bulldozer-price-prediction

September 12, 2023

1 Predicting sale price of Bulldozers using Machine Learning

1.1 1. Problem Definition

> Predict the future sale price of a Bulldozer based on it's characteristics and past sales of similar bulldozers.

1.2 2. Data

The data is taken from the Kaggle competition - `Blue Book for Bulldozers` : https://www.kaggle.com/competitions/bluebook-for-bulldozers/data

There are 3 datasets for the problem - * Train.csv is the training set, which contains data through the end of 2011. * Valid.csv is the validation set, which contains data from January 1, 2012 - April 30, 2012. * Test.csv is the test set which contains data from May 1, 2012 - November 2012.

1.3 3. Evaluation

The evaluation metric for this competition is the RMSLE (root mean squared log error) between the actual and predicted auction prices.
Note - In a regression problem, the goal is to reduce the error as much as possible. i.e. for the given problem, reduce RMSLE.

1.4 4. Features

Kaggle provides a data dictionary for the features present in the datasets.
Data Dictionary google spreadsheet : https://docs.google.com/spreadsheets/d/1TdR-DKtUNUdwcuawLolL_K8bA28_ms2z_7K5Hza0wng/edit?usp=sharing

Importing Modules

[60]:

```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import sklearn
from sklearn.ensemble import RandomForestRegressor

%matplotlib inline
```

1.4.1 Exploratory Data Analysis (EDA)

```
[2]: df = pd.read_csv("data/bluebook-for-bulldozers/TrainAndValid.csv", low_memory =␣
      ↪False)
```

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

```
[3]:    SalesID  SalePrice  MachineID  ModelID  datasource  auctioneerID  YearMade  \
     0  1139246    66000.0     999089     3157         121           3.0      2004
     1  1139248    57000.0     117657       77         121           3.0      1996
     2  1139249    10000.0     434808     7009         121           3.0      2001
     3  1139251    38500.0    1026470      332         121           3.0      2001
     4  1139253    11000.0    1057373    17311         121           3.0      2007

        MachineHoursCurrentMeter UsageBand         saledate  ...  \
     0                      68.0       Low  11/16/2006 0:00  ...
     1                    4640.0       Low   3/26/2004 0:00  ...
     2                    2838.0      High   2/26/2004 0:00  ...
     3                    3486.0      High   5/19/2011 0:00  ...
     4                     722.0    Medium   7/23/2009 0:00  ...

       Undercarriage_Pad_Width Stick_Length Thumb Pattern_Changer Grouser_Type  \
     0                     NaN          NaN   NaN             NaN          NaN
     1                     NaN          NaN   NaN             NaN          NaN
     2                     NaN          NaN   NaN             NaN          NaN
     3                     NaN          NaN   NaN             NaN          NaN
     4                     NaN          NaN   NaN             NaN          NaN

       Backhoe_Mounting Blade_Type Travel_Controls Differential_Type  \
     0              NaN        NaN             NaN          Standard
     1              NaN        NaN             NaN          Standard
     2              NaN        NaN             NaN               NaN
     3              NaN        NaN             NaN               NaN
     4              NaN        NaN             NaN               NaN

       Steering_Controls
     0      Conventional
     1      Conventional
     2               NaN
     3               NaN
     4               NaN

     [5 rows x 53 columns]
```

```
[4]: df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 412698 entries, 0 to 412697
```

```
Data columns (total 53 columns):
 #   Column                    Non-Null Count   Dtype
---  ------                    --------------   -----
 0   SalesID                   412698 non-null  int64
 1   SalePrice                 412698 non-null  float64
 2   MachineID                 412698 non-null  int64
 3   ModelID                   412698 non-null  int64
 4   datasource                412698 non-null  int64
 5   auctioneerID              392562 non-null  float64
 6   YearMade                  412698 non-null  int64
 7   MachineHoursCurrentMeter  147504 non-null  float64
 8   UsageBand                 73670 non-null   object
 9   saledate                  412698 non-null  object
 10  fiModelDesc               412698 non-null  object
 11  fiBaseModel               412698 non-null  object
 12  fiSecondaryDesc           271971 non-null  object
 13  fiModelSeries             58667 non-null   object
 14  fiModelDescriptor         74816 non-null   object
 15  ProductSize               196093 non-null  object
 16  fiProductClassDesc        412698 non-null  object
 17  state                     412698 non-null  object
 18  ProductGroup              412698 non-null  object
 19  ProductGroupDesc          412698 non-null  object
 20  Drive_System              107087 non-null  object
 21  Enclosure                 412364 non-null  object
 22  Forks                     197715 non-null  object
 23  Pad_Type                  81096 non-null   object
 24  Ride_Control              152728 non-null  object
 25  Stick                     81096 non-null   object
 26  Transmission              188007 non-null  object
 27  Turbocharged              81096 non-null   object
 28  Blade_Extension           25983 non-null   object
 29  Blade_Width               25983 non-null   object
 30  Enclosure_Type            25983 non-null   object
 31  Engine_Horsepower         25983 non-null   object
 32  Hydraulics                330133 non-null  object
 33  Pushblock                 25983 non-null   object
 34  Ripper                    106945 non-null  object
 35  Scarifier                 25994 non-null   object
 36  Tip_Control               25983 non-null   object
 37  Tire_Size                 97638 non-null   object
 38  Coupler                   220679 non-null  object
 39  Coupler_System            44974 non-null   object
 40  Grouser_Tracks            44875 non-null   object
 41  Hydraulics_Flow           44875 non-null   object
 42  Track_Type                102193 non-null  object
 43  Undercarriage_Pad_Width   102916 non-null  object
 44  Stick_Length              102261 non-null  object
 45  Thumb                     102332 non-null  object
 46  Pattern_Changer           102261 non-null  object
 47  Grouser_Type              102193 non-null  object
 48  Backhoe_Mounting          80712 non-null   object
 49  Blade_Type                81875 non-null   object
 50  Travel_Controls           81877 non-null   object
 51  Differential_Type         71564 non-null   object
 52  Steering_Controls         71522 non-null   object
dtypes: float64(3), int64(5), object(45)
memory usage: 166.9+ MB
```

[5]:

```
df.isna().sum()
```

[5]:

```
SalesID                          0
SalePrice                        0
MachineID                        0
ModelID                          0
datasource                       0
auctioneerID                 20136
YearMade                         0
MachineHoursCurrentMeter    265194
UsageBand                   339028
saledate                         0
fiModelDesc                      0
fiBaseModel                      0
fiSecondaryDesc             140727
fiModelSeries               354031
fiModelDescriptor           337882
ProductSize                 216605
fiProductClassDesc               0
state                            0
ProductGroup                     0
ProductGroupDesc                 0
Drive_System                305611
Enclosure                      334
Forks                       214983
Pad_Type                    331602
Ride_Control                259970
Stick                       331602
Transmission                224691
Turbocharged                331602
Blade_Extension             386715
Blade_Width                 386715
Enclosure_Type              386715
Engine_Horsepower           386715
Hydraulics                   82565
Pushblock                   386715
```

```
Ripper                     305753
Scarifier                  386704
Tip_Control                386715
Tire_Size                  315060
Coupler                    192019
Coupler_System             367724
Grouser_Tracks             367823
Hydraulics_Flow            367823
Track_Type                 310505
Undercarriage_Pad_Width    309782
Stick_Length               310437
Thumb                      310366
Pattern_Changer            310437
Grouser_Type               310505
Backhoe_Mounting           331986
Blade_Type                 330823
Travel_Controls            330821
Differential_Type          341134
Steering_Controls          341176
dtype: int64
```

[6]:

```
df["saledate"][:10]
```

[6]:

```
0    11/16/2006 0:00
1     3/26/2004 0:00
2     2/26/2004 0:00
3     5/19/2011 0:00
4     7/23/2009 0:00
5    12/18/2008 0:00
6     8/26/2004 0:00
7    11/17/2005 0:00
8     8/27/2009 0:00
9      8/9/2007 0:00
Name: saledate, dtype: object
```

[7]:

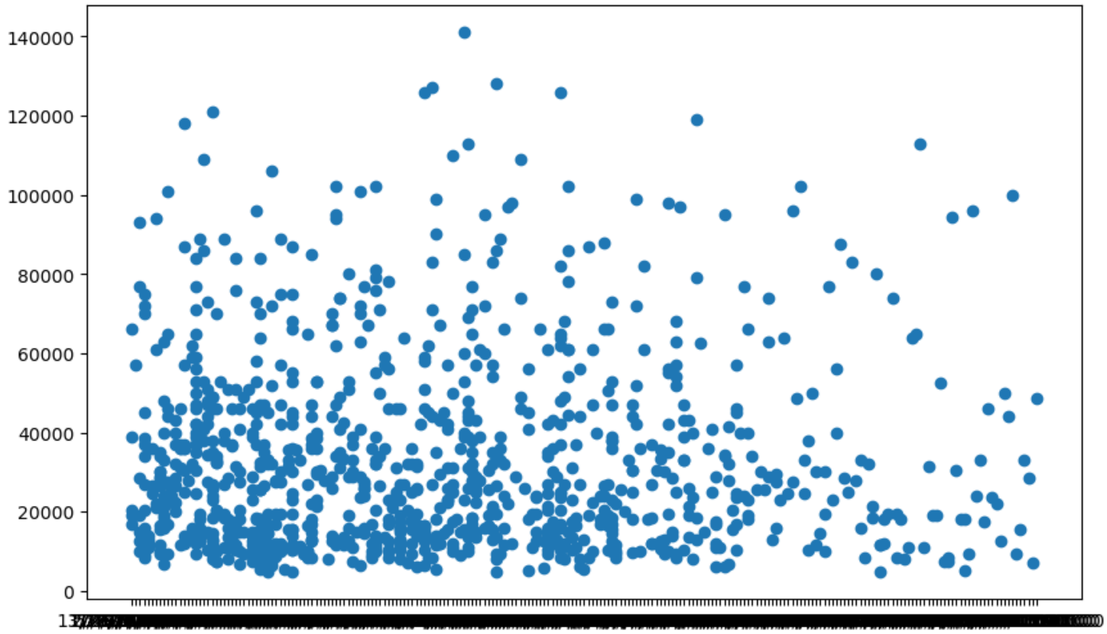
```
df["saledate"].dtype
```

[7]:

```
dtype('O')
```

[8]:

```
fig, ax = plt.subplots(figsize = (10,6))
ax = plt.scatter(df["saledate"][:1000], df["SalePrice"][:1000]);
```



The saledate column contains datetime data and must be parsed as datetime during importation

[9]:
```
# Reimporting with parsed datetime
df = pd.read_csv("data/bluebook-for-bulldozers/TrainAndValid.csv",␣
 ↪low_memory=False, parse_dates=["saledate"])
```

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

[10]:
```
   SalesID  SalePrice  MachineID  ModelID  datasource  auctioneerID  YearMade  \
0  1139246    66000.0     999089     3157         121           3.0      2004
1  1139248    57000.0     117657       77         121           3.0      1996
2  1139249    10000.0     434808     7009         121           3.0      2001
3  1139251    38500.0    1026470      332         121           3.0      2001
4  1139253    11000.0    1057373    17311         121           3.0      2007

   MachineHoursCurrentMeter UsageBand   saledate  … Undercarriage_Pad_Width  \
0                      68.0       Low 2006-11-16  …                     NaN
1                    4640.0       Low 2004-03-26  …                     NaN
2                    2838.0      High 2004-02-26  …                     NaN
3                    3486.0      High 2011-05-19  …                     NaN
4                     722.0    Medium 2009-07-23  …                     NaN

  Stick_Length Thumb Pattern_Changer Grouser_Type Backhoe_Mounting Blade_Type  \
0          NaN   NaN             NaN          NaN              NaN        NaN
1          NaN   NaN             NaN          NaN              NaN        NaN
2          NaN   NaN             NaN          NaN              NaN        NaN
```

```
3          NaN   NaN             NaN          NaN              NaN        NaN
4          NaN   NaN             NaN          NaN              NaN        NaN

  Travel_Controls Differential_Type Steering_Controls
0             NaN          Standard      Conventional
1             NaN          Standard      Conventional
2             NaN               NaN               NaN
3             NaN               NaN               NaN
4             NaN               NaN               NaN

[5 rows x 53 columns]
```

