House Price Prediction - Individual project

Importing data

The required data and libraries are imported and datasets are analyzed for Null values and their structure

In [6]:
```python
import pandas as pd

house_train = pd.read_csv(r'C:\Users\Riaz\Desktop\MSDS\Predictive Analysis\Week 2\train.
pd.set_option('display.max_columns', None)
print ("The Null values present in dataset\n",house_train[house_train.columns[house_trai
print("The house dataset is \n")
print(house_train.info())
```

```
The Null values present in dataset
 LotFrontage      259
Alley           1369
MasVnrType       872
MasVnrArea         8
BsmtQual          37
BsmtCond          37
BsmtExposure      38
BsmtFinType1      37
BsmtFinType2      38
Electrical         1
FireplaceQu      690
GarageType        81
GarageYrBlt       81
GarageFinish      81
GarageQual        81
GarageCond        81
PoolQC          1453
Fence           1179
MiscFeature     1406
dtype: int64
The house dataset is 

<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1460 entries, 0 to 1459
Data columns (total 81 columns):
 #   Column         Non-Null Count  Dtype  
---  ------         --------------  -----  
 0   Id             1460 non-null   int64  
 1   MSSubClass     1460 non-null   int64  
 2   MSZoning       1460 non-null   object 
 3   LotFrontage    1201 non-null   float64
 4   LotArea        1460 non-null   int64  
 5   Street         1460 non-null   object 
 6   Alley          91 non-null     object 
 7   LotShape       1460 non-null   object 
 8   LandContour    1460 non-null   object 
 9   Utilities      1460 non-null   object 
 10  LotConfig      1460 non-null   object 
 11  LandSlope      1460 non-null   object 
 12  Neighborhood   1460 non-null   object 
 13  Condition1     1460 non-null   object 
 14  Condition2     1460 non-null   object 
 15  BldgType       1460 non-null   object 
 16  HouseStyle     1460 non-null   object 
```

```
 17  OverallQual    1460 non-null   int64
 18  OverallCond    1460 non-null   int64
 19  YearBuilt      1460 non-null   int64
 20  YearRemodAdd   1460 non-null   int64
 21  RoofStyle      1460 non-null   object
 22  RoofMatl       1460 non-null   object
 23  Exterior1st    1460 non-null   object
 24  Exterior2nd    1460 non-null   object
 25  MasVnrType     588 non-null    object
 26  MasVnrArea     1452 non-null   float64
 27  ExterQual      1460 non-null   object
 28  ExterCond      1460 non-null   object
 29  Foundation     1460 non-null   object
 30  BsmtQual       1423 non-null   object
 31  BsmtCond       1423 non-null   object
 32  BsmtExposure   1422 non-null   object
 33  BsmtFinType1   1423 non-null   object
 34  BsmtFinSF1     1460 non-null   int64
 35  BsmtFinType2   1422 non-null   object
 36  BsmtFinSF2     1460 non-null   int64
 37  BsmtUnfSF      1460 non-null   int64
 38  TotalBsmtSF    1460 non-null   int64
 39  Heating        1460 non-null   object
 40  HeatingQC      1460 non-null   object
 41  CentralAir     1460 non-null   object
 42  Electrical     1459 non-null   object
 43  1stFlrSF       1460 non-null   int64
 44  2ndFlrSF       1460 non-null   int64
 45  LowQualFinSF   1460 non-null   int64
 46  GrLivArea      1460 non-null   int64
 47  BsmtFullBath   1460 non-null   int64
 48  BsmtHalfBath   1460 non-null   int64
 49  FullBath       1460 non-null   int64
 50  HalfBath       1460 non-null   int64
 51  BedroomAbvGr   1460 non-null   int64
 52  KitchenAbvGr   1460 non-null   int64
 53  KitchenQual    1460 non-null   object
 54  TotRmsAbvGrd   1460 non-null   int64
 55  Functional     1460 non-null   object
 56  Fireplaces     1460 non-null   int64
 57  FireplaceQu    770 non-null    object
 58  GarageType     1379 non-null   object
 59  GarageYrBlt    1379 non-null   float64
 60  GarageFinish   1379 non-null   object
 61  GarageCars     1460 non-null   int64
 62  GarageArea     1460 non-null   int64
 63  GarageQual     1379 non-null   object
 64  GarageCond     1379 non-null   object
 65  PavedDrive     1460 non-null   object
 66  WoodDeckSF     1460 non-null   int64
 67  OpenPorchSF    1460 non-null   int64
 68  EnclosedPorch  1460 non-null   int64
 69  3SsnPorch      1460 non-null   int64
 70  ScreenPorch    1460 non-null   int64
 71  PoolArea       1460 non-null   int64
 72  PoolQC         7 non-null      object
 73  Fence          281 non-null    object
 74  MiscFeature    54 non-null     object
 75  MiscVal        1460 non-null   int64
 76  MoSold         1460 non-null   int64
 77  YrSold         1460 non-null   int64
 78  SaleType       1460 non-null   object
 79  SaleCondition  1460 non-null   object
 80  SalePrice      1460 non-null   int64
dtypes: float64(3), int64(35), object(43)
```

```
memory usage: 924.0+ KB
None
```

Data Adjustments

Data has been adjusted and a new feature created by adding the columns of basement and living area, to come up with the total grand area.

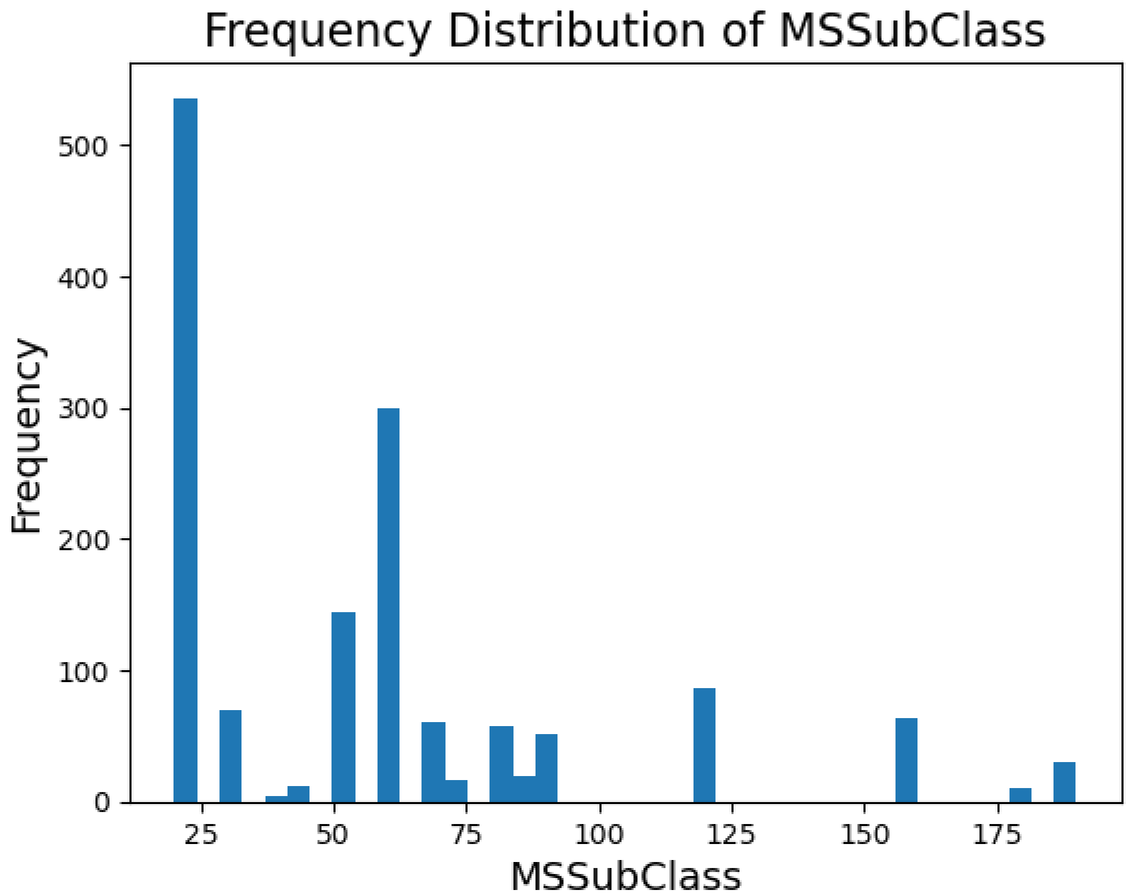
In [2]:
```python
# Total area including basement

house_train['GrandArea'] = house_train['TotalBsmtSF'] + house_train['GrLivArea']
```

Visualization

Various visualization like frequency distribution, box plots, bar charts has been plotted for different variables. For better understanding, please refer the accompanying word document.

