplot to get better observation

[59]:
```
n = 1
plt.figure(figsize=(20,10))

for i in numeric_features[:]:
  plt.subplot(3,3,n)
  n=n+1
  sns.boxplot(bike_df[i])
  plt.title(i)
  plt.tight_layout()
plt.show()
```





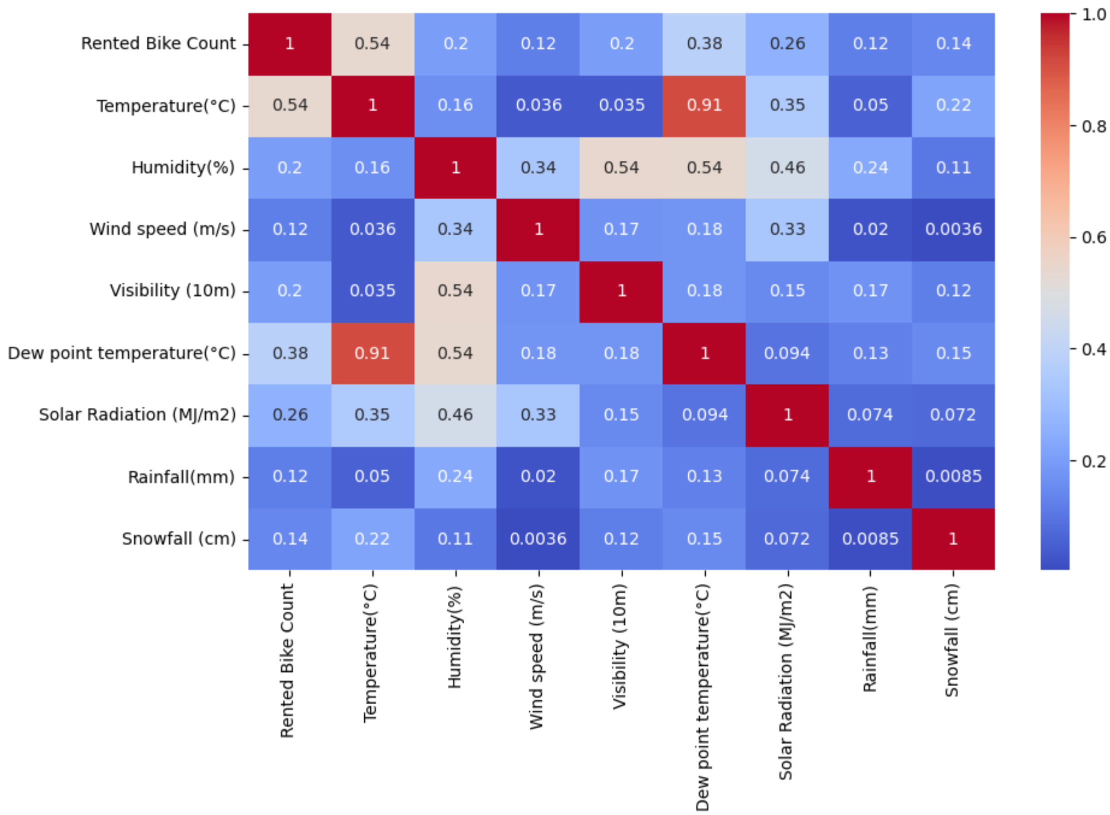
[60]:
```
bike_df.corr()
```

[60]:
```
                           Rented Bike Count  Temperature(°C)  Humidity(%)  \
Rented Bike Count                   1.000000         0.538558    -0.199780
Temperature(°C)                     0.538558         1.000000     0.159371
Humidity(%)                        -0.199780         0.159371     1.000000
Wind speed (m/s)                    0.121108        -0.036252    -0.336683
Visibility (10m)                    0.199280         0.034794    -0.543090
Dew point temperature(°C)           0.379788         0.912798     0.536894
Solar Radiation (MJ/m2)             0.261837         0.353505    -0.461919
```

```
Rainfall(mm)                        -0.123074         0.050282     0.236397
Snowfall (cm)                       -0.141804        -0.218405     0.108183

                           Wind speed (m/s)  Visibility (10m)  \
Rented Bike Count                   0.121108          0.199280
Temperature(°C)                    -0.036252          0.034794
Humidity(%)                        -0.336683         -0.543090
Wind speed (m/s)                    1.000000          0.171507
Visibility (10m)                    0.171507          1.000000
Dew point temperature(°C)          -0.176486         -0.176630
Solar Radiation (MJ/m2)             0.332274          0.149738
Rainfall(mm)                       -0.019674         -0.167629
Snowfall (cm)                      -0.003554         -0.121695

                           Dew point temperature(°C)  Solar Radiation (MJ/m2)  \
Rented Bike Count                           0.379788                 0.261837
Temperature(°C)                             0.912798                 0.353505
Humidity(%)                                 0.536894                -0.461919
Wind speed (m/s)                           -0.176486                 0.332274
Visibility (10m)                           -0.176630                 0.149738
Dew point temperature(°C)                   1.000000                 0.094381
Solar Radiation (MJ/m2)                     0.094381                 1.000000
Rainfall(mm)                                0.125597                -0.074290
Snowfall (cm)                              -0.150887                -0.072301

                           Rainfall(mm)  Snowfall (cm)
Rented Bike Count             -0.123074      -0.141804
Temperature(°C)                0.050282      -0.218405
Humidity(%)                    0.236397       0.108183
Wind speed (m/s)              -0.019674      -0.003554
Visibility (10m)              -0.167629      -0.121695
Dew point temperature(°C)      0.125597      -0.150887
Solar Radiation (MJ/m2)       -0.074290      -0.072301
Rainfall(mm)                   1.000000       0.008500
Snowfall (cm)                  0.008500       1.000000
```

0.1.12 Plot Heatmap to get better visualization about features correlation

[65]:
```
plt.figure(figsize=(10,6))
sns.heatmap(abs(bike_df.corr()), cmap='coolwarm', annot=True)
plt.show()
```



Now handeling categorical features by feature encoding

i.e. using one hot encoding (get dummies) or Data encoding method.

[67]:
```
new_bike_df = pd.get_dummies(bike_df, drop_first=True, sparse=True)
```

[68]:
```
new_bike_df.head(2)
```

[68]:
```
   Rented Bike Count  Temperature(°C)  Humidity(%)  Wind speed (m/s)  \
0                254             -5.2           37               2.2
1                204             -5.5           38               0.8

   Visibility (10m)  Dew point temperature(°C)  Solar Radiation (MJ/m2)  \
0              2000                      -17.6                      0.0
1              2000                      -17.6                      0.0

   Rainfall(mm)  Snowfall (cm)  Hour_Evening  …  month_February  \
0           0.0            0.0             0  …               0
1           0.0            0.0             0  …               0

   month_January  month_July  month_June  month_March  month_May  \
```

```
0                  1              0              0                0             0
1                  1              0              0                0             0

   month_November  month_October  month_September  week_Weekend
0               0              0                0             0
1               0              0                0             0

[2 rows x 30 columns]
```

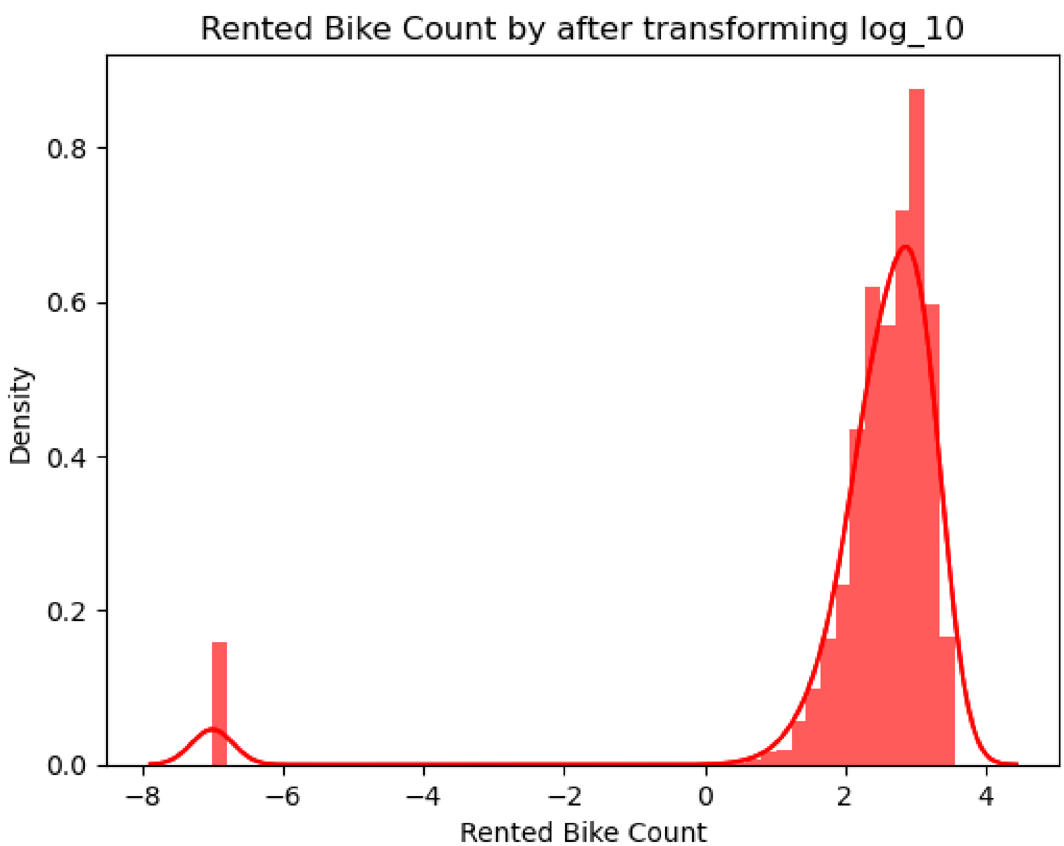
[69]:
```
new_bike_df.shape
```

[69]: (8760, 30)