[11]:

```
df["saledate"][:10]
```

[11]:

```
0   2006-11-16
1   2004-03-26
2   2004-02-26
3   2011-05-19
4   2009-07-23
5   2008-12-18
6   2004-08-26
7   2005-11-17
8   2009-08-27
9   2007-08-09
Name: saledate, dtype: datetime64[ns]
```

[12]:

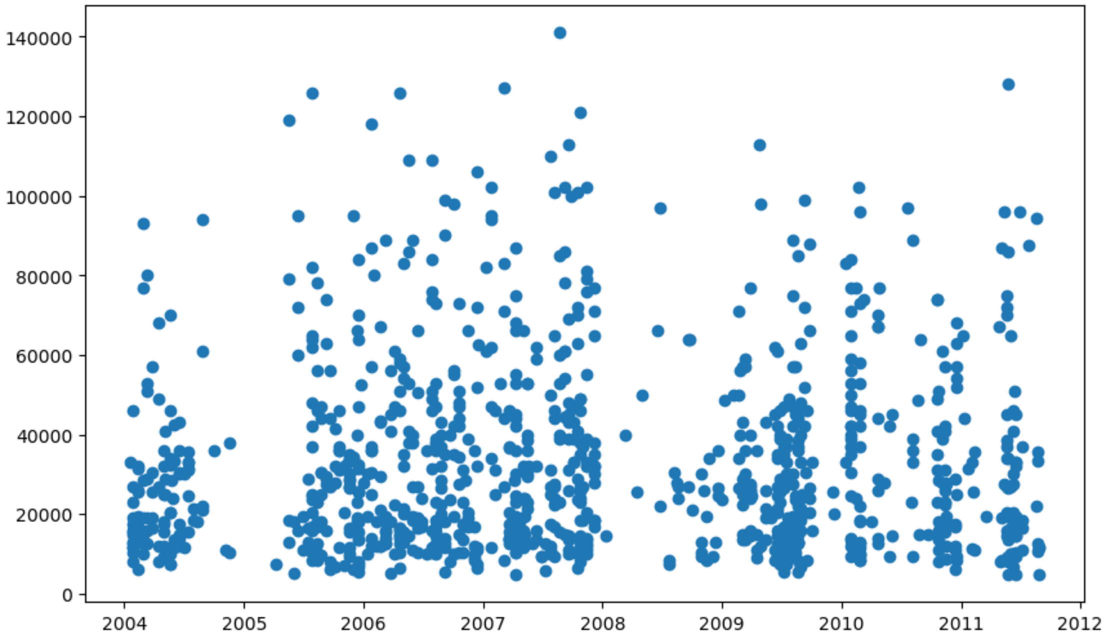
```
df["saledate"].dtype
```

[12]:

```
dtype('<M8[ns]')
```

[13]:

```
fig, ax = plt.subplots(figsize = (10,6))
ax = plt.scatter(df["saledate"][:1000], df["SalePrice"][:1000])
```



Since Jupyter Notebook truncates the data if the number of features is large let's view all the features in head() using it's transpose.

[14]:
```
df.head().T
```

[14]:
```
                                                                0  \
SalesID                                                   1139246
SalePrice                                                 66000.0
MachineID                                                  999089
ModelID                                                      3157
datasource                                                    121
auctioneerID                                                  3.0
YearMade                                                     2004
MachineHoursCurrentMeter                                     68.0
UsageBand                                                     Low
saledate                                      2006-11-16 00:00:00
fiModelDesc                                                  521D
fiBaseModel                                                   521
fiSecondaryDesc                                                 D
fiModelSeries                                                 NaN
fiModelDescriptor                                             NaN
ProductSize                                                   NaN
fiProductClassDesc          Wheel Loader - 110.0 to 120.0 Horsepower
state                                                     Alabama
ProductGroup                                                   WL
ProductGroupDesc                                     Wheel Loader
```

```
Drive_System                                                   NaN
Enclosure                                               EROPS w AC
Forks                                          None or Unspecified
Pad_Type                                                       NaN
Ride_Control                                   None or Unspecified
Stick                                                          NaN
Transmission                                                   NaN
Turbocharged                                                   NaN
Blade_Extension                                                NaN
Blade_Width                                                    NaN
Enclosure_Type                                                 NaN
Engine_Horsepower                                              NaN
Hydraulics                                                 2 Valve
Pushblock                                                      NaN
Ripper                                                         NaN
Scarifier                                                      NaN
Tip_Control                                                    NaN
Tire_Size                                      None or Unspecified
Coupler                                        None or Unspecified
Coupler_System                                                 NaN
Grouser_Tracks                                                 NaN
Hydraulics_Flow                                                NaN
Track_Type                                                     NaN
Undercarriage_Pad_Width                                        NaN
Stick_Length                                                   NaN
Thumb                                                          NaN
Pattern_Changer                                                NaN
Grouser_Type                                                   NaN
Backhoe_Mounting                                               NaN
Blade_Type                                                     NaN
Travel_Controls                                                NaN
Differential_Type                                         Standard
Steering_Controls                                     Conventional

                                                                 1  \
SalesID                                                    1139248
SalePrice                                                  57000.0
MachineID                                                   117657
ModelID                                                         77
datasource                                                     121
auctioneerID                                                   3.0
YearMade                                                      1996
MachineHoursCurrentMeter                                    4640.0
UsageBand                                                      Low
saledate                                       2004-03-26 00:00:00
fiModelDesc                                                 950FII
fiBaseModel                                                    950
```

```
fiSecondaryDesc                                                  F
fiModelSeries                                                   II
fiModelDescriptor                                              NaN
ProductSize                                                 Medium
fiProductClassDesc        Wheel Loader - 150.0 to 175.0 Horsepower
state                                               North Carolina
ProductGroup                                                    WL
ProductGroupDesc                                      Wheel Loader
Drive_System                                                   NaN
Enclosure                                               EROPS w AC
Forks                                          None or Unspecified
Pad_Type                                                       NaN
Ride_Control                                   None or Unspecified
Stick                                                          NaN
Transmission                                                   NaN
Turbocharged                                                   NaN
Blade_Extension                                                NaN
Blade_Width                                                    NaN
Enclosure_Type                                                 NaN
Engine_Horsepower                                              NaN
Hydraulics                                                 2 Valve
Pushblock                                                      NaN
Ripper                                                         NaN
Scarifier                                                      NaN
Tip_Control                                                    NaN
Tire_Size                                                     23.5
Coupler                                        None or Unspecified
Coupler_System                                                 NaN
Grouser_Tracks                                                 NaN
Hydraulics_Flow                                                NaN
Track_Type                                                     NaN
Undercarriage_Pad_Width                                        NaN
Stick_Length                                                   NaN
Thumb                                                          NaN
Pattern_Changer                                                NaN
Grouser_Type                                                   NaN
Backhoe_Mounting                                               NaN
Blade_Type                                                     NaN
Travel_Controls                                                NaN
Differential_Type                                         Standard
Steering_Controls                                     Conventional

                                                                          2  \
SalesID                                                             1139249
SalePrice                                                           10000.0
MachineID                                                            434808
ModelID                                                                7009
```

```
datasource                                                              121
auctioneerID                                                            3.0
YearMade                                                               2001
MachineHoursCurrentMeter                                             2838.0
UsageBand                                                              High
saledate                                                2004-02-26 00:00:00
fiModelDesc                                                             226
fiBaseModel                                                             226
fiSecondaryDesc                                                         NaN
fiModelSeries                                                           NaN
fiModelDescriptor                                                       NaN
ProductSize                                                             NaN
fiProductClassDesc        Skid Steer Loader - 1351.0 to 1601.0 Lb Operat…
state                                                              New York
ProductGroup                                                            SSL
ProductGroupDesc                                         Skid Steer Loaders
Drive_System                                                            NaN
Enclosure                                                             OROPS
Forks                                                 None or Unspecified
Pad_Type                                                                NaN
Ride_Control                                                            NaN
Stick                                                                   NaN
Transmission                                                            NaN
Turbocharged                                                            NaN
Blade_Extension                                                         NaN
Blade_Width                                                             NaN
Enclosure_Type                                                          NaN
Engine_Horsepower                                                       NaN
Hydraulics                                                        Auxiliary
Pushblock                                                               NaN
Ripper                                                                  NaN
Scarifier                                                               NaN
Tip_Control                                                             NaN
Tire_Size                                                               NaN
Coupler                                               None or Unspecified
Coupler_System                                        None or Unspecified
Grouser_Tracks                                        None or Unspecified
Hydraulics_Flow                                                    Standard
Track_Type                                                              NaN
Undercarriage_Pad_Width                                                 NaN
Stick_Length                                                            NaN
Thumb                                                                   NaN
Pattern_Changer                                                         NaN
Grouser_Type                                                            NaN
Backhoe_Mounting                                                        NaN
Blade_Type                                                              NaN
Travel_Controls                                                         NaN
```

```
Differential_Type                                                       NaN
Steering_Controls                                                       NaN

                                                                          3  \
SalesID                                                             1139251
SalePrice                                                           38500.0
MachineID                                                           1026470
ModelID                                                                 332
datasource                                                              121
auctioneerID                                                            3.0
YearMade                                                               2001
MachineHoursCurrentMeter                                             3486.0
UsageBand                                                              High
saledate                                                2011-05-19 00:00:00
fiModelDesc                                                        PC120-6E
fiBaseModel                                                           PC120
fiSecondaryDesc                                                         NaN
fiModelSeries                                                           -6E
fiModelDescriptor                                                       NaN
ProductSize                                                           Small
fiProductClassDesc        Hydraulic Excavator, Track - 12.0 to 14.0 Metr…
state                                                                 Texas
ProductGroup                                                            TEX
ProductGroupDesc                                           Track Excavators
Drive_System                                                            NaN
Enclosure                                                        EROPS w AC
Forks                                                                   NaN
Pad_Type                                                                NaN
Ride_Control                                                            NaN
Stick                                                                   NaN
Transmission                                                            NaN
Turbocharged                                                            NaN
Blade_Extension                                                         NaN
Blade_Width                                                             NaN
Enclosure_Type                                                          NaN
Engine_Horsepower                                                       NaN
Hydraulics                                                          2 Valve
Pushblock                                                               NaN
Ripper                                                                  NaN
Scarifier                                                               NaN
Tip_Control                                                             NaN
Tire_Size                                                               NaN
Coupler                                                 None or Unspecified
Coupler_System                                                          NaN
Grouser_Tracks                                                          NaN
Hydraulics_Flow                                                         NaN
Track_Type                                                              NaN
```

```
Undercarriage_Pad_Width                                                 NaN
Stick_Length                                                            NaN
Thumb                                                                   NaN
Pattern_Changer                                                         NaN
Grouser_Type                                                            NaN
Backhoe_Mounting                                                        NaN
Blade_Type                                                              NaN
Travel_Controls                                                         NaN
Differential_Type                                                       NaN
Steering_Controls                                                       NaN

                                                                          4
SalesID                                                             1139253
SalePrice                                                           11000.0
MachineID                                                           1057373
ModelID                                                               17311
datasource                                                              121
auctioneerID                                                            3.0
YearMade                                                               2007
MachineHoursCurrentMeter                                              722.0
UsageBand                                                            Medium
saledate                                                2009-07-23 00:00:00
fiModelDesc                                                            S175
fiBaseModel                                                            S175
fiSecondaryDesc                                                         NaN
fiModelSeries                                                           NaN
fiModelDescriptor                                                       NaN
ProductSize                                                             NaN
fiProductClassDesc        Skid Steer Loader - 1601.0 to 1751.0 Lb Operat…
state                                                              New York
ProductGroup                                                            SSL
ProductGroupDesc                                         Skid Steer Loaders
Drive_System                                                            NaN
Enclosure                                                             EROPS
Forks                                                   None or Unspecified
Pad_Type                                                                NaN
Ride_Control                                                            NaN
Stick                                                                   NaN
Transmission                                                            NaN
Turbocharged                                                            NaN
Blade_Extension                                                         NaN
Blade_Width                                                             NaN
Enclosure_Type                                                          NaN
Engine_Horsepower                                                       NaN
Hydraulics                                                        Auxiliary
Pushblock                                                               NaN
Ripper                                                                  NaN
```

```
Scarifier                                                               NaN
Tip_Control                                                             NaN
Tire_Size                                                               NaN
Coupler                                                 None or Unspecified
Coupler_System                                          None or Unspecified
Grouser_Tracks                                          None or Unspecified
Hydraulics_Flow                                                    Standard
Track_Type                                                              NaN
Undercarriage_Pad_Width                                                 NaN
Stick_Length                                                            NaN
Thumb                                                                   NaN
Pattern_Changer                                                         NaN
Grouser_Type                                                            NaN
Backhoe_Mounting                                                        NaN
Blade_Type                                                              NaN
Travel_Controls                                                         NaN
Differential_Type                                                       NaN
Steering_Controls                                                       NaN
```