In [3]:
```python
import matplotlib.pyplot as plt
plt.title('Frequency Distribution of MSSubClass', fontsize=16)
plt.xlabel('MSSubClass', fontsize=14)
plt.ylabel('Frequency', fontsize=14)
plt.hist(house_train['MSSubClass'],bins=40)
```

Out[3]:
```
(array([536.,   0.,  69.,   0.,   4.,  12.,   0., 144.,   0., 299.,   0.,
         60.,  16.,   0.,  58.,  20.,  52.,   0.,   0.,   0.,   0.,   0.,
          0.,  87.,   0.,   0.,   0.,   0.,   0.,   0.,   0.,   0.,  63.,
          0.,   0.,   0.,   0.,  10.,   0.,  30.]),
 array([ 20.  ,  24.25,  28.5 ,  32.75,  37.  ,  41.25,  45.5 ,  49.75,
         54.  ,  58.25,  62.5 ,  66.75,  71.  ,  75.25,  79.5 ,  83.75,
         88.  ,  92.25,  96.5 , 100.75, 105.  , 109.25, 113.5 , 117.75,
        122.  , 126.25, 130.5 , 134.75, 139.  , 143.25, 147.5 , 151.75,
        156.  , 160.25, 164.5 , 168.75, 173.  , 177.25, 181.5 , 185.75,
        190.  ]),
 <BarContainer object of 40 artists>)
```

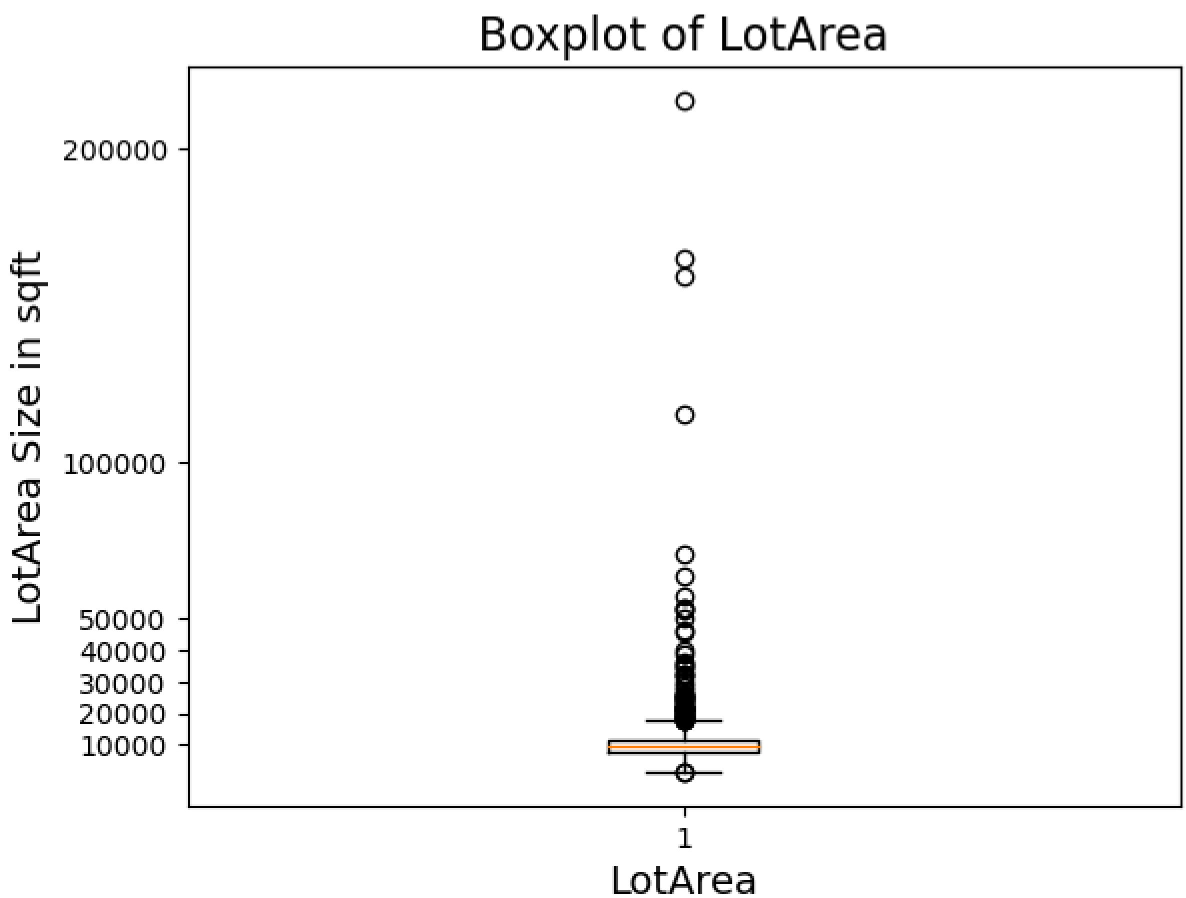


In [4]:
```
plt.title('Boxplot of LotArea', fontsize=16)
plt.xlabel('LotArea', fontsize=14)
plt.ylabel('LotArea Size in sqft', fontsize=14)
plt.boxplot(house_train['LotArea'])
plt.yticks([10000,20000,30000,40000,50000,100000,200000])
pd.set_option('display.max_columns', None)
house_train[house_train['LotArea'] > 30000]
```

Out[4]:

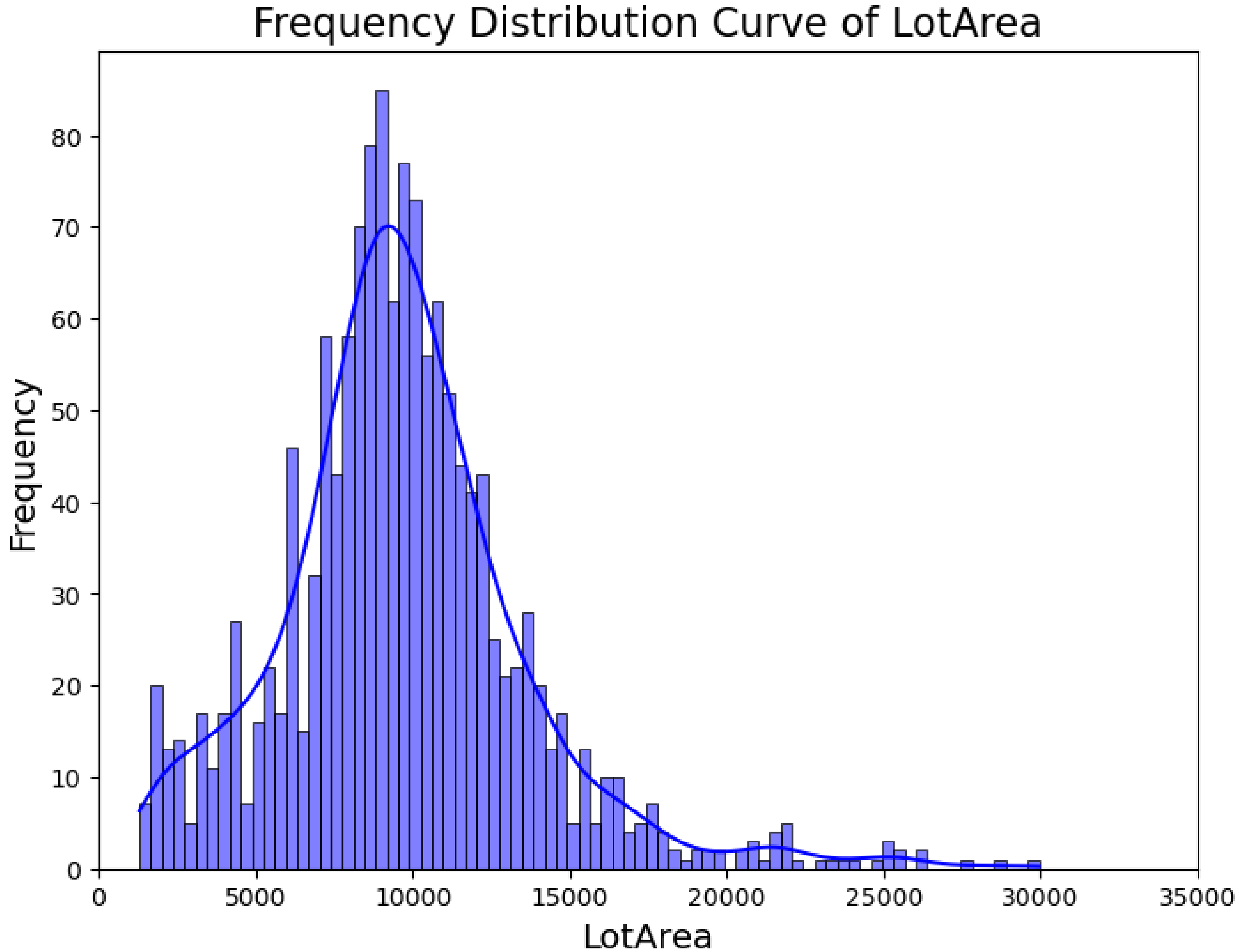
	Id	MSSubClass	MSZoning	LotFrontage	LotArea	Street	Alley	LotShape	LandContour	Utilities	LotC
53	54	20	RL	68.0	50271	Pave	NaN	IR1	Low	AllPub	I
171	172	20	RL	141.0	31770	Pave	NaN	IR1	Lvl	AllPub	C
249	250	50	RL	NaN	159000	Pave	NaN	IR2	Low	AllPub	Cu
271	272	20	RL	73.0	39104	Pave	NaN	IR1	Low	AllPub	Cu
313	314	20	RL	150.0	215245	Pave	NaN	IR3	Low	AllPub	I
335	336	190	RL	NaN	164660	Grvl	NaN	IR1	HLS	AllPub	C
384	385	60	RL	NaN	53107	Pave	NaN	IR2	Low	AllPub	C
411	412	190	RL	100.0	34650	Pave	NaN	Reg	Bnk	AllPub	I
451	452	20	RL	62.0	70761	Pave	NaN	IR1	Low	AllPub	I
457	458	20	RL	NaN	53227	Pave	NaN	IR1	Low	AllPub	Cu
523	524	60	RL	130.0	40094	Pave	NaN	IR1	Bnk	AllPub	I
529	530	20	RL	NaN	32668	Pave	NaN	IR1	Lvl	AllPub	Cu
661	662	60	RL	52.0	46589	Pave	NaN	IR2	Lvl	AllPub	Cu
706	707	20	RL	NaN	115149	Pave	NaN	IR2	Low	AllPub	Cu
769	770	60	RL	47.0	53504	Pave	NaN	IR2	HLS	AllPub	Cu