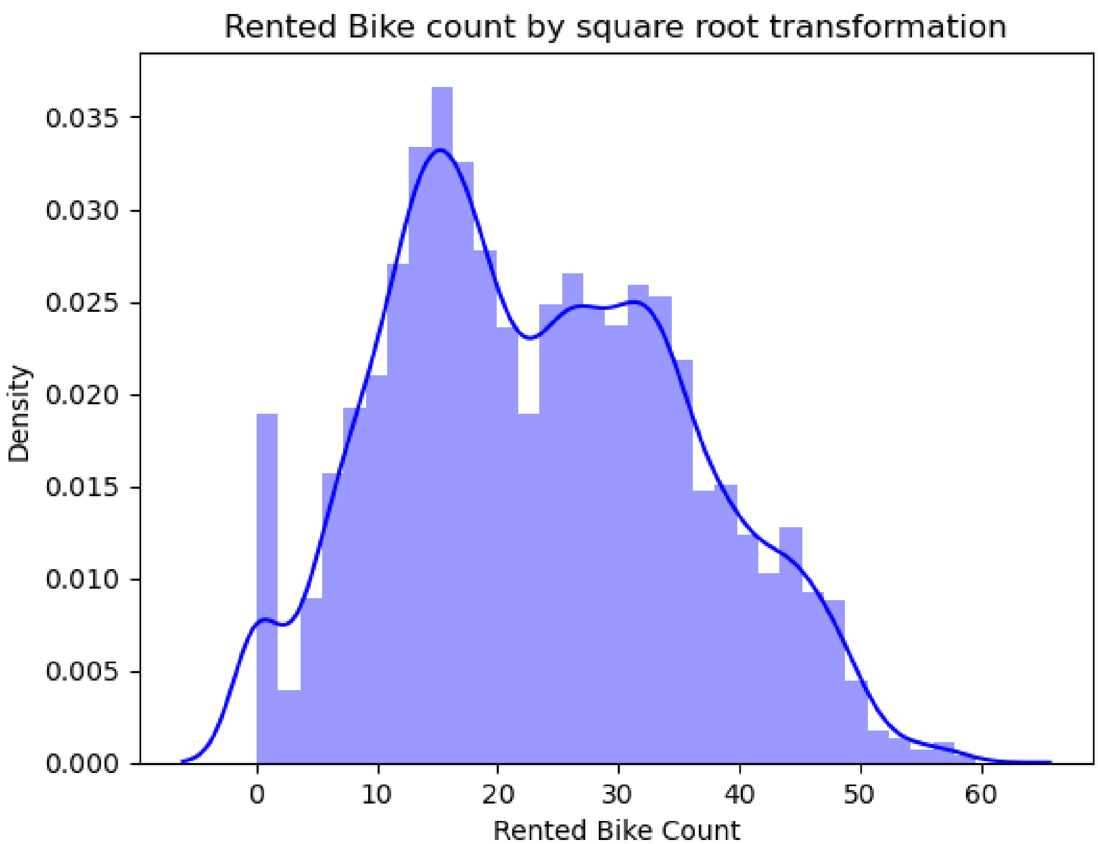
0.1.13 Model implementation

Since we know our Dependent feature is positivley skewed so for the better model prediction we have to Normalize it.

[72]:
```
sns.distplot(np.log10(new_bike_df['Rented Bike Count']+0.0000001),color='red').
 ↪set_title("Rented Bike Count by after transforming log_10")
plt.show()
```



[73]:
```
sns.distplot(np.sqrt(new_bike_df['Rented Bike Count']), color= 'blue').
 ↪set_title('Rented Bike count by square root transformation')
plt.show()
```



[74]:
```
x= new_bike_df.drop(columns=['Rented Bike Count'])
```

[75]:
```
x.head()
```

[75]:
```
   Temperature(°C)  Humidity(%)  Wind speed (m/s)  Visibility (10m)  \
0             -5.2           37               2.2              2000
1             -5.5           38               0.8              2000
2             -6.0           39               1.0              2000
3             -6.2           40               0.9              2000
4             -6.0           36               2.3              2000

   Dew point temperature(°C)  Solar Radiation (MJ/m2)  Rainfall(mm)  \
0                      -17.6                      0.0           0.0
1                      -17.6                      0.0           0.0
```

```
2                      -17.7                      0.0           0.0
3                      -17.6                      0.0           0.0
4                      -18.6                      0.0           0.0

   Snowfall (cm)  Hour_Evening  Hour_Morning  …  month_February  \
0            0.0             0             0  …               0
1            0.0             0             0  …               0
2            0.0             0             0  …               0
3            0.0             0             0  …               0
4            0.0             0             0  …               0

   month_January  month_July  month_June  month_March  month_May  \
0              1           0           0            0          0
1              1           0           0            0          0
2              1           0           0            0          0
3              1           0           0            0          0
4              1           0           0            0          0

   month_November  month_October  month_September  week_Weekend
0               0              0                0             0
1               0              0                0             0
2               0              0                0             0
3               0              0                0             0
4               0              0                0             0

[5 rows x 29 columns]
```

[76]:
```
x= x.drop(columns=['Dew point temperature(°C)'])
```

[77]:
```
y = np.sqrt(new_bike_df['Rented Bike Count'])
```

0.1.14 Spliting Data for Traning and Testing

[78]:
```
xtrain, xtest, ytrain, ytest = train_test_split(x, y, test_size=0.20,␣
↪random_state=10)
```

[80]:
```
xtrain.head(10)
```

[80]:
```
      Temperature(°C)  Humidity(%)  Wind speed (m/s)  Visibility (10m)  \
1036             -6.4           46               0.8              1993
302              -4.7           27               2.9              1883
6773             16.3           66               0.5              2000
6354             35.4           40               1.0              2000
5784             29.2           50               1.1              2000
5542             28.0           76               1.5              1542
1925             -1.8           44               0.5              1862
```

```
1112              1.2          68                0.6               411
324              -4.9          34                1.3              1768
4129             15.9          71                1.1              1312

      Solar Radiation (MJ/m2)  Rainfall(mm)  Snowfall (cm)  Hour_Evening  \
1036                     0.00           0.0            0.0             0
302                      1.12           0.0            0.0             0
6773                     0.00           0.0            0.0             0
6354                     0.34           0.0            0.0             1
5784                     0.00           0.0            0.0             0
5542                     0.00           0.0            0.0             1
1925                     0.00           0.0            0.0             0
1112                     0.00           0.0            0.0             0
324                      0.60           0.0            0.0             0
4129                     0.00           0.0            0.0             0

      Hour_Morning  Hour_Night  …  month_February  month_January  \
1036             0           1  …               0              1
302              0           0  …               0              0
6773             0           1  …               0              0
6354             0           0  …               0              0
5784             0           1  …               0              0
5542             0           0  …               0              0
1925             0           1  …               1              0
1112             1           0  …               0              1
324              0           0  …               0              0
4129             0           1  …               0              0

      month_July  month_June  month_March  month_May  month_November  \
1036           0           0            0          0               0
302            0           0            0          0               0
6773           0           0            0          0               0
6354           0           0            0          0               0
5784           1           0            0          0               0
5542           1           0            0          0               0
1925           0           0            0          0               0
1112           0           0            0          0               0
324            0           0            0          0               0
4129           0           0            0          1               0

      month_October  month_September  week_Weekend
1036              0                0             1
302               0                0             0
6773              0                1             1
6354              0                0             0
5784              0                0             0
5542              0                0             0
```

```
1925                 0                 0              0
1112                 0                 0              0
324                  0                 0              0
4129                 0                 0              0

[10 rows x 28 columns]
```

[81]:
```
ytrain.head()
```

[81]:
```
1036     6.855655
302     15.491933
6773    12.845233
6354    50.279220
5784    28.460499
Name: Rented Bike Count, dtype: float64
```

[83]:
```
ytest.head()
```

[83]:
```
389      5.567764
8461    30.083218
3588    37.080992
5086    33.271610
3366    20.346990
Name: Rented Bike Count, dtype: float64
```

[84]:
```
ytrain.shape
```

[84]:
```
(7008,)
```

[85]:
```
ytest.shape
```

[85]:
```
(1752,)
```

Creating a functions to train and evaluate the model with different parameters like MSE , RMSE, R2 Score, Best_params, Best score, Coefficient , intercept and feature importances