Since we are dealing with a timeseries data, it's better to sort the data according to the saledate

[15]:
```
df["saledate"].head(10)
```

[15]:
```
0   2006-11-16
1   2004-03-26
2   2004-02-26
3   2011-05-19
4   2009-07-23
5   2008-12-18
6   2004-08-26
7   2005-11-17
8   2009-08-27
9   2007-08-09
Name: saledate, dtype: datetime64[ns]
```

1.4.2 Sorting the Dataframe by Saledate

[16]:
```
df.sort_values(by = ["saledate"], inplace = True)
```

[17]:
```
df["saledate"].head(10)
```

[17]:
```
205615   1989-01-17
274835   1989-01-31
141296   1989-01-31
212552   1989-01-31
62755    1989-01-31
54653    1989-01-31
81383    1989-01-31
```

```
204924   1989-01-31
135376   1989-01-31
113390   1989-01-31
Name: saledate, dtype: datetime64[ns]
```

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

```
[18]:
        SalesID  SalePrice  MachineID  ModelID  datasource  auctioneerID  \
205615  1646770     9500.0    1126363     8434         132          18.0
274835  1821514    14000.0    1194089    10150         132          99.0
141296  1505138    50000.0    1473654     4139         132          99.0
212552  1671174    16000.0    1327630     8591         132          99.0
62755   1329056    22000.0    1336053     4089         132          99.0

        YearMade  MachineHoursCurrentMeter UsageBand   saledate  ...  \
205615      1974                       NaN       NaN 1989-01-17  ...
274835      1980                       NaN       NaN 1989-01-31  ...
141296      1978                       NaN       NaN 1989-01-31  ...
212552      1980                       NaN       NaN 1989-01-31  ...
62755       1984                       NaN       NaN 1989-01-31  ...

       Undercarriage_Pad_Width Stick_Length Thumb Pattern_Changer  \
205615                     NaN          NaN   NaN             NaN
274835                     NaN          NaN   NaN             NaN
141296                     NaN          NaN   NaN             NaN
212552                     NaN          NaN   NaN             NaN
62755                      NaN          NaN   NaN             NaN

       Grouser_Type     Backhoe_Mounting Blade_Type      Travel_Controls  \
205615          NaN  None or Unspecified   Straight  None or Unspecified
274835          NaN                  NaN        NaN                  NaN
141296          NaN  None or Unspecified   Straight  None or Unspecified
212552          NaN                  NaN        NaN                  NaN
62755           NaN  None or Unspecified        PAT                Lever

       Differential_Type Steering_Controls
205615               NaN               NaN
274835          Standard      Conventional
141296               NaN               NaN
212552          Standard      Conventional
62755                NaN               NaN

[5 rows x 53 columns]
```

Now let's make a copy of the data for further modifications.

Making a copy of the DataFrame

```
[19]: df_tmp = df.copy()
```

[20]:

```
df_tmp.head()
```

[20]:

```
        SalesID  SalePrice  MachineID  ModelID  datasource  auctioneerID  \
205615  1646770     9500.0    1126363     8434         132          18.0   
274835  1821514    14000.0    1194089    10150         132          99.0   
141296  1505138    50000.0    1473654     4139         132          99.0   
212552  1671174    16000.0    1327630     8591         132          99.0   
62755   1329056    22000.0    1336053     4089         132          99.0   

        YearMade  MachineHoursCurrentMeter UsageBand   saledate  …  \
205615      1974                       NaN       NaN 1989-01-17  …   
274835      1980                       NaN       NaN 1989-01-31  …   
141296      1978                       NaN       NaN 1989-01-31  …   
212552      1980                       NaN       NaN 1989-01-31  …   
62755       1984                       NaN       NaN 1989-01-31  …   

       Undercarriage_Pad_Width Stick_Length Thumb Pattern_Changer  \
205615                     NaN          NaN   NaN             NaN   
274835                     NaN          NaN   NaN             NaN   
141296                     NaN          NaN   NaN             NaN   
212552                     NaN          NaN   NaN             NaN   
62755                      NaN          NaN   NaN             NaN   

       Grouser_Type     Backhoe_Mounting Blade_Type      Travel_Controls  \
205615          NaN  None or Unspecified   Straight  None or Unspecified   
274835          NaN                  NaN        NaN                  NaN   
141296          NaN  None or Unspecified   Straight  None or Unspecified   
212552          NaN                  NaN        NaN                  NaN   
62755           NaN  None or Unspecified        PAT                Lever   

       Differential_Type Steering_Controls
205615               NaN               NaN
274835          Standard      Conventional
141296               NaN               NaN
212552          Standard      Conventional
62755                NaN               NaN

[5 rows x 53 columns]
```