848	849	50	RL	75.0	45600	Pave	NaN	IR2	Bnk	AllPub	I
1169	1170	60	RL	118.0	35760	Pave	NaN	IR1	Lvl	AllPub	Cu
1184	1185	20	RL	50.0	35133	Grvl	NaN	Reg	Lvl	AllPub	I
1190	1191	190	RL	NaN	32463	Pave	NaN	Reg	Low	AllPub	I
1287	1288	20	RL	NaN	36500	Pave	NaN	IR1	Low	AllPub	I
1298	1299	60	RL	313.0	63887	Pave	NaN	IR3	Bnk	AllPub	C
1396	1397	20	RL	NaN	57200	Pave	NaN	IR1	Bnk	AllPub	I

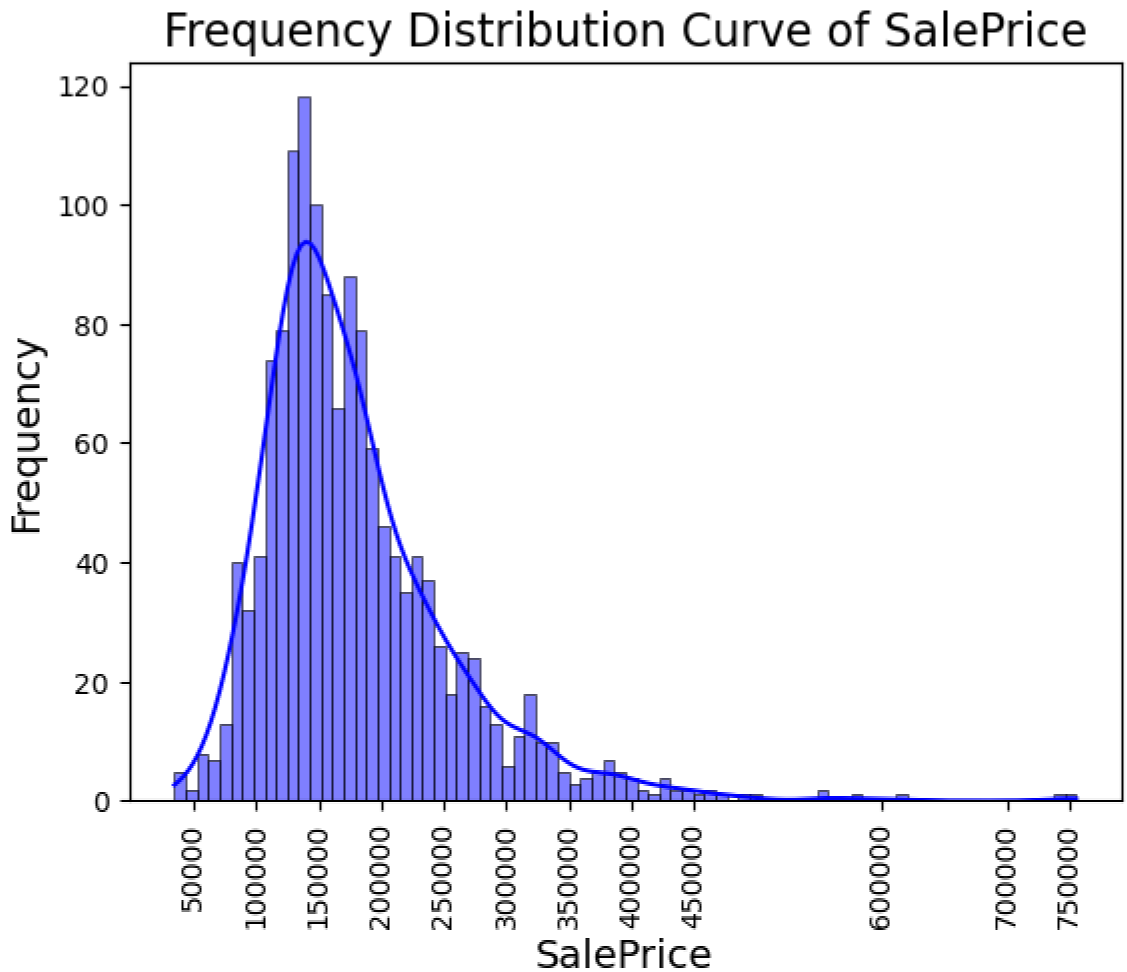


In [5]:
```
house_train_lotarea=house_train[house_train['LotArea'] < 30000]
```

In [6]:
```
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns

# Set up the plot
plt.figure(figsize=(8, 6))

# Plot a histogram with KDE (Kernel Density Estimate)
sns.histplot(house_train_lotarea['LotArea'], bins=80, kde=True, color='blue')

# Add titles and labels
plt.title('Frequency Distribution Curve of LotArea', fontsize=16)
plt.xlim(0,35000)
plt.xlabel('LotArea', fontsize=14)
plt.ylabel('Frequency', fontsize=14)

# Display the plot
plt.show()
```



In [7]:
```
sns.histplot(house_train_lotarea['SalePrice'], bins=80, kde=True, color='blue')

# Add titles and labels
plt.title('Frequency Distribution Curve of SalePrice', fontsize=16)
plt.xticks([50000,100000,150000,200000,250000,300000,350000,400000,450000,600000,700000,
plt.xlabel('SalePrice', fontsize=14)
plt.ylabel('Frequency', fontsize=14)


# Display the plot
plt.show()
```



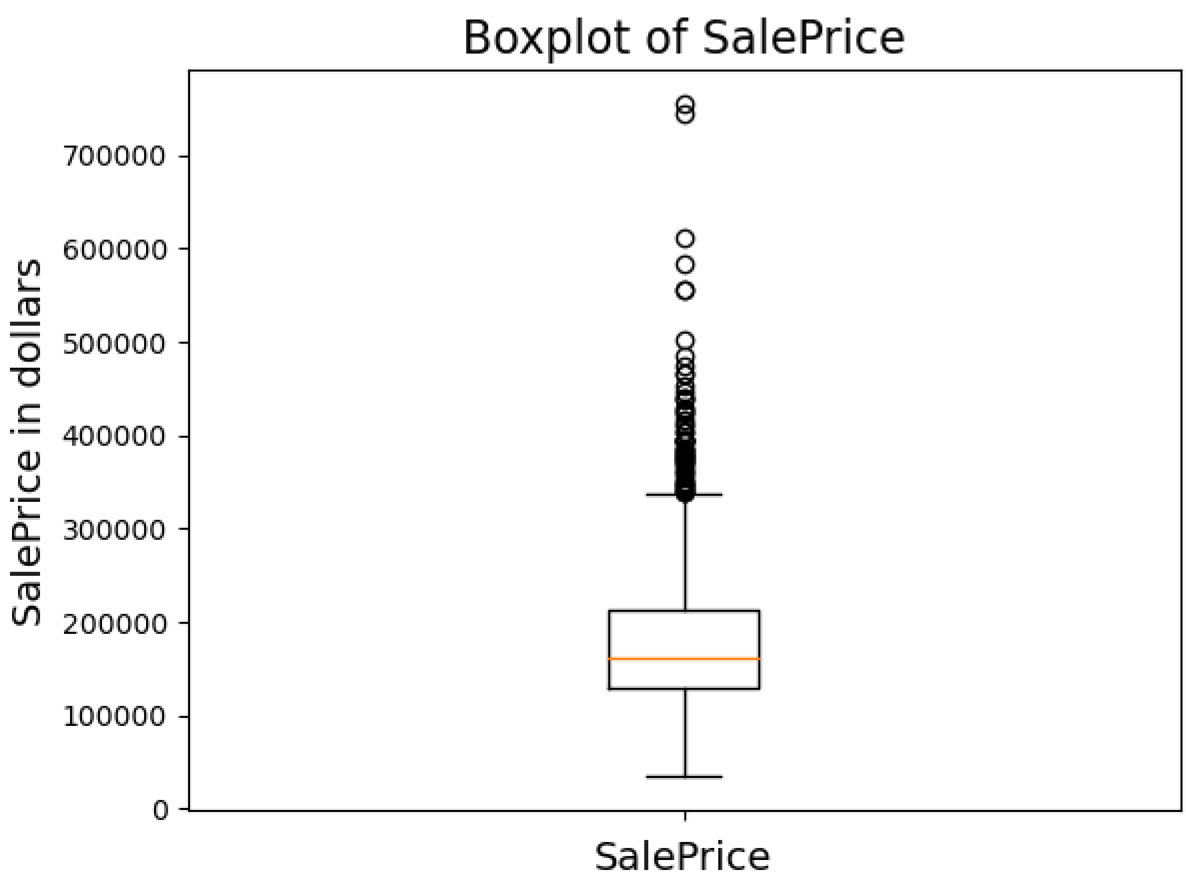
Rows having house sale price more than 400K USD has been displayed and it will be dropped.