[86]:
```
# Appending all models parameters to the corrosponding list
mean_absolut_error = []
mean_sq_error=[]
root_mean_sq_error=[]
training_score =[]
r2_list=[]
adj_r2_list=[]
from sklearn.metrics import mean_squared_error
from sklearn.metrics import mean_absolute_error
from sklearn.metrics import r2_score
```

```
def score_metrix (model,X_train,X_test,Y_train,Y_test):

  '''
    train the model and gives mae, mse,rmse,r2,adj r2 score of the model

  '''
  #training the model
  model.fit(X_train,Y_train)

  # Training Score
  training  = model.score(X_train,Y_train)
  print("Training score  =", training)

  try:
      # finding the best parameters of the model if any
    print(f"The best parameters found out to be :{model.best_params_} \nwhere␣
 ↪model best score is:  {model.best_score_} \n")
  except:
    pass


  #predicting the Test set and evaluting the models

  if model == LinearRegression() or model == Lasso() or model == Ridge():
    Y_pred = model.predict(X_test)

    #finding mean_absolute_error
    MAE  = mean_absolute_error(Y_test**2,Y_pred**2)
    print("MAE :" , MAE)

    #finding mean_squared_error
    MSE  = mean_squared_error(Y_test**2,Y_pred**2)
    print("MSE :" , MSE)

    #finding root mean squared error
    RMSE = np.sqrt(MSE)
    print("RMSE :" ,RMSE)

    #finding the r2 score

    r2 = r2_score(Y_test**2,Y_pred**2)
    print("R2 :" ,r2)
    #finding the adjusted r2 score
    adj_r2=1-(1-r2_score(Y_test**2,Y_pred**2))*((X_test.shape[0]-1)/(X_test.
 ↪shape[0]-X_test.shape[1]-1))
```

```
    print("Adjusted R2 : ",adj_r2,'\n')

  else:
    # for tree base models
    Y_pred = model.predict(X_test)

    #finding mean_absolute_error
    MAE  = mean_absolute_error(Y_test,Y_pred)
    print("MAE :" , MAE)

    #finding mean_squared_error
    MSE  = mean_squared_error(Y_test,Y_pred)
    print("MSE :" , MSE)

    #finding root mean squared error
    RMSE = np.sqrt(MSE)
    print("RMSE :" ,RMSE)

    #finding the r2 score

    r2 = r2_score(Y_test,Y_pred)
    print("R2 :" ,r2)
    #finding the adjusted r2 score
    adj_r2=1-(1-r2_score(Y_test,Y_pred))*((X_test.shape[0]-1)/(X_test.
↪shape[0]-X_test.shape[1]-1))
    print("Adjusted R2 : ",adj_r2,'\n')

    try:

      # ploting the graph of feature importance

      best = model.best_estimator_
      features = X_train.columns
      importances = best.feature_importances_
      indices = np.argsort(importances)
      plt.figure(figsize=(10,15))
      plt.title('Feature Importance')
      plt.barh(range(len(indices)), importances[indices], color='red',␣
↪align='center')
      plt.yticks(range(len(indices)), [features[i] for i in indices])
      plt.xlabel('Relative Importance')
      plt.show()

    except:
      pass

  # Here we appending the parameters for all models
```

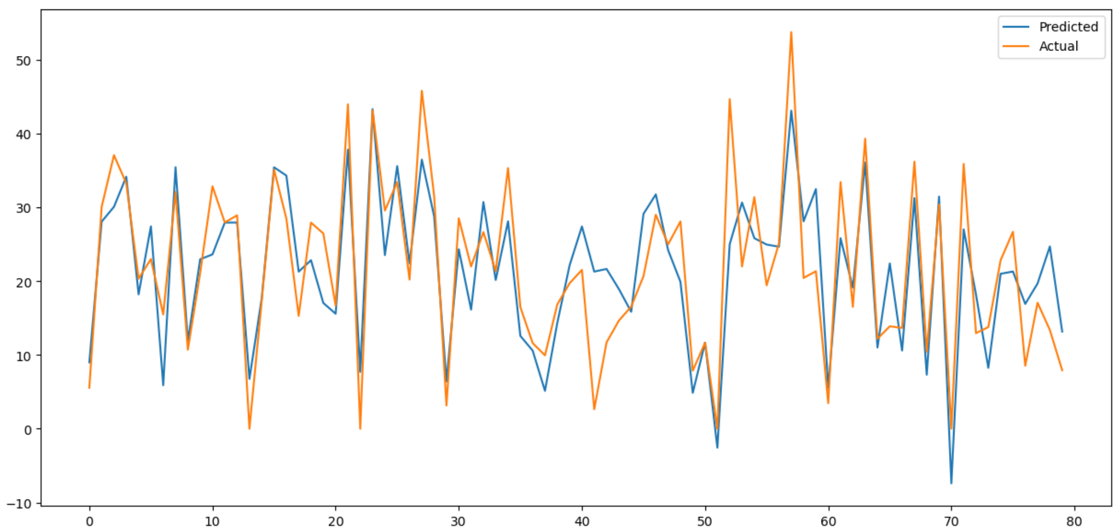
```
  mean_absolut_error.append(MAE)
  mean_sq_error.append(MSE)
  root_mean_sq_error.append(RMSE)
  training_score.append(training)
  r2_list.append(r2)
  adj_r2_list.append(adj_r2)

  print('*'*80)
  # print the cofficient and intercept of which model have these parameters and␣
↪else we just pass them
  try :
    print("coefficient \n",model.coef_)
    print('\n')
    print("Intercept  = " ,model.intercept_)
  except:
    pass
  print('\n')
  print('*'*20, 'ploting the graph of Actual and predicted only with 80␣
↪observation', '*'*20)

  # ploting the graph of Actual and predicted only with 80 observation for␣
↪better visualisation which model have these parameters and else we just pass␣
↪them
  try:
    # ploting the line graph of actual and predicted values
    plt.figure(figsize=(15,7))
    plt.plot((Y_pred)[:80])
    plt.plot((np.array(Y_test)[:80]))
    plt.legend(["Predicted","Actual"])
    plt.show()
  except:
    pass
```

0.1.15 Model 1: Linear Regression model

[87]:
```
score_metrix(LinearRegression(), xtrain, xtest, ytrain, ytest)
```

```
Training score  = 0.7031168479271276
MAE : 5.256832985963906
MSE : 44.35376150715582
RMSE : 6.659861973581421
R2 : 0.7161594175703074
Adjusted R2 :  0.7115468021854953

********************************************************************************
coefficient
 [ 5.14940824e-01 -1.60847945e-01  1.58427497e-01  4.73815016e-04
```

```
 -4.10264161e-01 -1.53176051e+00  1.92997496e-01  7.31743738e+00
  3.49826484e+00 -3.20286654e+00 -2.99804972e+00 -3.65497680e+00
 -7.77576392e+00  2.71595480e+00  2.80909776e+01 -2.32980211e+00
 -8.22718544e-01  1.64703992e-01 -4.94031472e-01  4.38354159e-01
 -1.80821191e-01  4.28441282e+00  3.96743044e-01  1.72452283e+00
  6.05512430e-01  2.08197536e+00 -4.89976098e-02 -6.51584135e-01]


Intercept  =  -0.1911980167566938


******************** ploting the graph of Actual and predicted only with 80
observation ********************
```



The linear regression model above demonstrates satisfactory outcomes.

—-> Based on the training score, we can conclude that the model is significantly overfit.

—-> To enhance the accuracy of the model, we can scale or transform the training data using methods such as min-max scaler, standard scalar, or power transformer.

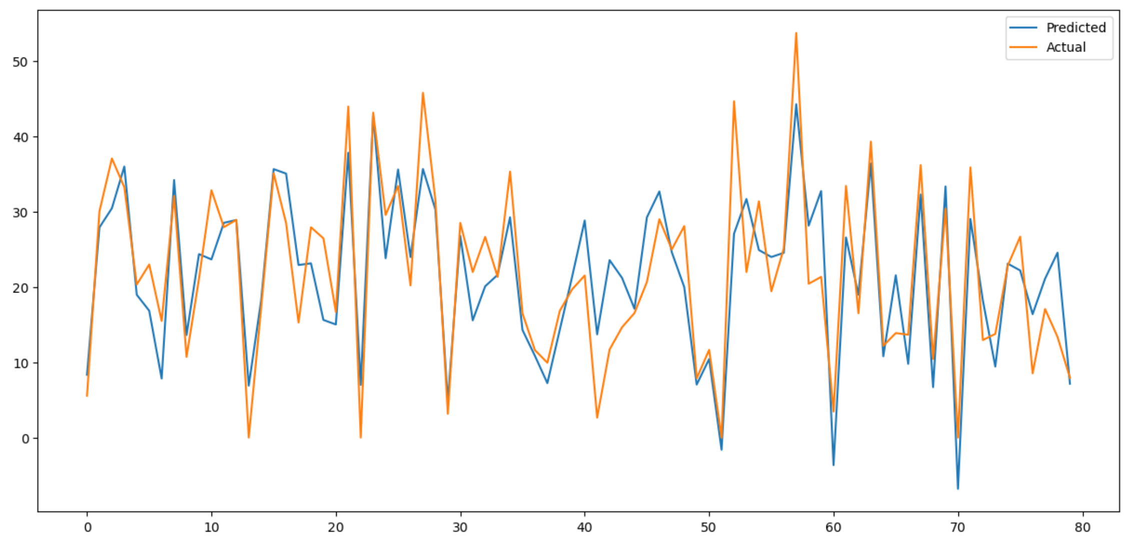
Power transformations are especially useful when dealing with skewed features, and the model is sensitive to the distribution's symmetry.