1.4.3 Feature engineering (Enriching data using the saledate feature)

[21]:

```
df_tmp["saleYear"] = df_tmp["saledate"].dt.year
df_tmp["saleMonth"] = df_tmp["saledate"].dt.month
df_tmp["saleDay"] = df_tmp["saledate"].dt.day
df_tmp["saleDayOfWeek"] = df_tmp["saledate"].dt.dayofweek
df_tmp["saleDayOfYear"] = df_tmp["saledate"].dt.dayofyear
df_tmp.head().T
```

```
[21]:                                                                       205615  \
      SalesID                                                              1646770
      SalePrice                                                             9500.0
      MachineID                                                            1126363
      ModelID                                                                 8434
      datasource                                                               132
      auctioneerID                                                            18.0
      YearMade                                                                1974
      MachineHoursCurrentMeter                                                 NaN
      UsageBand                                                                NaN
      saledate                                                 1989-01-17 00:00:00
      fiModelDesc                                                             TD20
      fiBaseModel                                                             TD20
      fiSecondaryDesc                                                          NaN
      fiModelSeries                                                            NaN
      fiModelDescriptor                                                        NaN
      ProductSize                                                           Medium
      fiProductClassDesc        Track Type Tractor, Dozer - 105.0 to 130.0 Hor…
      state                                                                  Texas
      ProductGroup                                                             TTT
      ProductGroupDesc                                         Track Type Tractors
      Drive_System                                                             NaN
      Enclosure                                                              OROPS
      Forks                                                                    NaN
      Pad_Type                                                                 NaN
      Ride_Control                                                             NaN
      Stick                                                                    NaN
      Transmission                                                    Direct Drive
      Turbocharged                                                             NaN
      Blade_Extension                                                          NaN
      Blade_Width                                                              NaN
      Enclosure_Type                                                           NaN
      Engine_Horsepower                                                        NaN
      Hydraulics                                                           2 Valve
      Pushblock                                                                NaN
      Ripper                                                   None or Unspecified
      Scarifier                                                                NaN
      Tip_Control                                                              NaN
      Tire_Size                                                                NaN
      Coupler                                                                  NaN
      Coupler_System                                                           NaN
      Grouser_Tracks                                                           NaN
      Hydraulics_Flow                                                          NaN
      Track_Type                                                               NaN
      Undercarriage_Pad_Width                                                  NaN
      Stick_Length                                                             NaN
      Thumb                                                                    NaN
```

```
Pattern_Changer                                                         NaN
Grouser_Type                                                            NaN
Backhoe_Mounting                                        None or Unspecified
Blade_Type                                                         Straight
Travel_Controls                                         None or Unspecified
Differential_Type                                                       NaN
Steering_Controls                                                       NaN
saleYear                                                               1989
saleMonth                                                                 1
saleDay                                                                  17
saleDayOfWeek                                                             1
saleDayOfYear                                                            17

                                                            274835  \
SalesID                                                    1821514
SalePrice                                                  14000.0
MachineID                                                  1194089
ModelID                                                      10150
datasource                                                     132
auctioneerID                                                  99.0
YearMade                                                      1980
MachineHoursCurrentMeter                                       NaN
UsageBand                                                      NaN
saledate                                       1989-01-31 00:00:00
fiModelDesc                                                    A66
fiBaseModel                                                    A66
fiSecondaryDesc                                                NaN
fiModelSeries                                                  NaN
fiModelDescriptor                                              NaN
ProductSize                                                    NaN
fiProductClassDesc        Wheel Loader - 120.0 to 135.0 Horsepower
state                                                      Florida
ProductGroup                                                    WL
ProductGroupDesc                                      Wheel Loader
Drive_System                                                   NaN
Enclosure                                                    OROPS
Forks                                          None or Unspecified
Pad_Type                                                       NaN
Ride_Control                                   None or Unspecified
Stick                                                          NaN
Transmission                                                   NaN
Turbocharged                                                   NaN
Blade_Extension                                                NaN
Blade_Width                                                    NaN
Enclosure_Type                                                 NaN
Engine_Horsepower                                              NaN
Hydraulics                                                 2 Valve
```

```
Pushblock                                                      NaN
Ripper                                                         NaN
Scarifier                                                      NaN
Tip_Control                                                    NaN
Tire_Size                                      None or Unspecified
Coupler                                        None or Unspecified
Coupler_System                                                 NaN
Grouser_Tracks                                                 NaN
Hydraulics_Flow                                                NaN
Track_Type                                                     NaN
Undercarriage_Pad_Width                                        NaN
Stick_Length                                                   NaN
Thumb                                                          NaN
Pattern_Changer                                                NaN
Grouser_Type                                                   NaN
Backhoe_Mounting                                               NaN
Blade_Type                                                     NaN
Travel_Controls                                                NaN
Differential_Type                                         Standard
Steering_Controls                                     Conventional
saleYear                                                      1989
saleMonth                                                        1
saleDay                                                         31
saleDayOfWeek                                                    1
saleDayOfYear                                                   31

                                                                     141296  \
SalesID                                                             1505138
SalePrice                                                           50000.0
MachineID                                                           1473654
ModelID                                                                4139
datasource                                                              132
auctioneerID                                                           99.0
YearMade                                                               1978
MachineHoursCurrentMeter                                                NaN
UsageBand                                                               NaN
saledate                                                1989-01-31 00:00:00
fiModelDesc                                                             D7G
fiBaseModel                                                              D7
fiSecondaryDesc                                                           G
fiModelSeries                                                           NaN
fiModelDescriptor                                                       NaN
ProductSize                                                           Large
fiProductClassDesc        Track Type Tractor, Dozer - 190.0 to 260.0 Hor…
state                                                               Florida
ProductGroup                                                            TTT
ProductGroupDesc                                        Track Type Tractors
```

```
Drive_System                                                            NaN
Enclosure                                                             OROPS
Forks                                                                   NaN
Pad_Type                                                                NaN
Ride_Control                                                            NaN
Stick                                                                   NaN
Transmission                                                       Standard
Turbocharged                                                            NaN
Blade_Extension                                                         NaN
Blade_Width                                                             NaN
Enclosure_Type                                                          NaN
Engine_Horsepower                                                       NaN
Hydraulics                                                          2 Valve
Pushblock                                                               NaN
Ripper                                                  None or Unspecified
Scarifier                                                               NaN
Tip_Control                                                             NaN
Tire_Size                                                               NaN
Coupler                                                                 NaN
Coupler_System                                                          NaN
Grouser_Tracks                                                          NaN
Hydraulics_Flow                                                         NaN
Track_Type                                                              NaN
Undercarriage_Pad_Width                                                 NaN
Stick_Length                                                            NaN
Thumb                                                                   NaN
Pattern_Changer                                                         NaN
Grouser_Type                                                            NaN
Backhoe_Mounting                                        None or Unspecified
Blade_Type                                                         Straight
Travel_Controls                                         None or Unspecified
Differential_Type                                                       NaN
Steering_Controls                                                       NaN
saleYear                                                               1989
saleMonth                                                                 1
saleDay                                                                  31
saleDayOfWeek                                                             1
saleDayOfYear                                                            31

                                               212552  \
SalesID                                       1671174
SalePrice                                     16000.0
MachineID                                     1327630
ModelID                                          8591
datasource                                        132
auctioneerID                                     99.0
YearMade                                         1980
```

```
MachineHoursCurrentMeter                          NaN
UsageBand                                         NaN
saledate                          1989-01-31 00:00:00
fiModelDesc                                       A62
fiBaseModel                                       A62
fiSecondaryDesc                                   NaN
fiModelSeries                                     NaN
fiModelDescriptor                                 NaN
ProductSize                                       NaN
fiProductClassDesc        Wheel Loader - Unidentified
state                                         Florida
ProductGroup                                       WL
ProductGroupDesc                         Wheel Loader
Drive_System                                      NaN
Enclosure                                       EROPS
Forks                             None or Unspecified
Pad_Type                                          NaN
Ride_Control                      None or Unspecified
Stick                                             NaN
Transmission                                      NaN
Turbocharged                                      NaN
Blade_Extension                                   NaN
Blade_Width                                       NaN
Enclosure_Type                                    NaN
Engine_Horsepower                                 NaN
Hydraulics                                    2 Valve
Pushblock                                         NaN
Ripper                                            NaN
Scarifier                                         NaN
Tip_Control                                       NaN
Tire_Size                         None or Unspecified
Coupler                           None or Unspecified
Coupler_System                                    NaN
Grouser_Tracks                                    NaN
Hydraulics_Flow                                   NaN
Track_Type                                        NaN
Undercarriage_Pad_Width                           NaN
Stick_Length                                      NaN
Thumb                                             NaN
Pattern_Changer                                   NaN
Grouser_Type                                      NaN
Backhoe_Mounting                                  NaN
Blade_Type                                        NaN
Travel_Controls                                   NaN
Differential_Type                            Standard
Steering_Controls                        Conventional
saleYear                                         1989
```

```
saleMonth                                           1
saleDay                                            31
saleDayOfWeek                                       1
saleDayOfYear                                      31

                                                                     62755
SalesID                                                            1329056
SalePrice                                                          22000.0
MachineID                                                          1336053
ModelID                                                               4089
datasource                                                             132
auctioneerID                                                          99.0
YearMade                                                              1984
MachineHoursCurrentMeter                                               NaN
UsageBand                                                              NaN
saledate                                               1989-01-31 00:00:00
fiModelDesc                                                            D3B
fiBaseModel                                                             D3
fiSecondaryDesc                                                          B
fiModelSeries                                                          NaN
fiModelDescriptor                                                      NaN
ProductSize                                                            NaN
fiProductClassDesc        Track Type Tractor, Dozer - 20.0 to 75.0 Horse…
state                                                              Florida
ProductGroup                                                           TTT
ProductGroupDesc                                       Track Type Tractors
Drive_System                                                           NaN
Enclosure                                                            OROPS
Forks                                                                  NaN
Pad_Type                                                               NaN
Ride_Control                                                           NaN
Stick                                                                  NaN
Transmission                                                      Standard
Turbocharged                                                           NaN
Blade_Extension                                                        NaN
Blade_Width                                                            NaN
Enclosure_Type                                                         NaN
Engine_Horsepower                                                      NaN
Hydraulics                                                         2 Valve
Pushblock                                                              NaN
Ripper                                                 None or Unspecified
Scarifier                                                              NaN
Tip_Control                                                            NaN
Tire_Size                                                              NaN
Coupler                                                                NaN
Coupler_System                                                         NaN
Grouser_Tracks                                                         NaN
```

```
Hydraulics_Flow                                                         NaN
Track_Type                                                              NaN
Undercarriage_Pad_Width                                                 NaN
Stick_Length                                                            NaN
Thumb                                                                   NaN
Pattern_Changer                                                         NaN
Grouser_Type                                                            NaN
Backhoe_Mounting                                        None or Unspecified
Blade_Type                                                              PAT
Travel_Controls                                                       Lever
Differential_Type                                                       NaN
Steering_Controls                                                       NaN
saleYear                                                               1989
saleMonth                                                                 1
saleDay                                                                  31
saleDayOfWeek                                                             1
saleDayOfYear                                                            31
```

Now we don't need saledate column so let's drop it. If required, it is present in the original copy of DataFrame `df`.

[22]:
```python
df_tmp.drop("saledate", axis = 1, inplace = True)
df_tmp.head().T
```