In [8]:
```
plt.title('Boxplot of SalePrice', fontsize=16)
plt.xticks([50000,100000,150000,200000,250000,300000,350000,400000,450000,600000,700000,
plt.xlabel('SalePrice', fontsize=14)
plt.ylabel('SalePrice in dollars', fontsize=14)
plt.boxplot(house_train_lotarea['SalePrice'])
house_train_lotarea[house_train_lotarea['SalePrice'] > 400000]
```

Out[8]:

	Id	MSSubClass	MSZoning	LotFrontage	LotArea	Street	Alley	LotShape	LandContour	Utilities	LotC
58	59	60	RL	66.0	13682	Pave	NaN	IR2	HLS	AllPub	Cu
161	162	60	RL	110.0	13688	Pave	NaN	IR1	Lvl	AllPub	I
178	179	20	RL	63.0	17423	Pave	NaN	IR1	Lvl	AllPub	Cu
185	186	75	RM	90.0	22950	Pave	NaN	IR2	Lvl	AllPub	I
231	232	60	RL	174.0	15138	Pave	NaN	IR1	Lvl	AllPub	I
278	279	20	RL	107.0	14450	Pave	NaN	Reg	Lvl	AllPub	I
349	350	60	RL	56.0	20431	Pave	NaN	IR2	Lvl	AllPub	I
389	390	60	RL	96.0	12474	Pave	NaN	Reg	Lvl	AllPub	I
440	441	20	RL	105.0	15431	Pave	NaN	Reg	Lvl	AllPub	I
473	474	20	RL	110.0	14977	Pave	NaN	IR1	Lvl	AllPub	I
496	497	20	RL	NaN	12692	Pave	NaN	IR1	Lvl	AllPub	I
515	516	20	RL	94.0	12220	Pave	NaN	Reg	Lvl	AllPub	I

527	528	60	RL	67.0	14948	Pave	NaN	IR1	Lvl	AllPub	I
591	592	60	RL	97.0	13478	Pave	NaN	IR1	Lvl	AllPub	C
664	665	20	RL	49.0	20896	Pave	NaN	IR2	Lvl	AllPub	Cu
691	692	60	RL	104.0	21535	Pave	NaN	IR1	Lvl	AllPub	C
798	799	60	RL	104.0	13518	Pave	NaN	Reg	Lvl	AllPub	I
803	804	60	RL	107.0	13891	Pave	NaN	Reg	Lvl	AllPub	I
898	899	20	RL	100.0	12919	Pave	NaN	IR1	Lvl	AllPub	I
1046	1047	60	RL	85.0	16056	Pave	NaN	IR1	Lvl	AllPub	I
1142	1143	60	RL	77.0	9965	Pave	NaN	Reg	Lvl	AllPub	I
1182	1183	60	RL	160.0	15623	Pave	NaN	IR1	Lvl	AllPub	C
1243	1244	20	RL	107.0	13891	Pave	NaN	Reg	Lvl	AllPub	I
1353	1354	50	RL	56.0	14720	Pave	NaN	IR1	Lvl	AllPub	Cu
1373	1374	20	RL	NaN	11400	Pave	NaN	Reg	Lvl	AllPub	I



Finding out if there are any houses withouch kitchen and it will be dropped subsequently

In [9]:
```
print ("There is a house where there are no kitchens\n\n",house_train_lotarea[house_trai
house_train_lotarea.loc[house_train_lotarea['KitchenAbvGr'] < 1 , 'KitchenAbvGr'] = 1
```

```
There is a house where there are no kitchens

       Id  MSSubClass MSZoning  LotFrontage  LotArea Street Alley LotShape  \
954  955          90       RL         35.0     9400   Pave   NaN      IR1

    LandContour Utilities LotConfig LandSlope Neighborhood Condition1  \
954         Lvl    AllPub   CulDSac       Gtl      Edwards       Norm
```

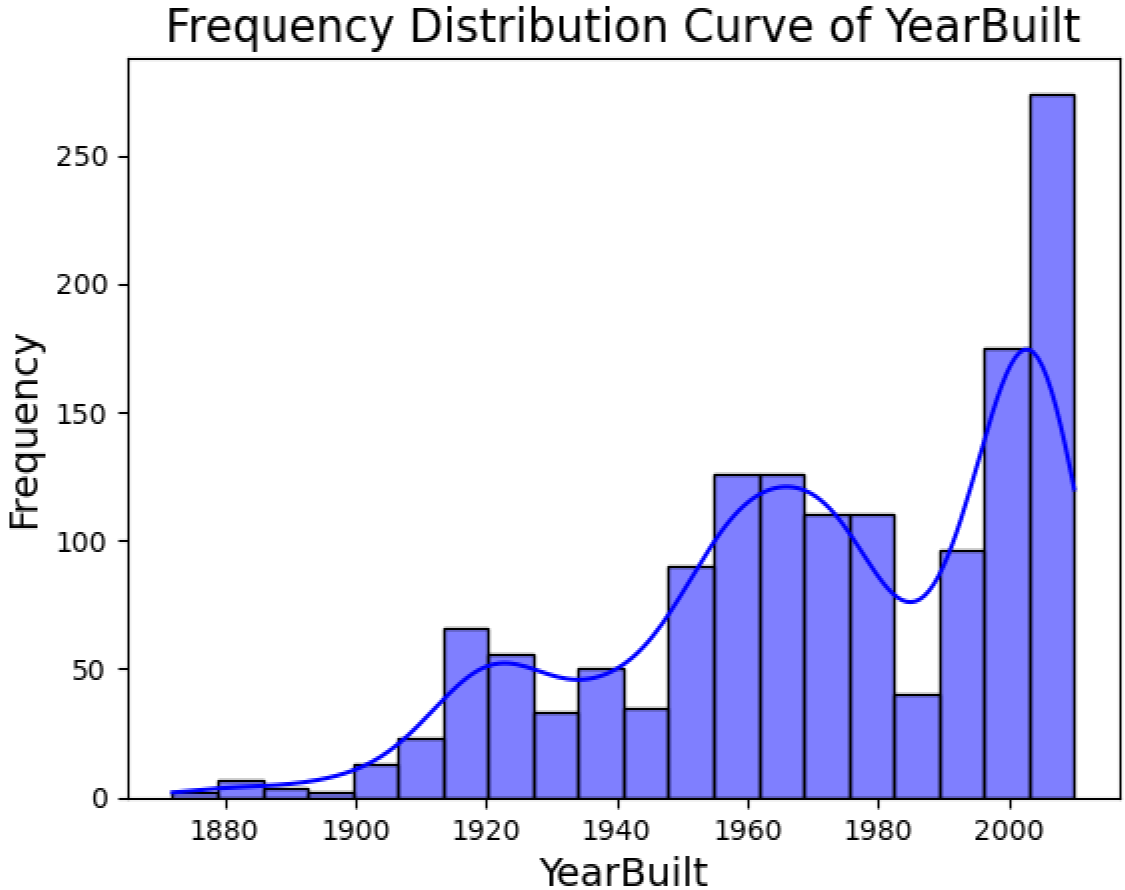
```
   Condition2 BldgType HouseStyle  OverallQual  OverallCond  YearBuilt  \
954       Norm   Duplex     SFoyer            6            5       1975

    YearRemodAdd RoofStyle RoofMatl Exterior1st Exterior2nd MasVnrType  \
954          1975      Flat  Tar&Grv     WdShing     Plywood    BrkFace

    MasVnrArea ExterQual ExterCond Foundation BsmtQual BsmtCond BsmtExposure  \
954      250.0        TA        TA     CBlock       Gd       Gd           Gd

   BsmtFinType1  BsmtFinSF1 BsmtFinType2  BsmtFinSF2  BsmtUnfSF  TotalBsmtSF  \
954          GLQ         945          Unf           0          0          945

   Heating HeatingQC CentralAir Electrical  1stFlrSF  2ndFlrSF  LowQualFinSF  \
954   GasA        TA          Y      SBrkr       980         0             0

    GrLivArea  BsmtFullBath  BsmtHalfBath  FullBath  HalfBath  BedroomAbvGr  \
954       980             0             2         2         0             4

    KitchenAbvGr KitchenQual  TotRmsAbvGrd Functional  Fireplaces  \
954             0          TA             4        Typ           0

   FireplaceQu GarageType  GarageYrBlt GarageFinish  GarageCars  GarageArea  \
954         NaN        NaN          NaN          NaN           0           0

   GarageQual GarageCond PavedDrive  WoodDeckSF  OpenPorchSF  EnclosedPorch  \
954        NaN        NaN          Y           0            0              0

    3SsnPorch  ScreenPorch  PoolArea PoolQC Fence MiscFeature  MiscVal  \
954          0            0         0    NaN   NaN         NaN        0

    MoSold  YrSold SaleType SaleCondition  SalePrice  GrandArea
954      10    2006       WD       AdjLand     127500       1925
```