The fit(data) method is utilized to determine the mean and standard deviation for a particular feature and is subsequently used for scaling. The transform(data) method is employed to perform scaling using the mean and standard deviation obtained through the fit() method.

[88]:
```python
from sklearn.preprocessing import PowerTransformer
pt = PowerTransformer()
xtrain_trans = pt.fit_transform(xtrain)      # fit transform the training set
xtest_trans = pt.transform(xtest)             #tranform the test set
```

```
[89]: score_metrix(LinearRegression(), xtrain_trans, xtest_trans, ytrain, ytest)
```

```
Training score  = 0.7358707972413249
MAE : 5.062774637284666
MSE : 41.52977444529125
RMSE : 6.444359894147071
R2 : 0.7342314390894797
Adjusted R2 :  0.7299125071652228

********************************************************************************
coefficient
 [ 5.61822803e+00 -1.87825798e+00  1.92424550e-01  3.52738715e-01
  7.77994109e-01 -3.15126857e+00  1.61361164e-01  3.70269979e+00
  1.29995677e+00 -1.06490861e+00 -1.24617734e+00 -1.47237748e+00
 -3.38114045e+00  5.81846210e-01  5.09717798e+00 -5.45365806e-01
 -2.95892271e-01  1.14990091e-02 -1.93466504e-01  2.17226406e-03
 -2.89652266e-01  1.03408433e+00 -1.35548401e-01  4.57829697e-01
  2.31829971e-02  3.82541530e-01 -5.31337743e-02 -3.49686409e-01]


Intercept  =  23.598336127191143


******************** ploting the graph of Actual and predicted only with 80
observation ********************
```



power transformer operation we have increased our training accuracy by some percent.

0.1.16 Model 2 - Build Linear Regression model by using polynomial features

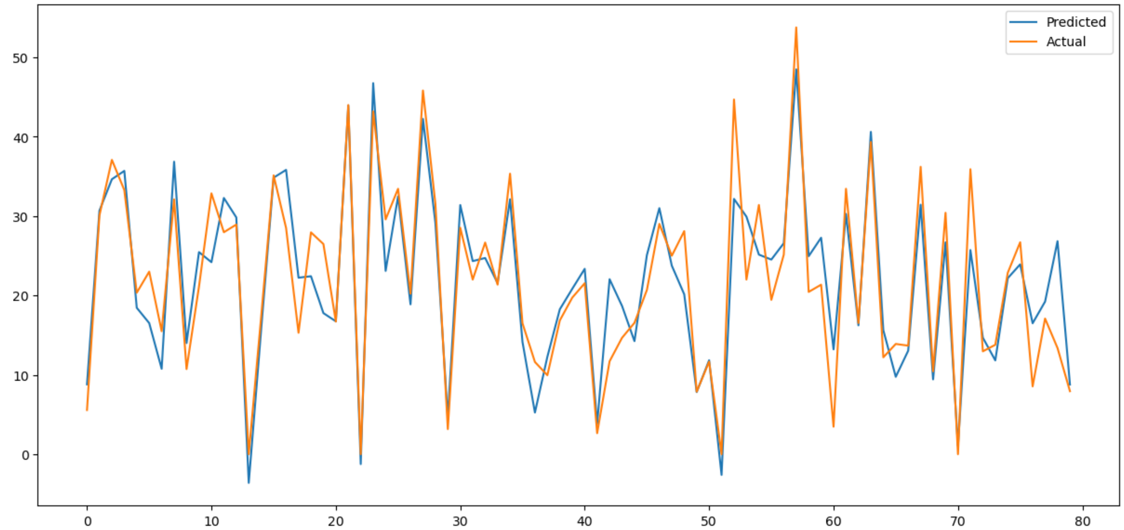
[91]:
```python
from sklearn.preprocessing import PolynomialFeatures
poly = PolynomialFeatures(2)
poly_xtrain = poly.fit_transform(xtrain_trans)
poly_xtest = poly.transform(xtest_trans)
```

[92]:
```python
score_metrix(LinearRegression(), poly_xtrain,poly_xtest,ytrain,ytest)
```

```
Training score  = 0.8514176744024103
MAE : 3.7032465524929217
MSE : 24.626439154483258
RMSE : 4.962503315312067
R2 : 0.8424038323863426
Adjusted R2 :  0.7903108742465699

********************************************************************************
coefficient
 [-2.42055653e+08  3.80350733e+00 -2.24863317e+00  2.07888675e-01
  8.66563759e-02 -8.17524798e-01  1.56993174e+00  8.75444129e+11
 -7.97028528e+11 -5.39714366e+10 -3.48062986e+11  1.98781223e+11
 -9.10339367e+11 -4.47588625e+10 -1.13748462e+12  3.75121270e+11
 -3.07372076e+11 -5.82770828e+10  1.35837978e+11  1.19867227e+11
 -4.08967101e+11  7.13816857e+10  5.61047037e+11 -4.01360812e+11
  3.06946549e+11 -2.50091104e+11 -2.77075671e+11 -1.12458243e+11
  1.82171804e+11 -2.86788750e+00  4.24423218e-01 -7.81192780e-02
  6.52954102e-01  4.62203979e-01 -5.47062159e-02 -1.07821655e+00
  1.31826210e+00 -1.44570160e+00 -3.32996368e-01 -4.26783562e-01
 -2.06634903e+00 -4.51168919e+00 -1.26311493e+00  2.72954178e+00
  3.44360352e-01 -9.86839294e-01 -6.12884521e-01 -1.11437988e+00
 -1.12908936e+00 -6.20909214e-01 -1.17614394e+00 -1.45097208e+00
 -7.18057632e-01 -1.40936756e+00 -1.64055920e+00  6.88596725e-01
  5.70297241e-01 -1.33689880e+00 -6.50048256e-01  4.24270630e-02
  5.79956055e-01  7.67684937e-01 -1.89826965e-01  5.86539268e-01
  1.07096863e+00  1.35455298e+00  8.17125320e-01  3.93287659e-01
  1.61888123e+00  1.91864014e-01 -3.23621750e-01  4.97970581e-02
 -2.47341156e-01 -6.10809326e-02 -3.65203857e-01  1.90773010e-01
  5.94833374e-01  1.52141571e-01  4.11298752e-01 -2.65565872e-01
  8.63199234e-01  2.95477867e-01  1.11171722e-01  2.34760284e-01
 -1.42812729e-01 -4.08695221e-01 -1.85875654e-01 -5.24349213e-02
  3.45039368e-03 -5.86357117e-02 -1.47266388e-01  1.18177414e-01
  2.94649124e-01  4.20497894e-01 -1.34498596e-01  8.29439163e-02
  1.98917389e-02  2.29339600e-02  8.75577927e-02  1.82228088e-01
  2.16526031e-01  1.06094360e-01  3.66329193e-01  2.03327179e-01
  1.98926926e-02  9.52529907e-03  2.19348907e-01 -4.99744415e-02
 -7.60726929e-02  5.39112091e-02 -1.57249451e-01  4.59548950e-01
  2.50503540e-01 -2.90939331e-01  3.83902073e-01  2.75082111e-01
```