[22]:
```
                                                                     205615  \
SalesID                                                             1646770
SalePrice                                                            9500.0
MachineID                                                           1126363
ModelID                                                                8434
datasource                                                              132
auctioneerID                                                           18.0
YearMade                                                               1974
MachineHoursCurrentMeter                                                NaN
UsageBand                                                               NaN
fiModelDesc                                                            TD20
fiBaseModel                                                            TD20
fiSecondaryDesc                                                         NaN
fiModelSeries                                                           NaN
fiModelDescriptor                                                       NaN
ProductSize                                                          Medium
fiProductClassDesc        Track Type Tractor, Dozer - 105.0 to 130.0 Hor…
state                                                                 Texas
ProductGroup                                                            TTT
ProductGroupDesc                                        Track Type Tractors
Drive_System                                                            NaN
Enclosure                                                             OROPS
Forks                                                                   NaN
Pad_Type                                                                NaN
```

```
Ride_Control                                                            NaN
Stick                                                                   NaN
Transmission                                                   Direct Drive
Turbocharged                                                            NaN
Blade_Extension                                                         NaN
Blade_Width                                                             NaN
Enclosure_Type                                                          NaN
Engine_Horsepower                                                       NaN
Hydraulics                                                          2 Valve
Pushblock                                                               NaN
Ripper                                                  None or Unspecified
Scarifier                                                               NaN
Tip_Control                                                             NaN
Tire_Size                                                               NaN
Coupler                                                                 NaN
Coupler_System                                                          NaN
Grouser_Tracks                                                          NaN
Hydraulics_Flow                                                         NaN
Track_Type                                                              NaN
Undercarriage_Pad_Width                                                 NaN
Stick_Length                                                            NaN
Thumb                                                                   NaN
Pattern_Changer                                                         NaN
Grouser_Type                                                            NaN
Backhoe_Mounting                                        None or Unspecified
Blade_Type                                                         Straight
Travel_Controls                                         None or Unspecified
Differential_Type                                                       NaN
Steering_Controls                                                       NaN
saleYear                                                               1989
saleMonth                                                                 1
saleDay                                                                  17
saleDayOfWeek                                                             1
saleDayOfYear                                                            17

                                                            274835  \
SalesID                                                    1821514
SalePrice                                                  14000.0
MachineID                                                  1194089
ModelID                                                      10150
datasource                                                     132
auctioneerID                                                  99.0
YearMade                                                      1980
MachineHoursCurrentMeter                                       NaN
UsageBand                                                      NaN
fiModelDesc                                                    A66
fiBaseModel                                                    A66
```

```
fiSecondaryDesc                                                NaN
fiModelSeries                                                  NaN
fiModelDescriptor                                              NaN
ProductSize                                                    NaN
fiProductClassDesc        Wheel Loader - 120.0 to 135.0 Horsepower
state                                                      Florida
ProductGroup                                                    WL
ProductGroupDesc                                      Wheel Loader
Drive_System                                                   NaN
Enclosure                                                    OROPS
Forks                                          None or Unspecified
Pad_Type                                                       NaN
Ride_Control                                   None or Unspecified
Stick                                                          NaN
Transmission                                                   NaN
Turbocharged                                                   NaN
Blade_Extension                                                NaN
Blade_Width                                                    NaN
Enclosure_Type                                                 NaN
Engine_Horsepower                                              NaN
Hydraulics                                                 2 Valve
Pushblock                                                      NaN
Ripper                                                         NaN
Scarifier                                                      NaN
Tip_Control                                                    NaN
Tire_Size                                      None or Unspecified
Coupler                                        None or Unspecified
Coupler_System                                                 NaN
Grouser_Tracks                                                 NaN
Hydraulics_Flow                                                NaN
Track_Type                                                     NaN
Undercarriage_Pad_Width                                        NaN
Stick_Length                                                   NaN
Thumb                                                          NaN
Pattern_Changer                                                NaN
Grouser_Type                                                   NaN
Backhoe_Mounting                                               NaN
Blade_Type                                                     NaN
Travel_Controls                                                NaN
Differential_Type                                         Standard
Steering_Controls                                     Conventional
saleYear                                                      1989
saleMonth                                                        1
saleDay                                                         31
saleDayOfWeek                                                    1
saleDayOfYear                                                   31
```

```
                                                                     141296  \
SalesID                                                             1505138
SalePrice                                                           50000.0
MachineID                                                           1473654
ModelID                                                                4139
datasource                                                              132
auctioneerID                                                           99.0
YearMade                                                               1978
MachineHoursCurrentMeter                                                NaN
UsageBand                                                               NaN
fiModelDesc                                                             D7G
fiBaseModel                                                              D7
fiSecondaryDesc                                                           G
fiModelSeries                                                           NaN
fiModelDescriptor                                                       NaN
ProductSize                                                           Large
fiProductClassDesc        Track Type Tractor, Dozer - 190.0 to 260.0 Hor…
state                                                               Florida
ProductGroup                                                            TTT
ProductGroupDesc                                        Track Type Tractors
Drive_System                                                            NaN
Enclosure                                                             OROPS
Forks                                                                   NaN
Pad_Type                                                                NaN
Ride_Control                                                            NaN
Stick                                                                   NaN
Transmission                                                       Standard
Turbocharged                                                            NaN
Blade_Extension                                                         NaN
Blade_Width                                                             NaN
Enclosure_Type                                                          NaN
Engine_Horsepower                                                       NaN
Hydraulics                                                          2 Valve
Pushblock                                                               NaN
Ripper                                                  None or Unspecified
Scarifier                                                               NaN
Tip_Control                                                             NaN
Tire_Size                                                               NaN
Coupler                                                                 NaN
Coupler_System                                                          NaN
Grouser_Tracks                                                          NaN
Hydraulics_Flow                                                         NaN
Track_Type                                                              NaN
Undercarriage_Pad_Width                                                 NaN
Stick_Length                                                            NaN
Thumb                                                                   NaN
Pattern_Changer                                                         NaN
```

```
Grouser_Type                                                            NaN
Backhoe_Mounting                                        None or Unspecified
Blade_Type                                                         Straight
Travel_Controls                                         None or Unspecified
Differential_Type                                                       NaN
Steering_Controls                                                       NaN
saleYear                                                               1989
saleMonth                                                                 1
saleDay                                                                  31
saleDayOfWeek                                                             1
saleDayOfYear                                                            31

                                               212552  \
SalesID                                       1671174
SalePrice                                     16000.0
MachineID                                     1327630
ModelID                                          8591
datasource                                        132
auctioneerID                                     99.0
YearMade                                         1980
MachineHoursCurrentMeter                          NaN
UsageBand                                         NaN
fiModelDesc                                       A62
fiBaseModel                                       A62
fiSecondaryDesc                                   NaN
fiModelSeries                                     NaN
fiModelDescriptor                                 NaN
ProductSize                                       NaN
fiProductClassDesc        Wheel Loader - Unidentified
state                                         Florida
ProductGroup                                       WL
ProductGroupDesc                         Wheel Loader
Drive_System                                      NaN
Enclosure                                       EROPS
Forks                             None or Unspecified
Pad_Type                                          NaN
Ride_Control                      None or Unspecified
Stick                                             NaN
Transmission                                      NaN
Turbocharged                                      NaN
Blade_Extension                                   NaN
Blade_Width                                       NaN
Enclosure_Type                                    NaN
Engine_Horsepower                                 NaN
Hydraulics                                    2 Valve
Pushblock                                         NaN
Ripper                                            NaN
```

```
Scarifier                                         NaN
Tip_Control                                       NaN
Tire_Size                         None or Unspecified
Coupler                           None or Unspecified
Coupler_System                                    NaN
Grouser_Tracks                                    NaN
Hydraulics_Flow                                   NaN
Track_Type                                        NaN
Undercarriage_Pad_Width                           NaN
Stick_Length                                      NaN
Thumb                                             NaN
Pattern_Changer                                   NaN
Grouser_Type                                      NaN
Backhoe_Mounting                                  NaN
Blade_Type                                        NaN
Travel_Controls                                   NaN
Differential_Type                            Standard
Steering_Controls                        Conventional
saleYear                                         1989
saleMonth                                           1
saleDay                                            31
saleDayOfWeek                                       1
saleDayOfYear                                      31
```

```
                                                                     62755
SalesID                                                            1329056
SalePrice                                                          22000.0
MachineID                                                          1336053
ModelID                                                               4089
datasource                                                             132
auctioneerID                                                          99.0
YearMade                                                              1984
MachineHoursCurrentMeter                                               NaN
UsageBand                                                              NaN
fiModelDesc                                                            D3B
fiBaseModel                                                             D3
fiSecondaryDesc                                                          B
fiModelSeries                                                          NaN
fiModelDescriptor                                                      NaN
ProductSize                                                            NaN
fiProductClassDesc        Track Type Tractor, Dozer - 20.0 to 75.0 Horse…
state                                                              Florida
ProductGroup                                                           TTT
ProductGroupDesc                                       Track Type Tractors
Drive_System                                                           NaN
Enclosure                                                            OROPS
Forks                                                                  NaN
```

```
Pad_Type                                                                NaN
Ride_Control                                                            NaN
Stick                                                                   NaN
Transmission                                                       Standard
Turbocharged                                                            NaN
Blade_Extension                                                         NaN
Blade_Width                                                             NaN
Enclosure_Type                                                          NaN
Engine_Horsepower                                                       NaN
Hydraulics                                                          2 Valve
Pushblock                                                               NaN
Ripper                                                  None or Unspecified
Scarifier                                                               NaN
Tip_Control                                                             NaN
Tire_Size                                                               NaN
Coupler                                                                 NaN
Coupler_System                                                          NaN
Grouser_Tracks                                                          NaN
Hydraulics_Flow                                                         NaN
Track_Type                                                              NaN
Undercarriage_Pad_Width                                                 NaN
Stick_Length                                                            NaN
Thumb                                                                   NaN
Pattern_Changer                                                         NaN
Grouser_Type                                                            NaN
Backhoe_Mounting                                        None or Unspecified
Blade_Type                                                              PAT
Travel_Controls                                                       Lever
Differential_Type                                                       NaN
Steering_Controls                                                       NaN
saleYear                                                               1989
saleMonth                                                                 1
saleDay                                                                  31
saleDayOfWeek                                                             1
saleDayOfYear                                                            31
```

Let's explore the sales by US States

```
[23]: df_tmp.value_counts("state")
```

```
[23]: state
      Florida           67320
      Texas             53110
      California        29761
      Washington        16222
      Georgia           14633
      Maryland          13322
      Mississippi       13240
```

```
Ohio              12369
Illinois          11540
Colorado          11529
New Jersey        11156
North Carolina    10636
Tennessee         10298
Alabama           10292
Pennsylvania      10234
South Carolina     9951
Arizona            9364
New York           8639
Connecticut        8276
Minnesota          7885
Missouri           7178
Nevada             6932
Louisiana          6627
Kentucky           5351
Maine              5096
Indiana            4124
Arkansas           3933
New Mexico         3631
Utah               3046
Unspecified        2801
Wisconsin          2745
New Hampshire      2738
Virginia           2353
Idaho              2025
Oregon             1911
Michigan           1831
Wyoming            1672
Montana            1336
Iowa               1336
Oklahoma           1326
Nebraska            866
West Virginia       840
Kansas              667
Delaware            510
North Dakota        480
Alaska              430
Massachusetts       347
Vermont             300
South Dakota        244
Hawaii              118
Rhode Island         83
Puerto Rico          42
Washington DC         2
dtype: int64
```

[24]:
```
df_tmp.value_counts("ProductGroupDesc")
```

[24]:
```
ProductGroupDesc
Track Excavators       104230
Track Type Tractors     82582
Backhoe Loaders         81401
Wheel Loader            73216
Skid Steer Loaders      45011
Motor Graders           26258
dtype: int64
```

Before we go ahead with modelling we need to convert `string` data into pandas **`categories`**.

1.4.4 Converting string data to pandas categories

[25]:
```
pd.api.types.is_string_dtype(df["state"])
```

[25]:
```
True
```

[26]:
```
df_tmp.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 412698 entries, 205615 to 409203
Data columns (total 57 columns):
 #   Column                    Non-Null Count   Dtype
---  ------                    --------------   -----
 0   SalesID                   412698 non-null  int64
 1   SalePrice                 412698 non-null  float64
 2   MachineID                 412698 non-null  int64
 3   ModelID                   412698 non-null  int64
 4   datasource                412698 non-null  int64
 5   auctioneerID              392562 non-null  float64
 6   YearMade                  412698 non-null  int64
 7   MachineHoursCurrentMeter  147504 non-null  float64
 8   UsageBand                 73670 non-null   object
 9   fiModelDesc               412698 non-null  object
 10  fiBaseModel               412698 non-null  object
 11  fiSecondaryDesc           271971 non-null  object
 12  fiModelSeries             58667 non-null   object
 13  fiModelDescriptor         74816 non-null   object
 14  ProductSize               196093 non-null  object
 15  fiProductClassDesc        412698 non-null  object
 16  state                     412698 non-null  object
 17  ProductGroup              412698 non-null  object
 18  ProductGroupDesc          412698 non-null  object
 19  Drive_System              107087 non-null  object
 20  Enclosure                 412364 non-null  object
 21  Forks                     197715 non-null  object
 22  Pad_Type                  81096 non-null   object
 23  Ride_Control              152728 non-null  object
 24  Stick                     81096 non-null   object
 25  Transmission              188007 non-null  object
 26  Turbocharged              81096 non-null   object
 27  Blade_Extension           25983 non-null   object
 28  Blade_Width               25983 non-null   object
 29  Enclosure_Type            25983 non-null   object
 30  Engine_Horsepower         25983 non-null   object
 31  Hydraulics                330133 non-null  object
 32  Pushblock                 25983 non-null   object
 33  Ripper                    106945 non-null  object
 34  Scarifier                 25994 non-null   object
 35  Tip_Control               25983 non-null   object
 36  Tire_Size                 97638 non-null   object
 37  Coupler                   220679 non-null  object
 38  Coupler_System            44974 non-null   object
 39  Grouser_Tracks            44875 non-null   object
 40  Hydraulics_Flow           44875 non-null   object
 41  Track_Type                102193 non-null  object
 42  Undercarriage_Pad_Width   102916 non-null  object
 43  Stick_Length              102261 non-null  object
 44  Thumb                     102332 non-null  object
 45  Pattern_Changer           102261 non-null  object
 46  Grouser_Type              102193 non-null  object
 47  Backhoe_Mounting          80712 non-null   object
 48  Blade_Type                81875 non-null   object
 49  Travel_Controls           81877 non-null   object
 50  Differential_Type         71564 non-null   object
 51  Steering_Controls         71522 non-null   object
 52  saleYear                  412698 non-null  int64
 53  saleMonth                 412698 non-null  int64
 54  saleDay                   412698 non-null  int64
 55  saleDayOfWeek             412698 non-null  int64
 56  saleDayOfYear             412698 non-null  int64
dtypes: float64(3), int64(10), object(44)
memory usage: 182.6+ MB
```

Let's itereate through the dataframe and check which features have string type values

[27]:
```
for col_name , col_content in df_tmp.items():
    if pd.api.types.is_string_dtype(col_content):
        print(col_name)
```

```
UsageBand
fiModelDesc
fiBaseModel
fiSecondaryDesc
fiModelSeries
```

```
fiModelDescriptor
ProductSize
fiProductClassDesc
state
ProductGroup
ProductGroupDesc
Drive_System
Enclosure
Forks
Pad_Type
Ride_Control
Stick
Transmission
Turbocharged
Blade_Extension
Blade_Width
Enclosure_Type
Engine_Horsepower
Hydraulics
Pushblock
Ripper
Scarifier
Tip_Control
Tire_Size
Coupler
Coupler_System
Grouser_Tracks
Hydraulics_Flow
Track_Type
Undercarriage_Pad_Width
Stick_Length
Thumb
Pattern_Changer
Grouser_Type
Backhoe_Mounting
Blade_Type
Travel_Controls
Differential_Type
Steering_Controls
```