In [10]:

```python
sns.histplot(house_train_lotarea['YearBuilt'], bins=20, kde=True, color='blue')

# Add titles and labels
plt.title('Frequency Distribution Curve of YearBuilt', fontsize=16)
plt.xlabel('YearBuilt', fontsize=14)
plt.ylabel('Frequency', fontsize=14)
```

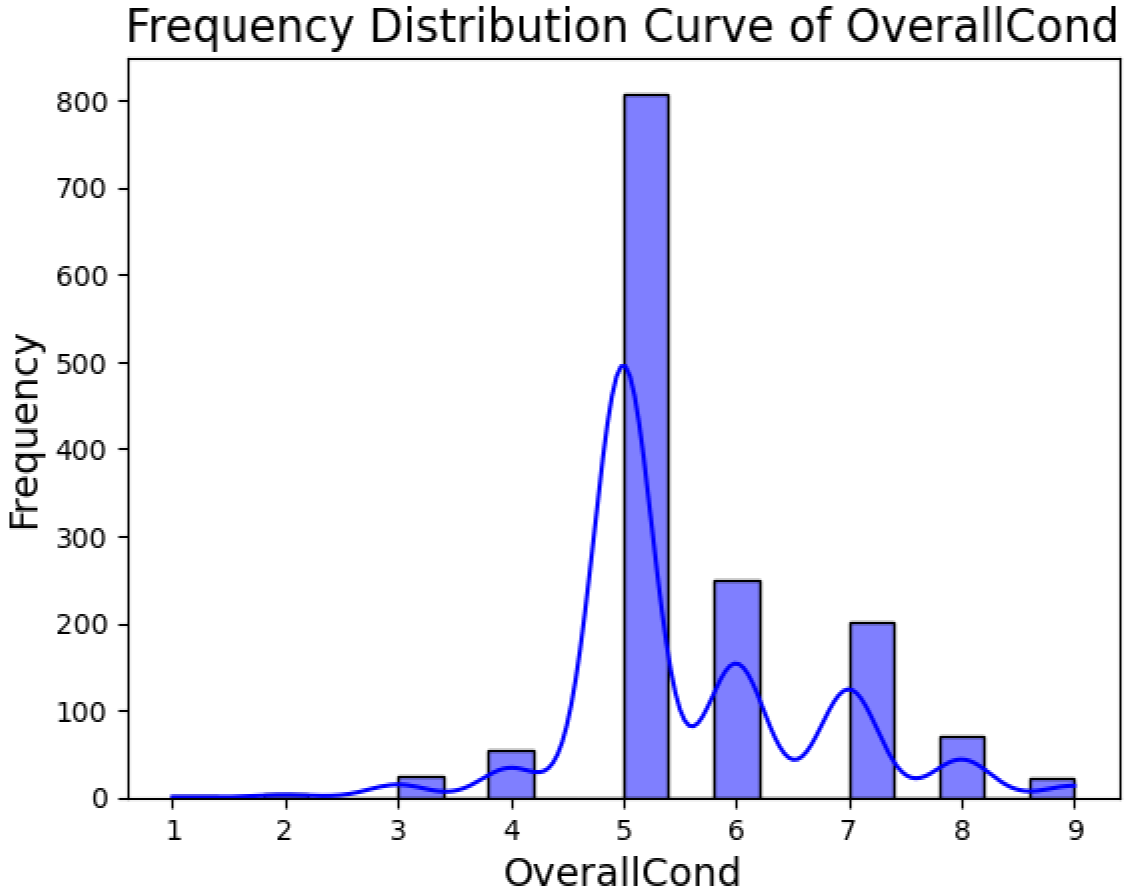
Out[10]:

```
Text(0, 0.5, 'Frequency')
```



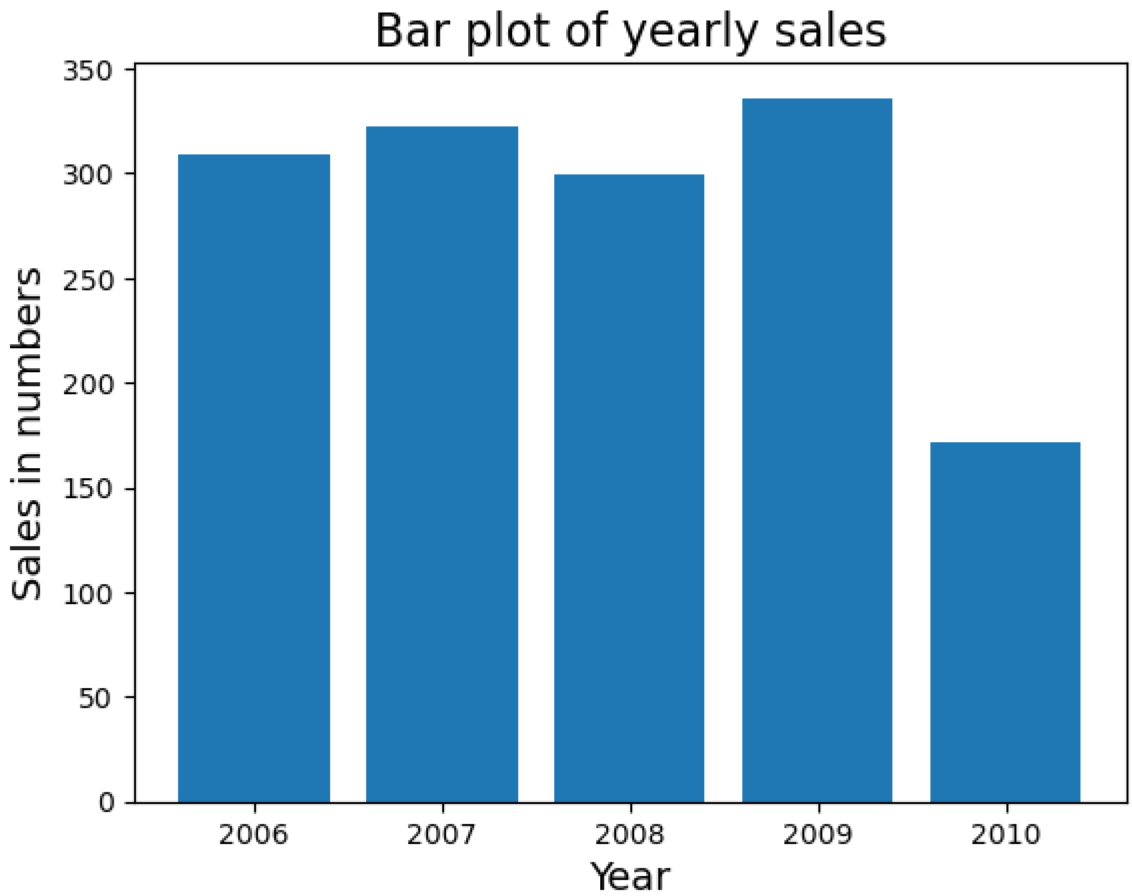
In [11]:
```
sns.histplot(house_train_lotarea['OverallCond'], bins=20, kde=True, color='blue')

# Add titles and labels
plt.title('Frequency Distribution Curve of OverallCond', fontsize=16)
plt.xlabel('OverallCond', fontsize=14)
plt.ylabel('Frequency', fontsize=14)
```

Out[11]:
```
Text(0, 0.5, 'Frequency')
```



In [12]:
```
plt.title('Bar plot of yearly sales', fontsize=16)
#plt.xticks([50000,100000,150000,200000,250000,300000,350000,400000,450000,600000,700000
plt.xlabel('Year', fontsize=14)
plt.ylabel('Sales in numbers', fontsize=14)

plt.bar(house_train_lotarea.groupby('YrSold')['SalePrice'].count().index,house_train_lot
```

Out[12]:
```
<BarContainer object of 5 artists>
```



Data Preparation

The data which does not add value to the model has been found out and will be dropped.
They are determined based on the number of record counts present or on the basic understanding of the real estate market.