3.40049744e-01	1.44487381e-01	-7.74185181e-01	4.78584290e-01
-1.01821899e-01	4.48799133e-03	2.50610352e-01	6.13689423e-03
-1.00860596e-02	-3.53500366e-01	-6.53839111e-02	1.33510590e-01
1.94010735e-01	-7.53092766e-03	-4.53186035e-01	2.29764462e-01
-2.57054567e-02	-2.91821003e-01	2.27185249e-01	-2.52635622e+00
4.07211304e-01	-1.75289154e-01	-1.56863785e+00	-1.35366058e+00
-5.31836700e+00	1.29162645e+00	4.39962387e-01	8.00765991e-01
2.19211578e-02	-1.68047905e-01	4.70588684e-01	-1.70553207e-01
-2.29618073e-01	-2.64467239e-01	-5.05990982e-02	-1.02407455e-01
2.02579498e-01	9.77611542e-02	4.66156006e-03	-4.09860611e-02
1.60215378e-01	2.52690315e-02	4.51375008e-01	-1.04663086e+00
1.01921082e-01	-9.07168388e-01	-5.19083023e-01	2.04086304e-03
4.84806061e-01	4.91797924e-03	1.36237240e+00	-2.87246704e-03
-6.57764435e-01	3.78593016e-01	1.72575831e-01	2.40169525e-01
1.01547241e-01	-2.54451752e-01	4.21731949e-01	1.25656128e-02
2.28912354e-01	-5.29088974e-02	3.63830566e-01	1.98313713e-01
7.56807327e-02	1.76274300e-01	1.88037109e+00	3.36265564e-02
-2.25864410e-01	-2.10033417e-01	3.07586699e+11	9.16430771e+10
-3.96904570e+11	-2.89871216e-01	1.85271227e+09	6.85424805e-02
-2.88046878e+10	-2.88264726e+10	-2.72403719e+10	-2.81171778e+10
-2.87391893e+10	-2.82072442e+10	-2.89350385e+10	-4.61954714e+09
-2.81525882e+11	-2.90860378e+10	-2.85855111e+10	-1.67312622e-02
4.64923741e+11	-1.50737447e+11	-2.87717511e+11	3.14088821e-01
4.74836349e-01	-2.58602142e-01	1.78209305e-01	5.24371147e-01
4.52751160e-01	-5.47256470e-02	9.01870728e-02	-3.10684204e-01
-1.34089351e-01	-1.49837971e-01	4.67729568e-03	-9.03091431e-02
1.84374809e-01	-3.66300583e-01	-1.90107346e-01	-8.21552277e-02
-4.28478241e-01	-1.79170231e+11	-4.13343922e+11	-2.62710571e-01
2.64371872e-01	-1.12331772e+00	2.71594524e-01	2.88494110e-01
4.24985886e-01	-2.42571831e-01	1.97982788e-02	-1.13143921e-01
-2.78791428e-01	-1.22075081e-01	-2.35469818e-01	-2.79658794e-01
5.14698029e-03	-3.21365833e-01	-4.43730354e-01	-9.05809402e-02
-9.12006378e-01	-5.06668773e+09	6.75426483e-01	3.58532906e-01
2.50473022e-01	-2.29711533e-01	-3.99480820e-01	4.80617523e-01
-2.22327203e-01	-9.26561356e-02	-3.70746613e-01	-1.75520420e-01
-8.18815231e-02	-6.93511963e-02	-3.35130692e-01	-1.44676208e-01
-5.02454758e-01	-5.44155121e-01	-2.20727921e-02	2.18719482e-01
1.45149931e+11	1.36771684e+11	2.82789726e+11	-1.66231791e+11
-1.08587789e+10	-4.85513316e+10	2.28780746e-01	-7.74074554e-01
6.70318604e-02	-5.54824829e-01	-3.84199619e-01	-1.62089348e-01
7.75909424e-03	9.78088379e-03	1.37966156e-01	-5.50483704e-01
7.76787132e-01	-4.67701912e-01	5.81786142e+11	-2.17152938e+11
9.64698144e+10	1.92469141e+11	5.85545706e+11	5.38389206e-01
4.87751007e-01	3.67706299e-01	1.14115715e-01	1.74348831e-01
5.78628540e-01	1.00256538e+00	2.16678619e-01	2.16698647e-01
4.51395035e-01	-1.16396904e-01	-3.62083435e-01	-4.75410689e+10
-1.63679503e+11	9.04601436e+10	2.39609485e+11	-7.55567074e-01
3.25851440e-01	-7.88375854e-01	-1.03632355e+00	-1.55344009e-01

```
 -1.00034618e+00 -6.07870102e-01 -6.76342964e-01 -1.23001099e+00
 -1.20551109e+00  8.00769806e-01  1.06605530e-01 -2.93901877e+11
  1.35990143e-01  2.93731236e+11 -7.22394540e+10  3.95586736e+11
  9.12796831e+10  9.42177695e+10  1.26658630e+11 -7.07411214e+10
 -1.03933761e+10  9.67403000e+10  1.49084188e+11  5.32520826e+10
 -1.02678269e+10  1.43966675e-02  3.80990971e+10  4.98879493e+10
 -8.24604703e+10 -1.20686058e+11 -1.74226761e-02  1.33938238e+11
  7.18112579e+10  5.12733459e-02  1.39401913e-01  9.85094285e+10
  6.82526250e+09  7.04914402e+09 -1.53778076e-01  2.10952759e-03
 -3.96238922e+10  3.78719330e-01  8.67340088e-01  4.55241203e-01
 -2.06054688e-01  1.75422192e-01  7.43818283e-02  7.18780518e-01
 -1.59814835e-01  2.92304993e-01  2.05401778e-01  3.34030151e-01
 -9.19837952e-01  4.00274843e+10  2.93732405e+10  6.74979909e+10
 -1.55738700e+11 -5.37216852e+10  5.76773429e+10  5.90962411e+10
  3.19621453e+10 -4.88927584e+10  1.01173158e+11  2.43293511e+10
 -1.25831604e-01 -7.89261697e+10 -6.87637742e+10  3.00123829e+10
 -1.78245666e+11  1.25615637e+11 -3.03155998e+10 -8.59724137e+08
  2.64568766e+10 -2.37881762e+10  1.64410045e+10 -9.72518921e-01
 -6.02673729e+10 -6.13699163e+10 -6.90758796e+10 -5.60844127e+10
 -7.34662872e+10 -6.58909321e+10  4.44595874e+10  3.82976363e+10
  9.12761406e+10  1.29108429e-01  5.77107259e+10 -9.06878875e+10
 -8.55973655e+10 -1.13037358e+11 -1.26468035e+11  3.24246812e+10
  3.29162585e+10 -5.31848085e+10 -5.71231842e-02 -9.64795738e+10
  5.44299512e+10  3.52439310e+10 -7.43398938e+10 -1.24722034e+11
  2.46927798e+10 -7.88032997e+10 -2.47680664e-01 -1.07883680e+11
  2.07704415e+11  1.35484474e+11  3.42480476e+10  1.56433899e+11
  8.64745115e+10  2.73971558e-02  1.69551304e+11  2.15533207e+10
  3.02119292e+10  1.14433365e+11  8.03274247e+10  3.40402780e-01
 -1.34753385e+11 -1.21478378e+11  2.46327831e+10  4.40777316e+09
  2.02579498e-01  1.66828295e+10 -1.46685896e+11 -4.84050218e+10
 -1.66396141e-01  1.22739671e+11  1.39079900e+10 -1.68920040e-01
  4.96600667e+10 -1.60930634e-01 -2.00550088e+11]


Intercept  =  -486626453486.25385


******************** ploting the graph of Actual and predicted only with 80
observation ********************
```



0.1.17 Regularization

Regularization is one of the most important concepts of machine learning. It is a technique to prevent the model from overfitting by adding extra information to it.

Two techniques of regularization are = 1) Lasso (l1 norm) and 2) Ridge regression (L2 norm)

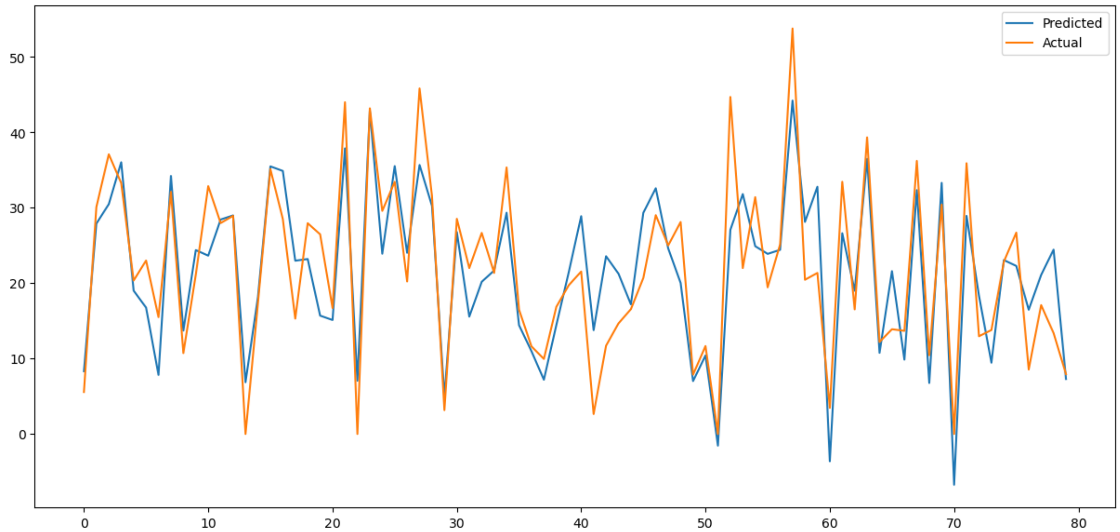
0.1.18 Model 3 - lasso regression

[94]:
```
L1 = Lasso() #creating variable
parameters = {'alpha':␣
↪[1e-15,1e-13,1e-10,1e-8,1e-5,1e-4,1e-3,1e-2,1e-1,1,5,10,20,30,40,45,50,55,60,100,0.
↪0014]} #lasso parameters
lasso_cv = GridSearchCV(L1, parameters, cv=5) #using gridsearchcv and cross␣
↪validate the model
```

[95]:
```
score_metrix(lasso_cv, xtrain_trans, xtest_trans, ytrain, ytest)
```

```
Training score  = 0.7358435727410344
The best parameters found out to be :{'alpha': 0.01}
where model best score is:  0.7329299487993713

MAE : 5.061698499519291
MSE : 41.512360555936745
RMSE : 6.443008657136566
R2 : 0.734342878758378
Adjusted R2 :  0.7300257578095879
```

```
********************************************************************************

******************* ploting the graph of Actual and predicted only with 80
observation *******************
```