Let's change the data type of these features to pandas categories

[28]:

```
for col_name, col_content in df_tmp.items():
    if pd.api.types.is_string_dtype(col_content):
        df_tmp[col_name] = col_content.astype("category").cat.as_ordered()
df_tmp.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 412698 entries, 205615 to 409203
```

```
Data columns (total 57 columns):
 #   Column                    Non-Null Count   Dtype
---  ------                    --------------   -----
 0   SalesID                   412698 non-null  int64
 1   SalePrice                 412698 non-null  float64
 2   MachineID                 412698 non-null  int64
 3   ModelID                   412698 non-null  int64
 4   datasource                412698 non-null  int64
 5   auctioneerID              392562 non-null  float64
 6   YearMade                  412698 non-null  int64
 7   MachineHoursCurrentMeter  147504 non-null  float64
 8   UsageBand                 73670 non-null   category
 9   fiModelDesc               412698 non-null  category
 10  fiBaseModel               412698 non-null  category
 11  fiSecondaryDesc           271971 non-null  category
 12  fiModelSeries             58667 non-null   category
 13  fiModelDescriptor         74816 non-null   category
 14  ProductSize               196093 non-null  category
 15  fiProductClassDesc        412698 non-null  category
 16  state                     412698 non-null  category
 17  ProductGroup              412698 non-null  category
 18  ProductGroupDesc          412698 non-null  category
 19  Drive_System              107087 non-null  category
 20  Enclosure                 412364 non-null  category
 21  Forks                     197715 non-null  category
 22  Pad_Type                  81096 non-null   category
 23  Ride_Control              152728 non-null  category
 24  Stick                     81096 non-null   category
 25  Transmission              188007 non-null  category
 26  Turbocharged              81096 non-null   category
 27  Blade_Extension           25983 non-null   category
 28  Blade_Width               25983 non-null   category
 29  Enclosure_Type            25983 non-null   category
 30  Engine_Horsepower         25983 non-null   category
 31  Hydraulics                330133 non-null  category
 32  Pushblock                 25983 non-null   category
 33  Ripper                    106945 non-null  category
 34  Scarifier                 25994 non-null   category
 35  Tip_Control               25983 non-null   category
 36  Tire_Size                 97638 non-null   category
 37  Coupler                   220679 non-null  category
 38  Coupler_System            44974 non-null   category
 39  Grouser_Tracks            44875 non-null   category
 40  Hydraulics_Flow           44875 non-null   category
 41  Track_Type                102193 non-null  category
 42  Undercarriage_Pad_Width   102916 non-null  category
 43  Stick_Length              102261 non-null  category
 44  Thumb                     102332 non-null  category
 45  Pattern_Changer           102261 non-null  category
 46  Grouser_Type              102193 non-null  category
 47  Backhoe_Mounting          80712 non-null   category
 48  Blade_Type                81875 non-null   category
 49  Travel_Controls           81877 non-null   category
 50  Differential_Type         71564 non-null   category
 51  Steering_Controls         71522 non-null   category
 52  saleYear                  412698 non-null  int64
 53  saleMonth                 412698 non-null  int64
 54  saleDay                   412698 non-null  int64
 55  saleDayOfWeek             412698 non-null  int64
 56  saleDayOfYear             412698 non-null  int64
dtypes: category(44), float64(3), int64(10)
memory usage: 63.2 MB
```

We have successfully changed the datatype to category

```
[29]: pd.api.types.is_string_dtype(df_tmp["state"])
```

```
[29]: False
```

```
[30]: pd.api.types.is_categorical_dtype(df_tmp["state"])
```

```
[30]: True
```

```
[31]: df_tmp["state"].cat.categories
```

```
[31]: Index(['Alabama', 'Alaska', 'Arizona', 'Arkansas', 'California', 'Colorado',
              'Connecticut', 'Delaware', 'Florida', 'Georgia', 'Hawaii', 'Idaho',
              'Illinois', 'Indiana', 'Iowa', 'Kansas', 'Kentucky', 'Louisiana',
              'Maine', 'Maryland', 'Massachusetts', 'Michigan', 'Minnesota',
              'Mississippi', 'Missouri', 'Montana', 'Nebraska', 'Nevada',
              'New Hampshire', 'New Jersey', 'New Mexico', 'New York',
              'North Carolina', 'North Dakota', 'Ohio', 'Oklahoma', 'Oregon',
              'Pennsylvania', 'Puerto Rico', 'Rhode Island', 'South Carolina',
              'South Dakota', 'Tennessee', 'Texas', 'Unspecified', 'Utah', 'Vermont',
              'Virginia', 'Washington', 'Washington DC', 'West Virginia', 'Wisconsin',
              'Wyoming'],
             dtype='object')
```

```
[32]: df_tmp["state"].cat.codes[:10]
```

```
[32]: 205615    43
      274835     8
      141296     8
      212552     8
      62755      8
      54653      8
```

```
81383     8
204924    8
135376    8
113390    8
dtype: int8
```

[33]:

```
df_tmp["state"][:10]
```

[33]:

```
205615      Texas
274835    Florida
141296    Florida
212552    Florida
62755     Florida
54653     Florida
81383     Florida
204924    Florida
135376    Florida
113390    Florida
Name: state, dtype: category
Categories (53, object): ['Alabama' < 'Alaska' < 'Arizona' < 'Arkansas' …
'Washington DC' < 'West Virginia' < 'Wisconsin' < 'Wyoming']
```

We can see that Texas has a code of 43 while Florida has a code of 8.
The code is set alphabetically.

1.4.5 Saving Preprocessed data

[34]:

```
df_tmp.to_csv("data/bluebook-for-bulldozers/train_valid_tmp.csv", index = False)
```

[35]:

```
df_tmp = pd.read_csv("data/bluebook-for-bulldozers/train_valid_tmp.csv",␣
 ↪low_memory = False)
```

1.4.6 Dealing with missing data

Our dataset contains a lot of missing data

[36]:

```
df_tmp.isnull().sum()
```

[36]:

```
SalesID                          0
SalePrice                        0
MachineID                        0
ModelID                          0
datasource                       0
auctioneerID                 20136
YearMade                         0
MachineHoursCurrentMeter    265194
UsageBand                   339028
fiModelDesc                      0
```

```
fiBaseModel                      0
fiSecondaryDesc             140727
fiModelSeries               354031
fiModelDescriptor           337882
ProductSize                 216605
fiProductClassDesc               0
state                            0
ProductGroup                     0
ProductGroupDesc                 0
Drive_System                305611
Enclosure                      334
Forks                       214983
Pad_Type                    331602
Ride_Control                259970
Stick                       331602
Transmission                224691
Turbocharged                331602
Blade_Extension             386715
Blade_Width                 386715
Enclosure_Type              386715
Engine_Horsepower           386715
Hydraulics                   82565
Pushblock                   386715
Ripper                      305753
Scarifier                   386704
Tip_Control                 386715
Tire_Size                   315060
Coupler                     192019
Coupler_System              367724
Grouser_Tracks              367823
Hydraulics_Flow             367823
Track_Type                  310505
Undercarriage_Pad_Width     309782
Stick_Length                310437
Thumb                       310366
Pattern_Changer             310437
Grouser_Type                310505
Backhoe_Mounting            331986
Blade_Type                  330823
Travel_Controls             330821
Differential_Type           341134
Steering_Controls           341176
saleYear                         0
saleMonth                        0
saleDay                          0
saleDayOfWeek                    0
saleDayOfYear                    0
```

```
      dtype: int64
```

```
[37]: df_tmp.isnull().sum() / len(df_tmp)
```

```
[37]: SalesID                     0.000000
      SalePrice                   0.000000
      MachineID                   0.000000
      ModelID                     0.000000
      datasource                  0.000000
      auctioneerID                0.048791
      YearMade                    0.000000
      MachineHoursCurrentMeter    0.642586
      UsageBand                   0.821492
      fiModelDesc                 0.000000
      fiBaseModel                 0.000000
      fiSecondaryDesc             0.340993
      fiModelSeries               0.857845
      fiModelDescriptor           0.818715
      ProductSize                 0.524851
      fiProductClassDesc          0.000000
      state                       0.000000
      ProductGroup                0.000000
      ProductGroupDesc            0.000000
      Drive_System                0.740520
      Enclosure                   0.000809
      Forks                       0.520921
      Pad_Type                    0.803498
      Ride_Control                0.629928
      Stick                       0.803498
      Transmission                0.544444
      Turbocharged                0.803498
      Blade_Extension             0.937041
      Blade_Width                 0.937041
      Enclosure_Type              0.937041
      Engine_Horsepower           0.937041
      Hydraulics                  0.200062
      Pushblock                   0.937041
      Ripper                      0.740864
      Scarifier                   0.937014
      Tip_Control                 0.937041
      Tire_Size                   0.763415
      Coupler                     0.465277
      Coupler_System              0.891024
      Grouser_Tracks              0.891264
      Hydraulics_Flow             0.891264
      Track_Type                  0.752378
      Undercarriage_Pad_Width     0.750626
```

```
Stick_Length                0.752213
Thumb                       0.752041
Pattern_Changer             0.752213
Grouser_Type                0.752378
Backhoe_Mounting            0.804428
Blade_Type                  0.801610
Travel_Controls             0.801606
Differential_Type           0.826595
Steering_Controls           0.826697
saleYear                    0.000000
saleMonth                   0.000000
saleDay                     0.000000
saleDayOfWeek               0.000000
saleDayOfYear               0.000000
dtype: float64
```

1.4.7 Filling Features with Numerical Data

Let's first see all the features with numerical data

[38]:

```
for col_name, col_content in df_tmp.items():
    if pd.api.types.is_numeric_dtype(col_content):
        print(col_name)
```

```
SalesID
SalePrice
MachineID
ModelID
datasource
auctioneerID
YearMade
MachineHoursCurrentMeter
saleYear
saleMonth
saleDay
saleDayOfWeek
saleDayOfYear
```

Let's check the missing values in numerical features

[39]:

```
for col_name, col_content in df_tmp.items():
    if pd.api.types.is_numeric_dtype(col_content):
        if col_content.isnull().sum():
            print(col_name, col_content.isnull().sum())
```

```
auctioneerID 20136
MachineHoursCurrentMeter 265194
```

Let's fill these missing numeric values with median of the feature

[44]:

```
for col_name, col_content in df_tmp.items():
    if pd.api.types.is_numeric_dtype(col_content):
        if pd.isnull(col_content).sum():
            df_tmp[col_name] = col_content.fillna(col_content.median())
            df_tmp[col_name + "is_missing"] = pd.isnull(col_content)
            # making new cols to check if data was missing.
```

Let's check for missing values again

[45]:

```
for col_name, col_content in df_tmp.items():
    if pd.api.types.is_numeric_dtype(col_content):
        if col_content.isnull().sum():
            print(col_name, col_content.isnull().sum())
```

No missing values left.
Now let's check how many values were filled.

[46]:

```
df_tmp["auctioneerIDis_missing"].value_counts()
```

[46]:

```
False    392562
True      20136
Name: auctioneerIDis_missing, dtype: int64
```

[47]:

```
df_tmp["MachineHoursCurrentMeteris_missing"].value_counts()
```

[47]:

```
True     265194
False    147504
Name: MachineHoursCurrentMeteris_missing, dtype: int64
```

1.4.8 Filling missing categories and turning categorical data into numeric data

[53]:

```
pd.Categorical(df_tmp["state"]).codes
```

[53]:

```
array([43,  8,  8, …,  4,  4,  4], dtype=int8)
```

By default missing values in pandas has a category of -1

[55]:

```
pd.Categorical(df_tmp["UsageBand"]).codes
```

[55]:

```
array([-1, -1, -1, …, -1, -1, -1], dtype=int8)
```

[56]:

```
for col_name, col_content in df_tmp.items():
    if not pd.api.types.is_numeric_dtype(col_content):
        # Creating a binary feature showing if the value was missing
        df_tmp[col_name + "_is_missing"] = col_content.isnull()
        # Turning Categories into Numbers and Filling Null Vals
        df_tmp[col_name] = pd.Categorical(col_content).codes + 1
```

Adding +1 to the category codes will make Null's value from -1 to 0.