In [13]:
```
print("Following are the count of columns which do not add any value to the model\n")
print("The count of Utilities column\n",house_train_lotarea['Utilities'].value_counts())
print("The count of Street column\n",house_train_lotarea['Street'].value_counts())
print("The count of PoolQC column\n",house_train_lotarea['PoolQC'].value_counts())
print("The count of Alley column\n",house_train_lotarea['Alley'].value_counts())
print("The count of MiscFeature column\n",house_train_lotarea['MiscFeature'].value_count
print("The count of Fence column\n",house_train_lotarea['Fence'].value_counts())
house_train_lotarea_dropped = house_train_lotarea.drop(['Utilities','Street','PoolQC','A
```

```
Following are the count of columns which do not add any value to the model

The count of Utilities column
 Utilities
AllPub    1437
NoSeWa       1
Name: count, dtype: int64
The count of Street column
 Street
Pave    1434
Grvl       4
Name: count, dtype: int64
The count of PoolQC column
 PoolQC
Ex    2
Fa    2
Gd    2
```

```
Name: count, dtype: int64
The count of Alley column
 Alley
Grvl    50
Pave    41
Name: count, dtype: int64
The count of MiscFeature column
 MiscFeature
Shed    47
Gar2     2
Othr     2
TenC     1
Name: count, dtype: int64
The count of Fence column
 Fence
MnPrv    157
GdPrv     59
GdWo      54
MnWw      11
Name: count, dtype: int64
```

NaN values are filled appropriately and for some columns they are dropped

In [14]:
```
house_train_lotarea_dropped['MasVnrType'].fillna("None",inplace=True)
house_train_lotarea_dropped['MasVnrArea'].fillna(0,inplace=True)
house_train_lotarea_dropped['FireplaceQu'].fillna("None",inplace=True)
house_train_lotarea_dropped['GarageType'].fillna("None",inplace=True)
house_train_lotarea_dropped['LotFrontage'].fillna(house_train_lotarea_dropped['LotFronta
house_train_lotarea_dropped.drop(['GarageYrBlt','GarageFinish','GarageQual','GarageCond'
```

In [15]:
```
print ("The NAN values after performing above data cleansing\n",house_train_lotarea_drop
#house_train_lotarea_dropped['BsmtQual'].value_counts()
house_train_lotarea_dropped_1 = house_train_lotarea_dropped.dropna()
house_train_lotarea_dropped_1
```

```
The NAN values after performing above data cleansing
 BsmtQual        37
BsmtCond        37
BsmtExposure    38
BsmtFinType1    37
BsmtFinType2    38
Electrical       1
dtype: int64
```

Out[15]:

	MSSubClass	MSZoning	LotFrontage	LotArea	LotShape	LandContour	LotConfig	LandSlope	Neighborho
0	60	RL	65.0	8450	Reg	Lvl	Inside	Gtl	Collg
1	20	RL	80.0	9600	Reg	Lvl	FR2	Gtl	Veenk
2	60	RL	68.0	11250	IR1	Lvl	Inside	Gtl	Collg
3	70	RL	60.0	9550	IR1	Lvl	Corner	Gtl	Craw
4	60	RL	84.0	14260	IR1	Lvl	FR2	Gtl	NoRid
...	...	...	...	...	...	...	...	...	
1455	60	RL	62.0	7917	Reg	Lvl	Inside	Gtl	Gilb
1456	20	RL	85.0	13175	Reg	Lvl	Inside	Gtl	NWAm
1457	70	RL	66.0	9042	Reg	Lvl	Inside	Gtl	Craw
1458	20	RL	68.0	9717	Reg	Lvl	Inside	Gtl	NAm
1459	20	RL	75.0	9937	Reg	Lvl	Inside	Gtl	Edwar

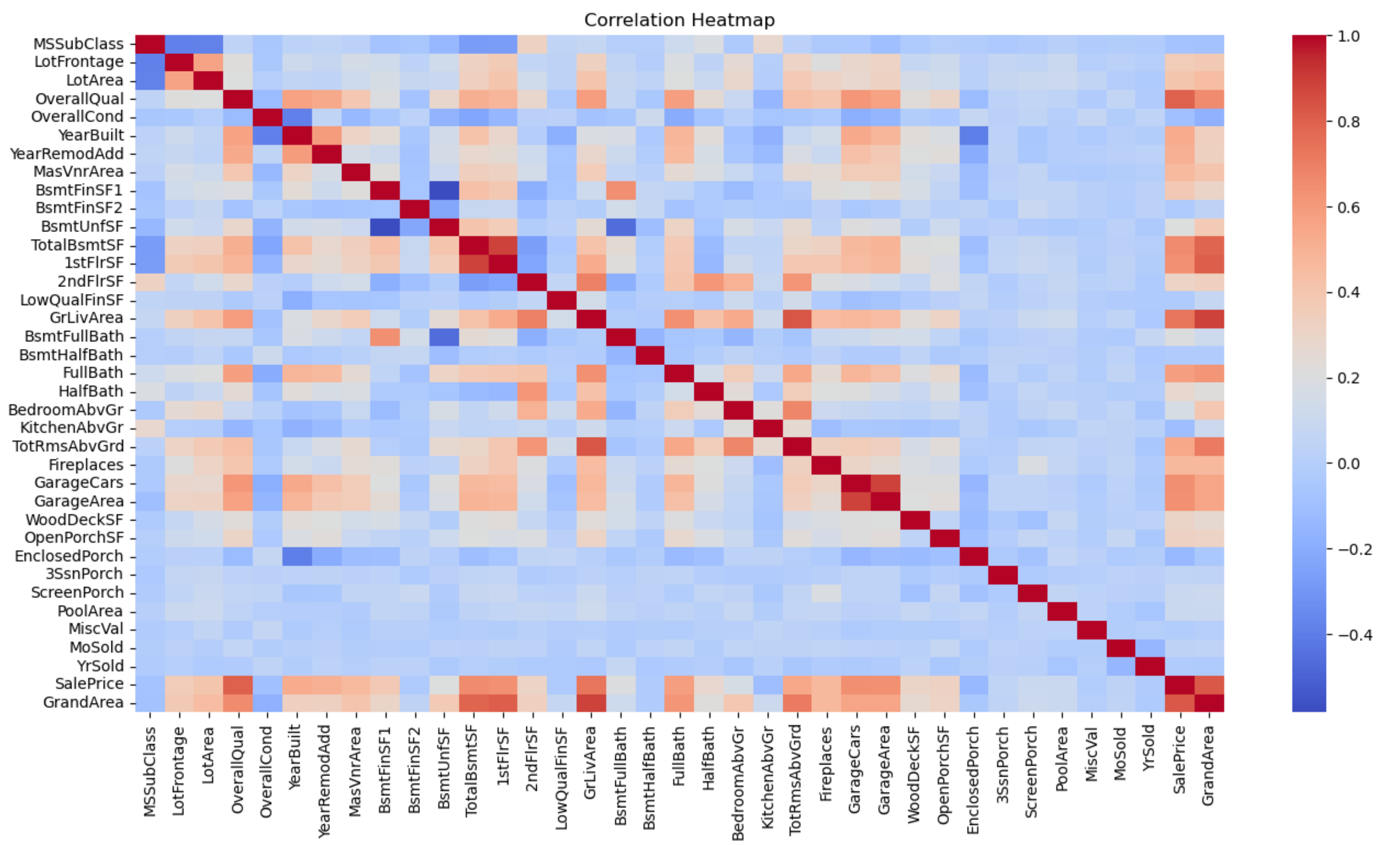
1398 rows × 71 columns

Correlation matrix

Finding the numerical columns and plotting a correlation matrix.
There is a high correlation between GrLivArea and GrandArea, because previously we calculated GrandArea as the sum of TotalBsmtSF and GrLivArea.
Because of that GrLivArea column will be dropped.