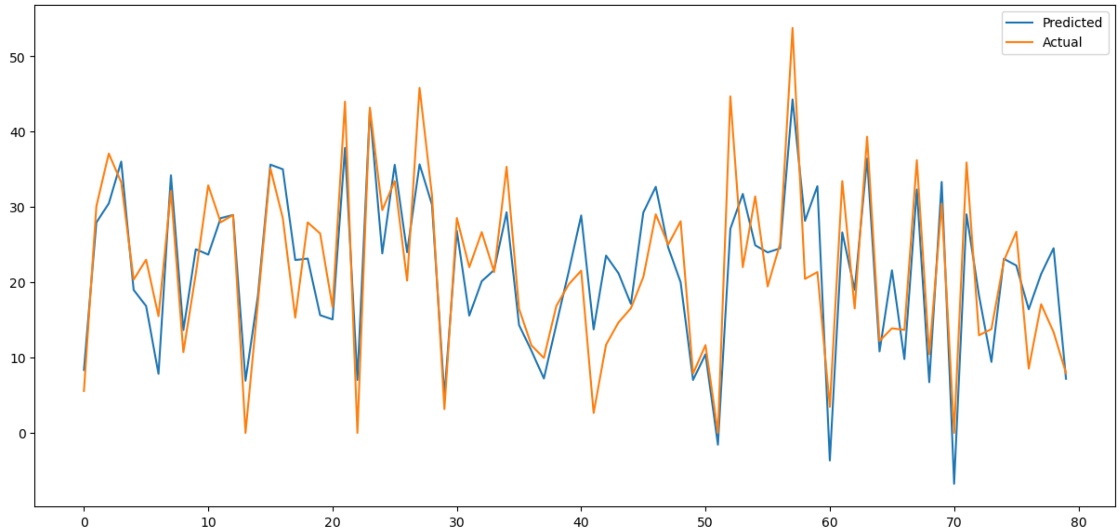


0.1.19 Model 4 - Ridge regression

[97]:
```
L2 = Ridge()
parameters = {'alpha':␣
↪[1e-15,1e-10,1e-8,1e-5,1e-4,1e-3,1e-2,1,5,10,20,30,40,45,50,55,60,100,0.5,1.
↪5,1.6,1.7,1.8,1.9]}
L2_cv = GridSearchCV(L2, parameters, scoring='r2', cv=5)
score_metrix(L2_cv,xtrain_trans,xtest_trans,ytrain,ytest)
```

```
Training score  = 0.7358671502026775
The best parameters found out to be :{'alpha': 10}
where model best score is:  0.732882411744482

MAE : 5.062807136059968
MSE : 41.52017837206753
RMSE : 6.4436153184425535
R2 : 0.7342928488757146
Adjusted R2 :  0.7299749149050355

********************************************************************************
```

```
******************** ploting the graph of Actual and predicted only with 80
observation ********************
```



0.1.20 Model 5 - Decission Tree

decission tree multicollinearity of features does not affect the model accuracy. So in previous models we have removed multicollinear features (such as "Dew Point Temperature").

[99]:
```python
new_x = new_bike_df.drop(columns='Rented Bike Count')
new_y = new_bike_df['Rented Bike Count']
```

[100]:
```python
new_xtrain, new_xtest, new_ytrain, new_ytest = train_test_split(new_x, new_y,␣
↪test_size= 0.20, random_state = 10)
```

[101]:
```python
new_xtrain.shape,   new_xtest.shape,   new_ytrain.shape,  new_ytest.shape
```

[101]: ((7008, 29), (1752, 29), (7008,), (1752,))

[102]:
```python
from sklearn.tree import DecisionTreeRegressor
```

[103]:
```python
param_grid = {'criterion' : ["mse"],
              'splitter' : ["best", "random"],
              'max_depth' : [10,15,25, 'none'],
              'min_samples_split': [10,50,100],
              'max_features' :[24,35,40,49]}

# using grid search cv
```

```python
Dt_grid_search =␣
↪GridSearchCV(DecisionTreeRegressor(),param_grid=param_grid,cv=2,n_jobs=-1)
```

[104]:
```python
score_metrix(Dt_grid_search, new_xtrain,  new_xtest, new_ytrain,new_ytest)
```

```
/home/melke/anaconda3/lib/python3.9/site-
packages/sklearn/utils/validation.py:624: UserWarning: pandas.DataFrame with
sparse columns found.It will be converted to a dense numpy array.
  warnings.warn(
/home/melke/anaconda3/lib/python3.9/site-packages/sklearn/tree/_classes.py:359:
FutureWarning: Criterion 'mse' was deprecated in v1.0 and will be removed in
version 1.2. Use `criterion='squared_error'` which is equivalent.
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FutureWarning: Criterion 'mse' was deprecated in v1.0 and will be removed in
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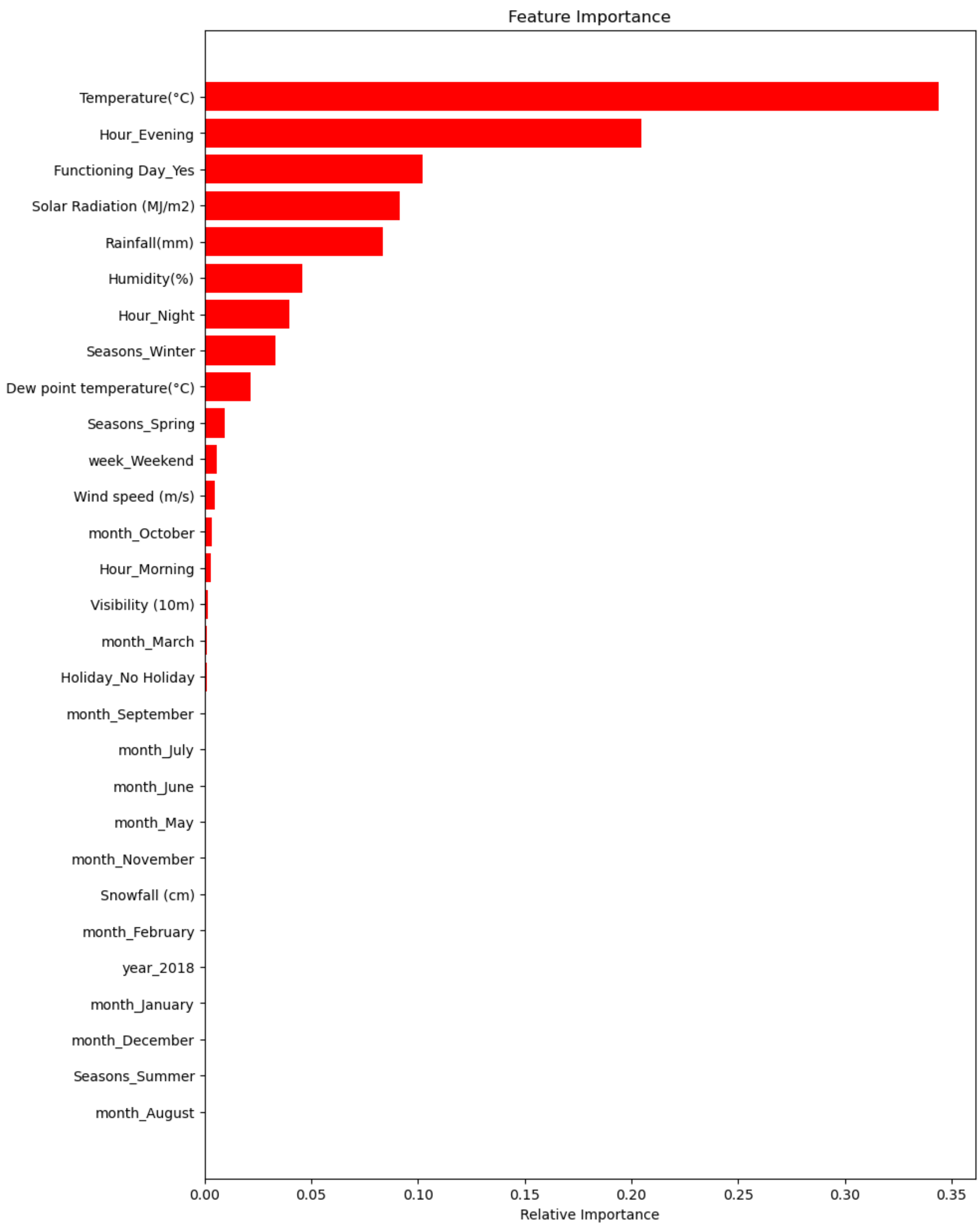
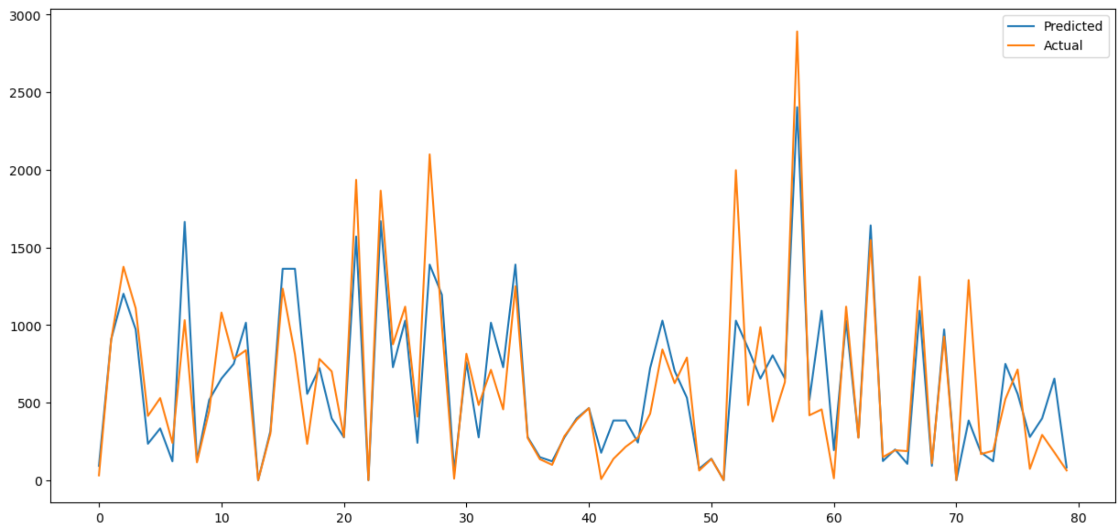
Training score  = 0.8303890114087835
The best parameters found out to be :{'criterion': 'mse', 'max_depth': 10,
'max_features': 24, 'min_samples_split': 50, 'splitter': 'best'}
where model best score is:  0.759140548788605

MAE : 195.82807426204894
MSE : 88982.43794805292
RMSE : 298.29924228541535
R2 : 0.7808631232602943
Adjusted R2 :  0.7771726648250727
```




```
********************************************************************************

******************** ploting the graph of Actual and predicted only with 80
observation ********************
```