[57]:

```
df_tmp.isnull().sum()
```

[57]:

```
SalesID                           0
SalePrice                         0
MachineID                         0
ModelID                           0
datasource                        0
                                 ..
Backhoe_Mounting_is_missing       0
Blade_Type_is_missing             0
Travel_Controls_is_missing        0
Differential_Type_is_missing      0
Steering_Controls_is_missing      0
Length: 103, dtype: int64
```

All the null values have been filled

[58]:

```
df_tmp.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 412698 entries, 0 to 412697
Columns: 103 entries, SalesID to Steering_Controls_is_missing
dtypes: bool(46), float64(3), int16(4), int64(10), int8(40)
memory usage: 77.9 MB
```

1.5 5. Modelling

Now that we have turned dtypes to Numerical and Filled the missing data, we can start modelling

[61]:

```
%%time

np.random.seed(0)

X = df_tmp.drop("SalePrice", axis = 1)
y = df_tmp["SalePrice"]

model = RandomForestRegressor(n_jobs = -1, random_state = 0)

model.fit(X, y)
```

```
CPU times: user 11min 31s, sys: 6.46 s, total: 11min 37s
Wall time: 1min 46s
```

[61]:

```
RandomForestRegressor(n_jobs=-1, random_state=0)
```

Let's initally score the model on the same dataset

[62]:

```
model.score(X, y)
```

[62]:

```
0.9875764803061743
```

This scoring metric is on the same set that the model was trained on. So it isn't an accurate representation of the model's generalization

1.5.1 Splitting the data into Training ang Validation Sets

The validation set is the data for the year 2012

```
[67]: df_train = df_tmp[df_tmp["saleYear"] != 2012]
      df_val = df_tmp[df_tmp["saleYear"] == 2012]
```

```
[68]: len(df_train), len(df_val)
```

```
[68]: (401125, 11573)
```

```
[78]: X_train, y_train = df_train.drop("SalePrice", axis = 1), df_train["SalePrice"]
      X_val, y_val = df_val.drop("SalePrice", axis = 1), df_val["SalePrice"]
```

```
[79]: len(X_train), len(y_train), len(X_val), len(y_val)
```

```
[79]: (401125, 401125, 11573, 11573)
```

1.5.2 Building an evaluation function

```
[83]: from sklearn.metrics import mean_squared_log_error, mean_absolute_error,␣
       ↪r2_score

      def rmsle(y_true, y_preds):
          '''
          Function that returns the Root Mean Squared Log Error (RMSLE) of y_true and␣
       ↪y_preds.
          '''
          return np.sqrt(mean_squared_log_error(y_true, y_preds))

      def eval_model(model, X_train, X_test, y_train, y_test):
          '''
          Makes prediction and evaluations on given model based on X_train, X_test,␣
       ↪y_train and y_test data.
          '''
          train_preds = model.predict(X_train)
          test_preds = model.predict(X_test)

          eval_scores = {
              "Train Mean Absolute Error" : mean_absolute_error(y_train, train_preds),
              "Test Mean Absolute Error" : mean_absolute_error(y_test, test_preds),
              "Train Root Mean Squared Log Error" : rmsle(y_train, train_preds),
              "Test Root Mean Squared Log Error" : rmsle(y_test, test_preds),
              "Train R^2" : r2_score(y_train, train_preds),
              "Test R^2" : r2_score(y_test, test_preds)
```

```
    }
    return eval_scores
```

1.5.3 Testing our model on a subset of the data (to tune the hyperparameters)

[90]:

```
%%time
model = RandomForestRegressor(n_jobs = -1, random_state = 0, max_samples =␣
 ↪10000)
model.fit(X_train, y_train)
```

```
CPU times: user 22.7 s, sys: 264 ms, total: 22.9 s
Wall time: 3.19 s
```

[90]:

```
RandomForestRegressor(max_samples=10000, n_jobs=-1, random_state=0)
```

[91]:

```
baseline_scores = eval_model(model, X_train, X_val, y_train, y_val)
baseline_scores
```

[91]:

```
{'Train Mean Absolute Error': 5558.52439820505,
 'Test Mean Absolute Error': 7171.1105391860365,
 'Train Root Mean Squared Log Error': 0.25777132630598937,
 'Test Root Mean Squared Log Error': 0.2925990620389206,
 'Train R^2': 0.8606818966052752,
 'Test R^2': 0.832049867497664}
```

1.5.4 Tuning the hyperparameters using RandomizedSearchCV

[96]:

```
%%time

from sklearn.model_selection import RandomizedSearchCV

rs_grid = {
    "n_estimators": np.arange(10,200,20),
    "max_depth": [None, 3, 5, 10],
    "min_samples_split": np.arange(2,20,2),
    "min_samples_leaf": np.arange(1,20,2),
    "max_features": [0.5, 1, "sqrt"],
    "max_samples": [10000]
}

rs_model = RandomizedSearchCV(RandomForestRegressor(n_jobs = -1,␣
 ↪random_state=0),
                              param_distributions = rs_grid,
                              cv = 5,
                              n_iter = 100,
                              verbose = True)
rs_model.fit(X_train, y_train)
```

```
Fitting 5 folds for each of 100 candidates, totalling 500 fits
CPU times: user 5min 18s, sys: 49.6 s, total: 6min 7s
Wall time: 9min 36s
```

```
[96]: RandomizedSearchCV(cv=5,
                         estimator=RandomForestRegressor(n_jobs=-1, random_state=0),
                         n_iter=100,
                         param_distributions={'max_depth': [None, 3, 5, 10],
                                              'max_features': [0.5, 1, 'sqrt'],
                                              'max_samples': [10000],
                                              'min_samples_leaf': array([ 1,  3,  5,
      7,  9, 11, 13, 15, 17, 19]),
                                              'min_samples_split': array([ 2,  4,  6,
      8, 10, 12, 14, 16, 18]),
                                              'n_estimators': array([ 10,  30,  50,
      70,  90, 110, 130, 150, 170, 190])},
                         verbose=True)
```

```
[97]: rs_model.best_params_
```

```
[97]: {'n_estimators': 130,
       'min_samples_split': 10,
       'min_samples_leaf': 3,
       'max_samples': 10000,
       'max_features': 0.5,
       'max_depth': None}
```

```
[98]: baseline_scores
```

```
[98]: {'Train Mean Absolute Error': 5558.52439820505,
       'Test Mean Absolute Error': 7171.1105391860365,
       'Train Root Mean Squared Log Error': 0.25777132630598937,
       'Test Root Mean Squared Log Error': 0.2925990620389206,
       'Train R^2': 0.8606818966052752,
       'Test R^2': 0.832049867497664}
```

```
[99]: rs_scores = eval_model(rs_model, X_train, X_val, y_train, y_val)
      rs_scores
```

```
[99]: {'Train Mean Absolute Error': 5911.904418786114,
       'Test Mean Absolute Error': 7268.799278416505,
       'Train Root Mean Squared Log Error': 0.27010028208693937,
       'Test Root Mean Squared Log Error': 0.29567630218568863,
       'Train R^2': 0.8437098487721018,
       'Test R^2': 0.8271379483482113}
```

1.5.5 Traininga a model with the tuned hyperparamets

[102]:
```
tuned_model = RandomForestRegressor(n_estimators = 130,
                                    min_samples_split = 10,
                                    min_samples_leaf = 3,
                                    max_samples = None,
                                    max_features = 0.5,
                                    max_depth = None,
                                    n_jobs = -1,
                                    random_state = 0)
tuned_model.fit(X_train, y_train)
```

[102]:
```
RandomForestRegressor(max_features=0.5, min_samples_leaf=3,
                      min_samples_split=10, n_estimators=130, n_jobs=-1,
                      random_state=0)
```

[104]:
```
tuned_model_scores = eval_model(tuned_model, X_train, X_val, y_train, y_val)
tuned_model_scores
```

[104]:
```
{'Train Mean Absolute Error': 2844.8336474314638,
 'Test Mean Absolute Error': 5884.576654930028,
 'Train Root Mean Squared Log Error': 0.1423311430882674,
 'Test Root Mean Squared Log Error': 0.2417827606636782,
 'Train R^2': 0.9597602190360334,
 'Test R^2': 0.8834509262663633}
```

1.5.6 Making Prediction on the Test Data

[122]:
```
df_test = pd.read_csv("data/bluebook-for-bulldozers/Test.csv",␣
 ↪low_memory=False, parse_dates=["saledate"])
df_test.head()
```

[122]:
```
   SalesID  MachineID  ModelID  datasource  auctioneerID  YearMade  \
0  1227829    1006309     3168         121             3      1999
1  1227844    1022817     7271         121             3      1000
2  1227847    1031560    22805         121             3      2004
3  1227848      56204     1269         121             3      2006
4  1227863    1053887    22312         121             3      2005

   MachineHoursCurrentMeter UsageBand   saledate fiModelDesc  ...  \
0                    3688.0       Low 2012-05-03        580G  ...
1                   28555.0      High 2012-05-10         936  ...
2                    6038.0    Medium 2012-05-10     EC210BLC  ...
3                    8940.0      High 2012-05-10       330CL  ...
4                    2286.0       Low 2012-05-10        650K  ...

  Undercarriage_Pad_Width         Stick_Length   Thumb      Pattern_Changer  \
0                     NaN                  NaN     NaN                  NaN
```

```
1                     NaN                  NaN     NaN                  NaN
2     None or Unspecified                9' 6"  Manual  None or Unspecified
3     None or Unspecified  None or Unspecified  Manual                  Yes
4                     NaN                  NaN     NaN                  NaN

  Grouser_Type     Backhoe_Mounting Blade_Type      Travel_Controls  \
0          NaN                  NaN        NaN                  NaN
1          NaN                  NaN        NaN                  NaN
2       Double                  NaN        NaN                  NaN
3       Triple                  NaN        NaN                  NaN
4          NaN  None or Unspecified        PAT  None or Unspecified

  Differential_Type Steering_Controls
0               NaN               NaN
1          Standard      Conventional
2               NaN               NaN
3               NaN               NaN
4               NaN               NaN

[5 rows x 52 columns]
```

The test data must first be preprocessed to be in the same format as that of our training set

[123]:
```
X_train.columns
```

[123]:
```
Index(['SalesID', 'MachineID', 'ModelID', 'datasource', 'auctioneerID',
       'YearMade', 'MachineHoursCurrentMeter', 'UsageBand', 'fiModelDesc',
       'fiBaseModel',
       …
       'Undercarriage_Pad_Width_is_missing', 'Stick_Length_is_missing',
       'Thumb_is_missing', 'Pattern_Changer_is_missing',
       'Grouser_Type_is_missing', 'Backhoe_Mounting_is_missing',
       'Blade_Type_is_missing', 'Travel_Controls_is_missing',
       'Differential_Type_is_missing', 'Steering_Controls_is_missing'],
      dtype='object', length=102)
```