In [16]:

```
# Find the columns with numerical type,

col = house_train_lotarea_dropped_1.select_dtypes(include=['number']).columns

# Correlation between the numerical columns

import seaborn as sns
import matplotlib.pyplot as plt

# Correlation matrix
corr_matrix = house_train_lotarea_dropped_1[col].corr()

plt.figure(figsize=(16, 8))

# Plotting heatmap
sns.heatmap(corr_matrix, cmap='coolwarm')
plt.title("Correlation Heatmap")
plt.show()
```



In [17]:

```
# There is a high correlation between GrLivArea and GrandArea, because previously we cal

house_train_lotarea_dropped_1['GrLivArea'].corr(house_train_lotarea_dropped_1['GrandArea
house_train_lotarea_dropped_2 = house_train_lotarea_dropped_1.drop(['GrLivArea'],axis=1)
house_train_lotarea_dropped_2
```

Out[17]:

	MSSubClass	MSZoning	LotFrontage	LotArea	LotShape	LandContour	LotConfig	LandSlope	Neighborho
0	60	RL	65.0	8450	Reg	Lvl	Inside	Gtl	Collg
1	20	RL	80.0	9600	Reg	Lvl	FR2	Gtl	Veenl
2	60	RL	68.0	11250	IR1	Lvl	Inside	Gtl	Collg
3	70	RL	60.0	9550	IR1	Lvl	Corner	Gtl	Craw
4	60	RL	84.0	14260	IR1	Lvl	FR2	Gtl	NoRid
...	...	...	...	...	...	...	...	...	
1455	60	RL	62.0	7917	Reg	Lvl	Inside	Gtl	Gilb
1456	20	RL	85.0	13175	Reg	Lvl	Inside	Gtl	NWAm
1457	70	RL	66.0	9042	Reg	Lvl	Inside	Gtl	Craw
1458	20	RL	68.0	9717	Reg	Lvl	Inside	Gtl	NAm
1459	20	RL	75.0	9937	Reg	Lvl	Inside	Gtl	Edwar

1398 rows × 70 columns

Finding the object value columns alone to do encoding.
Encoding the categorical values using onehotencoder.

In [18]:

```
house_train_lotarea_dropped_2['BsmtFinType2'].value_counts()
col_cat = house_train_lotarea_dropped_1.select_dtypes(include=['object']).columns

col_cat = col_cat.tolist()


import pandas as pd
from sklearn.preprocessing import OneHotEncoder

# Initialize the encoder
encoder = OneHotEncoder()

# Fit and transform the data
onehot_encoded = encoder.fit_transform(house_train_lotarea_dropped_1[col_cat])

# Convert to a DataFrame (optional, for better readability)
onehot_df = pd.DataFrame(onehot_encoded.toarray(), columns=encoder.get_feature_names_out
col_cat
house_train_lotarea_dropped_1.columns
```

Out[18]:

```
Index(['MSSubClass', 'MSZoning', 'LotFrontage', 'LotArea', 'LotShape',
       'LandContour', 'LotConfig', 'LandSlope', 'Neighborhood', 'Condition1',
       'Condition2', 'BldgType', 'HouseStyle', 'OverallQual', 'OverallCond',
       'YearBuilt', 'YearRemodAdd', 'RoofStyle', 'RoofMatl', 'Exterior1st',
       'Exterior2nd', 'MasVnrType', 'MasVnrArea', 'ExterQual', 'ExterCond',
       'Foundation', 'BsmtQual', 'BsmtCond', 'BsmtExposure', 'BsmtFinType1',
       'BsmtFinSF1', 'BsmtFinType2', 'BsmtFinSF2', 'BsmtUnfSF', 'TotalBsmtSF',
       'Heating', 'HeatingQC', 'CentralAir', 'Electrical', '1stFlrSF',
       '2ndFlrSF', 'LowQualFinSF', 'GrLivArea', 'BsmtFullBath', 'BsmtHalfBath',
       'FullBath', 'HalfBath', 'BedroomAbvGr', 'KitchenAbvGr', 'KitchenQual',
       'TotRmsAbvGrd', 'Functional', 'Fireplaces', 'FireplaceQu', 'GarageType',
       'GarageCars', 'GarageArea', 'PavedDrive', 'WoodDeckSF', 'OpenPorchSF',
       'EnclosedPorch', '3SsnPorch', 'ScreenPorch', 'PoolArea', 'MiscVal',
       'MoSold', 'YrSold', 'SaleType', 'SaleCondition', 'SalePrice',
       'GrandArea'],
      dtype='object')
```

Concatenating the encoded values and the numerical values by resetting the index, so that they align properly.

In [19]:
```
import pandas as pd
import numpy as np

# Reset the index for both (if necessary)
df1_reset = house_train_lotarea_dropped_1.reset_index(drop=True)
df2_reset = onehot_df.reset_index(drop=True)

# Concatenate using numpy to avoid column alignment issues
concatenated = pd.concat ([df1_reset, df2_reset], axis=1)


#print(result)
modeldata=concatenated.drop(columns=col_cat)
modeldata
```

Out[19]:

	MSSubClass	LotFrontage	LotArea	OverallQual	OverallCond	YearBuilt	YearRemodAdd	MasVnrArea	Bsm
0	60	65.0	8450	7	5	2003	2003	196.0	
1	20	80.0	9600	6	8	1976	1976	0.0	
2	60	68.0	11250	7	5	2001	2002	162.0	
3	70	60.0	9550	7	5	1915	1970	0.0	
4	60	84.0	14260	8	5	2000	2000	350.0	
...	...	...	...	...	...	...	...	...	
1393	60	62.0	7917	6	5	1999	2000	0.0	
1394	20	85.0	13175	6	6	1978	1988	119.0	
1395	70	66.0	9042	7	9	1941	2006	0.0	
1396	20	68.0	9717	5	6	1950	1996	0.0	
1397	20	75.0	9937	5	6	1965	1965	0.0	

1398 rows × 255 columns

Splitting the dataset to train and test using 80/20 %.