0.1.21 Model 6 - Random Forest Regression

[106]:
```
from sklearn.ensemble import RandomForestRegressor
rf_param_grid ={"n_estimators":[50,100,150],
              'max_depth' : [10,15,20,25,'none'],
              'min_samples_split': [10,50,100],
              'max_features' :[24,35,40,49]}
Ranom_forest_Grid_search =␣
 ↪GridSearchCV(RandomForestRegressor(),param_grid=rf_param_grid,n_jobs=-1,verbose=2)
```

[107]:
```
score_metrix(Ranom_forest_Grid_search, new_xtrain, new_xtest, new_ytrain,␣
 ↪new_ytest)
```

```
Fitting 5 folds for each of 180 candidates, totalling 900 fits

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total time=   0.2s
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total time=   0.2s
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total time=   0.1s
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total time=   0.1s
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total time=   0.1s
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total time=   0.1s
```

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total time=   2.1s
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total time=   1.6s
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total time=   1.7s
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total time=   6.3s
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total time=   5.6s
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total time=   5.4s
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total time=   6.0s
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total time=   0.1s
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total time=   0.1s
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total time=   0.1s
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total time=   0.1s
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total time=   0.1s
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total time=   0.2s
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total time=   0.3s
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total time=   0.1s
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total time=   0.1s
```

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total time=   0.1s
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total time=   0.2s
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total time=   0.2s
[CV] END max_depth=25, max_features=40, min_samples_split=50, n_estimators=100;
total time=   0.2s
[CV] END max_depth=25, max_features=40, min_samples_split=50, n_estimators=150;
total time=   0.4s
```

```
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total time=   0.3s
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total time=   0.1s
[CV] END max_depth=25, max_features=49, min_samples_split=50, n_estimators=150;
total time=   0.3s
[CV] END max_depth=25, max_features=49, min_samples_split=100, n_estimators=100;
total time=   0.2s
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total time=   0.2s
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n_estimators=150; total time=   0.3s
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n_estimators=100; total time=   0.2s
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total time=   0.2s
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n_estimators=150; total time=   0.3s
[CV] END max_depth=none, max_features=35, min_samples_split=100,
n_estimators=50; total time=   0.2s
```

```
/home/melke/anaconda3/lib/python3.9/site-
packages/sklearn/utils/validation.py:624: UserWarning: pandas.DataFrame with
sparse columns found.It will be converted to a dense numpy array.
  warnings.warn(
/home/melke/anaconda3/lib/python3.9/site-
packages/sklearn/utils/validation.py:624: UserWarning: pandas.DataFrame with
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```

```
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```

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```

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total time=   0.1s
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total time=   0.2s
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total time=   0.2s
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total time=   0.1s
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total time=   0.2s
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total time=   0.1s
```

```
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total time=   0.1s
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total time=   0.1s
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total time=   0.1s
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total time=   0.2s
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total time=   5.2s
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total time=   2.0s
[CV] END max_depth=20, max_features=24, min_samples_split=100, n_estimators=100;
total time=   3.6s
[CV] END max_depth=20, max_features=35, min_samples_split=50, n_estimators=100;
total time=   0.3s
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total time=   0.1s
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total time=   0.2s
[CV] END max_depth=20, max_features=40, min_samples_split=50, n_estimators=50;
total time=   0.1s
[CV] END max_depth=20, max_features=40, min_samples_split=50, n_estimators=150;
total time=   0.2s
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total time=   0.1s
[CV] END max_depth=20, max_features=40, min_samples_split=100, n_estimators=100;
total time=   0.2s
[CV] END max_depth=20, max_features=40, min_samples_split=100, n_estimators=150;
total time=   0.3s
```

```
[CV] END max_depth=20, max_features=49, min_samples_split=10, n_estimators=100;
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[CV] END max_depth=20, max_features=49, min_samples_split=10, n_estimators=150;
total time=   0.2s
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total time=   0.2s
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total time=   7.9s
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total time=   5.7s
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total time=   2.2s
[CV] END max_depth=25, max_features=24, min_samples_split=100, n_estimators=150;
total time=   6.1s
[CV] END max_depth=25, max_features=49, min_samples_split=10, n_estimators=100;
total time=   0.2s
[CV] END max_depth=25, max_features=49, min_samples_split=10, n_estimators=150;
total time=   0.3s
[CV] END max_depth=25, max_features=49, min_samples_split=50, n_estimators=100;
total time=   0.2s
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total time=   0.2s
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n_estimators=50; total time=   0.2s
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n_estimators=150; total time=   0.3s
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n_estimators=100; total time=   0.2s
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n_estimators=50; total time=   0.2s
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n_estimators=100; total time=   0.2s
[CV] END max_depth=none, max_features=40, min_samples_split=10,
n_estimators=100; total time=   0.2s
```

```
[CV] END max_depth=none, max_features=40, min_samples_split=50, n_estimators=50;
total time=   0.2s
```

```
/home/melke/anaconda3/lib/python3.9/site-
packages/sklearn/utils/validation.py:624: UserWarning: pandas.DataFrame with
sparse columns found.It will be converted to a dense numpy array.
  warnings.warn(
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```

```
packages/sklearn/utils/validation.py:624: UserWarning: pandas.DataFrame with
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  warnings.warn(
```