[124]:
```
df_test.columns
```

[124]:
```
Index(['SalesID', 'MachineID', 'ModelID', 'datasource', 'auctioneerID',
       'YearMade', 'MachineHoursCurrentMeter', 'UsageBand', 'saledate',
       'fiModelDesc', 'fiBaseModel', 'fiSecondaryDesc', 'fiModelSeries',
       'fiModelDescriptor', 'ProductSize', 'fiProductClassDesc', 'state',
       'ProductGroup', 'ProductGroupDesc', 'Drive_System', 'Enclosure',
       'Forks', 'Pad_Type', 'Ride_Control', 'Stick', 'Transmission',
       'Turbocharged', 'Blade_Extension', 'Blade_Width', 'Enclosure_Type',
       'Engine_Horsepower', 'Hydraulics', 'Pushblock', 'Ripper', 'Scarifier',
       'Tip_Control', 'Tire_Size', 'Coupler', 'Coupler_System',
       'Grouser_Tracks', 'Hydraulics_Flow', 'Track_Type',
       'Undercarriage_Pad_Width', 'Stick_Length', 'Thumb', 'Pattern_Changer',
       'Grouser_Type', 'Backhoe_Mounting', 'Blade_Type', 'Travel_Controls',
       'Differential_Type', 'Steering_Controls'],
      dtype='object')
```

1.5.7 Preprocessing the data

[125]:

```
def preprocess_data(df):

    # Feature Engineering using saledate feature
    df["saleYear"] = df["saledate"].dt.year
    df["saleMonth"] = df["saledate"].dt.month
    df["saleDay"] = df["saledate"].dt.day
    df["saleDayOfWeek"] = df["saledate"].dt.dayofweek
    df["saleDayOfYear"] = df["saledate"].dt.dayofyear
    df.drop("saledate", axis = 1, inplace = True)

    # Converting String data to Categories
    for col_name, col_content in df.items():
        if pd.api.types.is_string_dtype(col_content):
            df[col_name] = col_content.astype("category").cat.as_ordered()

    # Filling data
    for col_name, col_content in df.items():

        # Numerical Data
        if pd.api.types.is_numeric_dtype(col_content):
            if pd.isnull(col_content).sum():
                df[col_name] = col_content.fillna(col_content.median())
                df[col_name + "is_missing"] = pd.isnull(col_content)
                # making new cols to check if data was missing.

        # Categorical Data
        if not pd.api.types.is_numeric_dtype(col_content):
            # Creating a binary feature showing if the value was missing
            df[col_name + "_is_missing"] = col_content.isnull()
            # Turning Categories into Numbers and Filling Null Vals
            df[col_name] = pd.Categorical(col_content).codes + 1

    return df
```

[126]:

```
df_test = preprocess_data(df_test)
df_test.head()
```

[126]:

```
   SalesID  MachineID  ModelID  datasource  auctioneerID  YearMade  \
0  1227829    1006309     3168         121             3      1999
1  1227844    1022817     7271         121             3      1000
```

```
2  1227847    1031560    22805         121             3      2004
3  1227848      56204     1269         121             3      2006
4  1227863    1053887    22312         121             3      2005

   MachineHoursCurrentMeter  UsageBand  fiModelDesc  fiBaseModel  …  \
0                    3688.0          2          499          180  …
1                   28555.0          1          831          292  …
2                    6038.0          3         1177          404  …
3                    8940.0          1          287          113  …
4                    2286.0          2          566          196  …

   Undercarriage_Pad_Width_is_missing  Stick_Length_is_missing  \
0                                True                     True
1                                True                     True
2                               False                    False
3                               False                    False
4                                True                     True

   Thumb_is_missing  Pattern_Changer_is_missing  Grouser_Type_is_missing  \
0              True                        True                     True
1              True                        True                     True
2             False                       False                    False
3             False                       False                    False
4              True                        True                     True

   Backhoe_Mounting_is_missing  Blade_Type_is_missing  \
0                         True                   True
1                         True                   True
2                         True                   True
3                         True                   True
4                        False                  False

   Travel_Controls_is_missing  Differential_Type_is_missing  \
0                        True                          True
1                        True                         False
2                        True                          True
3                        True                          True
4                       False                          True

   Steering_Controls_is_missing
0                          True
1                         False
2                          True
3                          True
4                          True

[5 rows x 101 columns]
```

```
[127]: len(df_test.columns), len(X_train.columns)
```

```
[127]: (101, 102)
```

```
[129]: set(X_train.columns) - set(df_test.columns)
```

```
[129]: {'auctioneerIDis_missing'}
```

There is no auctioneerID Null values in Test Dataset hence this feature is missing. We can manually add the feature

```
[130]: df_test["auctioneerIDis_missing"] = False
```

```
[139]: df_test = df_test.reindex(columns=list(X_train.columns))
```

```
[140]: len(df_test.columns), len(X_train.columns)
```

```
[140]: (102, 102)
```

1.5.8 Making Predictions on the Test set

```
[141]: test_preds = tuned_model.predict(df_test)
```

```
[142]: test_preds
```

```
[142]: array([17347.62069212, 18622.20832936, 49162.08708438, …,
              12535.01052965, 17110.6827157 , 28608.18839628])
```

```
[143]: test_preds_df = pd.DataFrame()
        test_preds_df["SalesID"] = df_test["SalesID"]
        test_preds_df["SalesPrice"] = test_preds
```

```
[144]: test_preds_df
```

```
[144]:        SalesID    SalesPrice
        0      1227829  17347.620692
        1      1227844  18622.208329
        2      1227847  49162.087084
        3      1227848  68131.719246
        4      1227863  54513.445507
        …          …             …
        12452  6643171  39808.592619
        12453  6643173  12412.197032
        12454  6643184  12535.010530
        12455  6643186  17110.682716
        12456  6643196  28608.188396

        [12457 rows x 2 columns]
```

[145]:
```
test_preds_df.to_csv("data/bluebook-for-bulldozers/predicted_sales_price.csv")
```

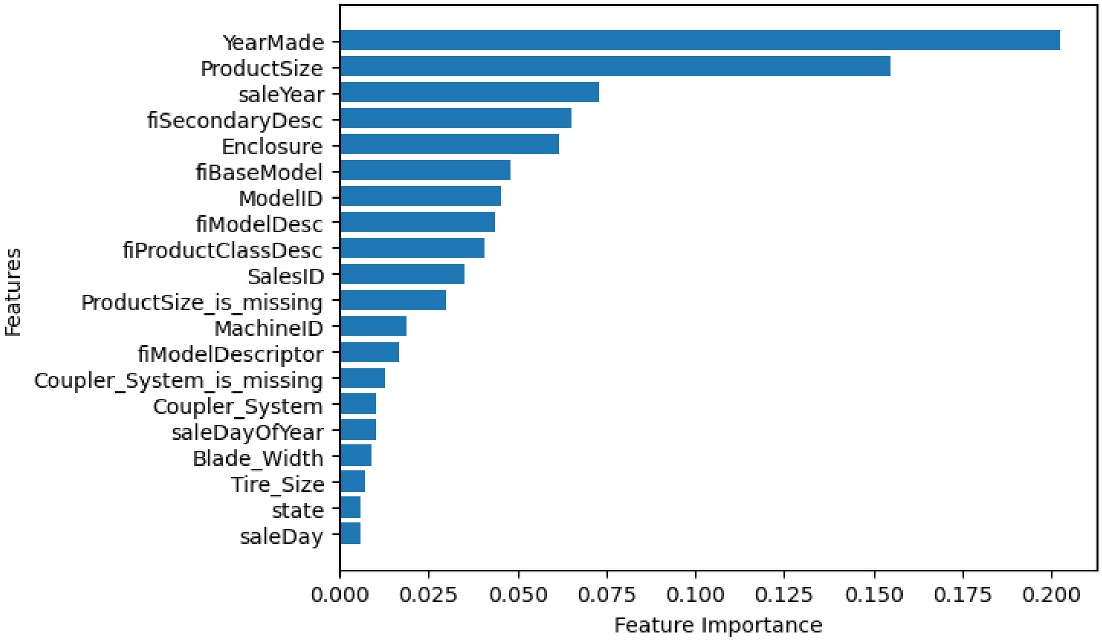
1.5.9 Feature Importance

[146]:
```
tuned_model.feature_importances_
```

[146]:
```
array([3.53002628e-02, 1.87088656e-02, 4.52479013e-02, 1.69110698e-03,
       3.31467160e-03, 2.02627988e-01, 3.03853416e-03, 1.06132675e-03,
       4.36857562e-02, 4.82178584e-02, 6.51843745e-02, 4.59642257e-03,
       1.65203621e-02, 1.54674399e-01, 4.05789591e-02, 6.16942667e-03,
       4.80438342e-03, 1.99096712e-03, 3.24624206e-03, 6.15668687e-02,
       5.12113586e-04, 1.57350151e-04, 8.97199123e-04, 1.72662045e-04,
       1.28939126e-03, 1.73156754e-05, 1.57434491e-03, 8.80231196e-03,
       2.74317863e-03, 1.18944838e-03, 4.88483269e-03, 2.81428978e-03,
       3.32742596e-03, 1.04646077e-03, 1.54317753e-03, 7.08262326e-03,
       8.90458833e-04, 1.01528916e-02, 1.97574037e-03, 2.80213202e-03,
       1.11086498e-03, 1.00593958e-03, 2.27993834e-03, 6.42687057e-04,
       6.23172487e-04, 3.74938015e-04, 4.75575766e-04, 2.21729496e-03,
       8.54676772e-04, 2.84932304e-04, 2.18368761e-04, 7.27219199e-02,
       4.25316178e-03, 6.11113228e-03, 3.09441578e-03, 1.01481018e-02,
       1.94622167e-04, 1.39379163e-03, 3.91264434e-04, 0.00000000e+00,
       0.00000000e+00, 2.69055831e-03, 1.32994136e-03, 5.85428315e-03,
       2.98569168e-02, 0.00000000e+00, 0.00000000e+00, 0.00000000e+00,
       0.00000000e+00, 6.20083472e-05, 2.01636053e-06, 1.90010416e-04,
       5.17599255e-06, 1.47236631e-04, 4.46252777e-06, 2.46546900e-04,
       2.14456025e-05, 1.28003835e-03, 2.09497500e-03, 1.62409227e-03,
       1.41079037e-03, 1.89688471e-03, 2.68196484e-03, 1.40299783e-03,
       3.40674675e-04, 8.94960103e-04, 3.26197466e-03, 1.62380902e-04,
       1.29479445e-02, 1.84729085e-03, 2.08935085e-03, 4.30793411e-05,
       6.66216316e-05, 6.92148014e-05, 3.88438616e-05, 4.72939387e-05,
       4.84143312e-05, 3.59376961e-04, 1.90987770e-04, 1.01040481e-04,
       8.28277842e-05, 1.06552600e-04])
```

[147]:
```
def plot_features(cols, importance, n = 20):
    df = (pd.DataFrame({"features" : cols,
                       "Feature Importance" : importance}).
          sort_values("Feature Importance", "ascending).
          reset_index(drop = True))
    #plotting
    fig, ax = plt.subplots()
    ax.barh(df["features"][:n], df["Feature Importance"][:n])
    ax.set_ylabel("Features")
    ax.set_xlabel("Feature Importance")
    ax.invert_yaxis();
```

[151]:
```
plot_features(X_train.columns, tuned_model.feature_importances_)
```


YearMade
ProductSize
saleYear
fiSecondaryDesc
Enclosure
fiBaseModel
ModelID
fiModelDesc
fiProductClassDesc
SalesID
ProductSize_is_missing
MachineID
fiModelDescriptor
Coupler_System_is_missing
Coupler_System
saleDayOfYear
Blade_Width
Tire_Size
state
saleDay
Features
0.000
0.025
0.050
0.075
0.100
0.125
0.150
0.175
0.200
Feature Importance