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[CV] END max_depth=10, max_features=24, min_samples_split=10, n_estimators=100;
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total time=   0.1s
```

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total time=   0.1s
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total time=   0.2s
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total time=   4.4s
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total time=   3.8s
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total time=   2.1s
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total time=   4.1s
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total time=   0.1s
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total time=   0.1s
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total time=   0.2s
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total time=   0.1s
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total time=   0.1s
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total time=   0.1s
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total time=   3.3s
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total time=   4.2s
```

```
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total time=   2.8s
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```

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total time=   0.2s
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total time=   0.1s
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total time=   0.1s
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total time=   1.7s
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total time=   3.2s
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total time=   0.1s
[CV] END max_depth=20, max_features=35, min_samples_split=10, n_estimators=100;
total time=   0.2s
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total time=   0.2s
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total time=   0.1s
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total time=   0.2s
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total time=   0.1s
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total time=   0.1s
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total time=   0.1s
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total time=   0.1s
[CV] END max_depth=20, max_features=40, min_samples_split=10, n_estimators=150;
total time=   0.2s
```

```
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total time=   0.2s
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total time=   0.3s
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total time=   0.1s
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total time=   0.2s
[CV] END max_depth=20, max_features=49, min_samples_split=100, n_estimators=50;
total time=   0.1s
[CV] END max_depth=20, max_features=49, min_samples_split=100, n_estimators=100;
total time=   0.1s
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total time=   8.8s
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total time=   6.7s
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total time=   0.1s
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total time=   0.2s
[CV] END max_depth=25, max_features=35, min_samples_split=10, n_estimators=150;
total time=   0.1s
[CV] END max_depth=25, max_features=35, min_samples_split=50, n_estimators=50;
total time=   0.1s
[CV] END max_depth=25, max_features=35, min_samples_split=50, n_estimators=50;
total time=   0.1s
[CV] END max_depth=25, max_features=35, min_samples_split=50, n_estimators=150;
total time=   0.2s
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total time=   0.2s
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total time=   0.1s
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total time=   0.1s
[CV] END max_depth=25, max_features=40, min_samples_split=10, n_estimators=150;
total time=   0.3s
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total time=   0.2s
[CV] END max_depth=25, max_features=40, min_samples_split=50, n_estimators=150;
total time=   0.3s
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total time=   0.1s
```

```
[CV] END max_depth=25, max_features=40, min_samples_split=100, n_estimators=100;
total time=   0.2s
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total time=   0.2s
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total time=   0.1s
[CV] END max_depth=25, max_features=49, min_samples_split=10, n_estimators=150;
total time=   0.3s
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total time=   0.2s
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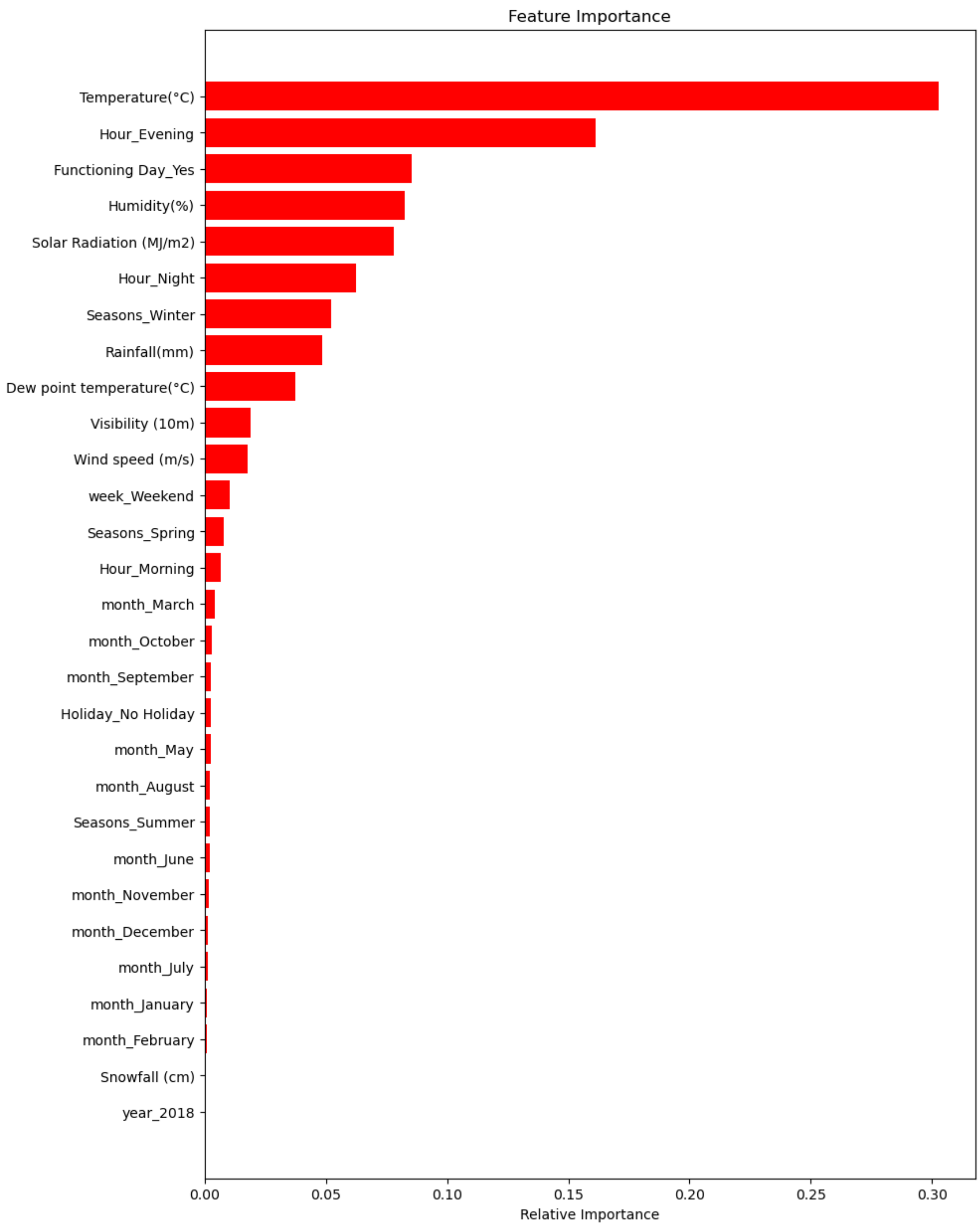
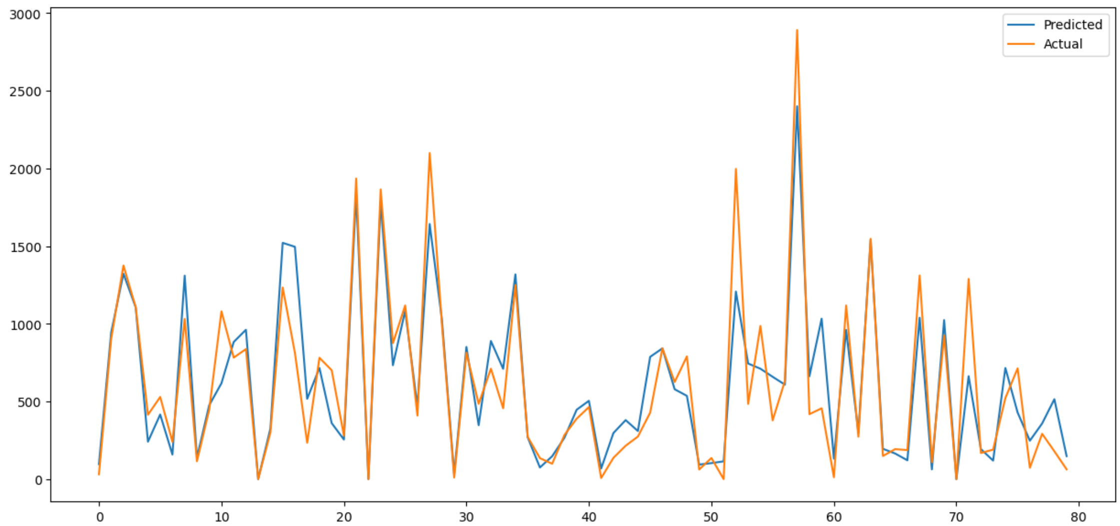
total time=   0.2s
[CV] END max_depth=none, max_features=49, min_samples_split=10,
n_estimators=100; total time=   0.2s
[CV] END max_depth=none, max_features=49, min_samples_split=50, n_estimators=50;
total time=   0.1s
[CV] END max_depth=none, max_features=49, min_samples_split=100,
n_estimators=50; total time=   0.2s
Training score  = 0.9466379140634524
The best parameters found out to be :{'max_depth': 25, 'max_features': 24,
'min_samples_split': 10, 'n_estimators': 150}
where model best score is:  0.8369157056804472
```

```
MAE : 162.77671988601767
MSE : 64059.96892160072
RMSE : 253.10070904997622
R2 : 0.8422396392227712
Adjusted R2 :  0.8395828154930735
```



```
********************************************************************************

******************* ploting the graph of Actual and predicted only with 80
observation *******************
```



0.2 Conclusions of Project

EDA Insights

1. The summer season sees the highest number of bike rentals, while the winter season sees the lowest.
2. Non-holiday days account for 98% of bike rentals, indicating that most users rent bikes for their daily commute to work.
3. Bike rentals peak in the temperature range of 15 to 30 degrees.
4. Bike rentals are highest when there is no snowfall or rainfall.
5. Most bikes are rented when humidity is between 30% and 70%.
6. Bike rental count gradually increases from 6am to 10am, possibly due to employees heading to work, and then slightly decreases until 4pm before increasing again until 8pm, likely when employees return home.
7. The 18th hour (6pm) sees the highest number of bike rentals, while the 4th hour (4am) sees the lowest.
8. High visibility conditions see the most bike rentals.
9. Demand for rented bikes increased in 2018 compared to the previous year, possibly indicating increased awareness and adoption of bike rental services.

ML models observation

model 1 Linear Regression

Evaluation matrices :

```
Training score = 0.7031168479271276
MAE : 5.256832985963903
MSE : 44.35376150715583
RMSE : 6.659861973581422
R2 : 0.7161594175703074
Adjusted R2 :  0.7115468021854953
```

model 2 LR By polynomial features

Evaluation matrices :

```
Training score  = 0.8514176478921974
MAE : 3.7037638918076135
MSE : 24.62886174549538
RMSE : 4.962747398920822
R2 : 0.8423883290869492
Adjusted R2 :  0.7902902463763283
```

model 3 Lasso Regression

Evaluation matrices :

```
Training score  = 0.7358435727410344
The best parameters found out to be :{'alpha': 0.01}
where model best score is:  0.7329299487993713

MAE : 5.06169849951929
MSE : 41.51236055593674
RMSE : 6.443008657136566
R2 : 0.7343428787583781
Adjusted R2 :  0.7300257578095879
```

model 4 Ridge Regression

Evaluation matrices :

```
Training score  = 0.7358671502026775
The best parameters found out to be :{'alpha': 10}
   where model best score is:  0.7328824117444819

MAE : 5.062807136059967
MSE : 41.52017837206752
RMSE : 6.443615318442553
R2 : 0.7342928488757146
Adjusted R2 :  0.7299749149050355
```

model 5 Decision Tree

Evaluation matrices :

```
Training score  = 0.8280441022565106
     The best parameters found out to be :{'criterion': 'mse', 'max_
   where model best score is:  0.762736405229868

   MAE : 198.53362785980028
   MSE : 91206.7120267727
   RMSE : 302.004490077172
   R2 : 0.7753854078159468
   Adjusted R2 :  0.771602699817493
```

Model 6 Random Forest Regression

Evaluation matrices :

```
Fitting 5 folds for each of 180 candidates, totalling 900 fits
Training score  = 0.9462585885010566
The best parameters found out to be :{'max_depth': 25, 'max_features': 24, 'min_sampl
where model best score is:  0.8368912182495061

MAE : 162.8700295318971
MSE : 63993.77680319597
RMSE : 252.96991284181598
R2 : 0.8424026504239306
Adjusted R2 :  0.8397485719467495
```

From analyzing the model insights, we can conclude that the Random Forest Regression model performs the best in predicting bike rental counts with an R2 score of 0.842402, while the Linear Regression model performs the worst with an R2 score of 0.7161594175703074. Visualizations of actual versus predicted values have been created for all six models, and feature importance graphs have been used to explain each model. Furthermore, temperature and hour are the two most significant factors in predicting bike rental counts according to all six models, making them useful features for modeling purposes.