In [20]:
```
from sklearn.model_selection import train_test_split
import pandas as pd

# Features and target variable
X = modeldata.drop(columns=['SalePrice'])  # Independent variables (features)
y = modeldata['SalePrice']  # Dependent variable (target)

# Split the data into 80% training and 20% testing sets
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2, random_state=42

# Output the results
print("Training Features:\n", X_train)
print("Testing Features:\n", X_test)
print("Training Labels:\n", y_train)
print("Testing Labels:\n", y_test)
```

```
Training Features:
       MSSubClass  LotFrontage  LotArea  OverallQual  OverallCond  YearBuilt  \
```

```
48            60   69.655724    13869            6            6        1997
155           60  110.000000    13688            9            5        2003
756           60   92.000000     9920            7            5        1996
1070          20   70.000000     7560            5            5        1959
303           60   71.000000     7795            7            5        2004
...          ...         ...      ...          ...          ...         ...
1095         190   60.000000    12180            4            4        1941
1130         120   64.000000     5587            8            5        2008
1294          50   56.000000    14720            8            5        1995
860           20   69.655724     7340            4            6        1971
1126          20   37.000000     6951            5            5        1984

      YearRemodAdd  MasVnrArea  BsmtFinSF1  BsmtFinSF2  BsmtUnfSF  \
48            1997         0.0         182           0        612
155           2004       664.0        1016           0        556
756           1997         0.0         862           0        255
1070          1959         0.0         369           0        671
303           2005         0.0         425           0        291
...            ...         ...         ...         ...        ...
1095          1950         0.0         348           0        324
1130          2008       186.0        1480           0        120
1294          1996       579.0         816           0       1217
860           1971         0.0         322           0        536
1126          1985         0.0         658           0        218

      TotalBsmtSF  1stFlrSF  2ndFlrSF  LowQualFinSF  GrLivArea  BsmtFullBath  \
48            794       794       676             0       1470             0
155          1572      1572      1096             0       2668             1
756          1117      1127       886             0       2013             1
1070         1040      1040         0             0       1040             0
303           716       716       716             0       1432             1
...           ...       ...       ...           ...        ...           ...
1095          672       672       252             0        924             1
1130         1600      1652         0             0       1652             1
1294         2033      2053      1185             0       3238             1
860           858       858         0             0        858             0
1126          876       923         0             0        923             1

      BsmtHalfBath  FullBath  HalfBath  BedroomAbvGr  KitchenAbvGr  \
48               1         2         0             3             1
155              0         2         1             3             1
756              0         2         1             3             1
1070             0         1         0             3             1
303              0         2         1             3             1
...            ...       ...       ...           ...           ...
1095             0         1         0             2             1
1130             1         2         0             2             1
1294             0         2         1             4             1
860              0         1         0             2             1
1126             0         1         0             3             1

      TotRmsAbvGrd  Fireplaces  GarageCars  GarageArea  WoodDeckSF  \
48               6           0           2         388           0
155             10           2           3         726         400
756              8           1           2         455         180
1070             6           0           1         286         140
303              6           1           2         432         100
...            ...         ...         ...         ...         ...
1095             5           0           1         280           0
1130             5           1           2         482         162
1294             9           1           3         666         283
860              4           0           1         684           0
1126             5           0           1         264         362

      OpenPorchSF  EnclosedPorch  3SsnPorch  ScreenPorch  PoolArea  MiscVal  \
48             75              0          0            0         0        0
```

```
155          0            0         0           0        0       0
756        130            0         0           0        0       0
1070         0          252         0           0        0       0
303         51            0         0           0        0       0
...        ...          ...       ...         ...      ...     ...
1095         0            0         0           0        0       0
1130        53            0       153           0        0       0
1294        86            0         0           0        0       0
860          0            0         0           0        0       0
1126         0            0         0           0        0       0

      MoSold  YrSold  GrandArea  MSZoning_C (all)  MSZoning_FV  MSZoning_RH  \
48         7    2007       2264               0.0          0.0          0.0
155        3    2008       4240               0.0          0.0          0.0
756        6    2007       3130               0.0          0.0          0.0
1070       7    2006       2080               0.0          0.0          0.0
303        7    2009       2148               0.0          0.0          0.0
...      ...     ...        ...               ...          ...          ...
1095       7    2010       1596               0.0          0.0          0.0
1130      11    2008       3252               0.0          0.0          0.0
1294       3    2010       5271               0.0          0.0          0.0
860        6    2007       1716               0.0          0.0          0.0
1126      10    2008       1799               0.0          0.0          0.0

      MSZoning_RL  MSZoning_RM  LotShape_IR1  LotShape_IR2  LotShape_IR3  \
48            1.0          0.0           0.0           1.0           0.0
155           1.0          0.0           1.0           0.0           0.0
756           1.0          0.0           1.0           0.0           0.0
1070          1.0          0.0           0.0           0.0           0.0
303           1.0          0.0           1.0           0.0           0.0
...           ...          ...           ...           ...           ...
1095          1.0          0.0           0.0           0.0           0.0
1130          0.0          1.0           1.0           0.0           0.0
1294          1.0          0.0           1.0           0.0           0.0
860           1.0          0.0           1.0           0.0           0.0
1126          1.0          0.0           1.0           0.0           0.0

      LotShape_Reg  LandContour_Bnk  LandContour_HLS  LandContour_Low  \
48             0.0              0.0              0.0              0.0
155            0.0              0.0              0.0              0.0
756            0.0              0.0              0.0              0.0
1070           1.0              0.0              0.0              0.0
303            0.0              0.0              0.0              0.0
...            ...              ...              ...              ...
1095           1.0              0.0              0.0              0.0
1130           0.0              0.0              1.0              0.0
1294           0.0              0.0              0.0              0.0
860            0.0              0.0              0.0              0.0
1126           0.0              0.0              0.0              0.0

      LandContour_Lvl  LotConfig_Corner  LotConfig_CulDSac  LotConfig_FR2  \
48                1.0               1.0                0.0            0.0
155               1.0               0.0                0.0            0.0
756               1.0               0.0                1.0            0.0
1070              1.0               0.0                0.0            0.0
303               1.0               0.0                0.0            0.0
...               ...               ...                ...            ...
1095              1.0               0.0                0.0            0.0
1130              0.0               0.0                0.0            0.0
1294              1.0               0.0                1.0            0.0
860               1.0               0.0                0.0            0.0
1126              1.0               0.0                1.0            0.0

      LotConfig_FR3  LotConfig_Inside  LandSlope_Gtl  LandSlope_Mod  \
48              0.0               0.0            1.0            0.0
155             0.0               1.0            1.0            0.0
```

```
756           0.0             0.0           1.0           0.0
1070          0.0             1.0           1.0           0.0
303           0.0             1.0           1.0           0.0
...           ...             ...           ...           ...
1095          0.0             1.0           1.0           0.0
1130          0.0             1.0           0.0           1.0
1294          0.0             0.0           1.0           0.0
860           0.0             1.0           1.0           0.0
1126          0.0             0.0           1.0           0.0

      LandSlope_Sev  Neighborhood_Blmngtn  Neighborhood_Blueste  \
48              0.0                   0.0                   0.0
155             0.0                   0.0                   0.0
756             0.0                   0.0                   0.0
1070            0.0                   0.0                   0.0
303             0.0                   0.0                   0.0
...             ...                   ...                   ...
1095            0.0                   0.0                   0.0
1130            0.0                   0.0                   0.0
1294            0.0                   0.0                   0.0
860             0.0                   0.0                   0.0
1126            0.0                   0.0                   0.0

      Neighborhood_BrDale  Neighborhood_BrkSide  Neighborhood_ClearCr  \
48                    0.0                   0.0                   0.0
155                   0.0                   0.0                   0.0
756                   0.0                   0.0                   0.0
1070                  0.0                   0.0                   0.0
303                   0.0                   0.0                   0.0
...                   ...                   ...                   ...
1095                  0.0                   0.0                   0.0
1130                  0.0                   0.0                   0.0
1294                  0.0                   0.0                   0.0
860                   0.0                   0.0                   0.0
1126                  0.0                   0.0                   0.0

      Neighborhood_CollgCr  Neighborhood_Crawfor  Neighborhood_Edwards  \
48                     0.0                   0.0                   0.0
155                    0.0                   0.0                   0.0
756                    0.0                   0.0                   0.0
1070                   0.0                   0.0                   0.0
303                    0.0                   0.0                   0.0
...                    ...                   ...                   ...
1095                   0.0                   0.0                   1.0
1130                   0.0                   1.0                   0.0
1294                   0.0                   0.0                   0.0
860                    0.0                   0.0                   0.0
1126                   0.0                   0.0                   0.0

      Neighborhood_Gilbert  Neighborhood_IDOTRR  Neighborhood_MeadowV  \
48                     1.0                  0.0                   0.0
155                    0.0                  0.0                   0.0
756                    0.0                  0.0                   0.0
1070                   0.0                  0.0                   0.0
303                    1.0                  0.0                   0.0
...                    ...                  ...                   ...
1095                   0.0                  0.0                   0.0
1130                   0.0                  0.0                   0.0
1294                   0.0                  0.0                   0.0
860                    0.0                  0.0                   0.0
1126                   0.0                  0.0                   0.0

      Neighborhood_Mitchel  Neighborhood_NAmes  Neighborhood_NPkVill  \
48                     0.0                 0.0                   0.0
155                    0.0                 0.0                   0.0
756                    0.0                 0.0                   0.0
```

```
1070                   0.0                  1.0                    0.0
303                    0.0                  0.0                    0.0
...                    ...                  ...                    ...
1095                   0.0                  0.0                    0.0
1130                   0.0                  0.0                    0.0
1294                   0.0                  0.0                    0.0
860                    0.0                  1.0                    0.0
1126                   1.0                  0.0                    0.0

      Neighborhood_NWAmes  Neighborhood_NoRidge  Neighborhood_NridgHt  \
48                    0.0                   0.0                   0.0
155                   0.0                   0.0                   1.0
756                   0.0                   1.0                   0.0
1070                  0.0                   0.0                   0.0
303                   0.0                   0.0                   0.0
...                   ...                   ...                   ...
1095                  0.0                   0.0                   0.0
1130                  0.0                   0.0                   0.0
1294                  0.0                   1.0                   0.0
860                   0.0                   0.0                   0.0
1126                  0.0                   0.0                   0.0

      Neighborhood_OldTown  Neighborhood_SWISU  Neighborhood_Sawyer  \
48                     0.0                 0.0                  0.0
155                    0.0                 0.0                  0.0
756                    0.0                 0.0                  0.0
1070                   0.0                 0.0                  0.0
303                    0.0                 0.0                  0.0
...                    ...                 ...                  ...
1095                   0.0                 0.0                  0.0
1130                   0.0                 0.0                  0.0
1294                   0.0                 0.0                  0.0
860                    0.0                 0.0                  0.0
1126                   0.0                 0.0                  0.0

      Neighborhood_SawyerW  Neighborhood_Somerst  Neighborhood_StoneBr  \
48                     0.0                   0.0                   0.0
155                    0.0                   0.0                   0.0
756                    0.0                   0.0                   0.0
1070                   0.0                   0.0                   0.0
303                    0.0                   0.0                   0.0
...                    ...                   ...                   ...
1095                   0.0                   0.0                   0.0
1130                   0.0                   0.0                   0.0
1294                   0.0                   0.0                   0.0
860                    0.0                   0.0                   0.0
1126                   0.0                   0.0                   0.0

      Neighborhood_Timber  Neighborhood_Veenker  Condition1_Artery  \
48                    0.0                   0.0                0.0
155                   0.0                   0.0                0.0
756                   0.0                   0.0                0.0
1070                  0.0                   0.0                0.0
303                   0.0                   0.0                0.0
...                   ...                   ...                ...
1095                  0.0                   0.0                0.0
1130                  0.0                   0.0                0.0
1294                  0.0                   0.0                0.0
860                   0.0                   0.0                0.0
1126                  0.0                   0.0                0.0

      Condition1_Feedr  Condition1_Norm  Condition1_PosA  Condition1_PosN  \
48                 0.0              1.0              0.0              0.0
155                0.0              1.0              0.0              0.0
756                0.0              1.0              0.0              0.0
1070               0.0              1.0              0.0              0.0
```

303	0.0	1.0	0.0	0.0
...	...	...	...	...
1095	0.0	1.0	0.0	0.0
1130	0.0	1.0	0.0	0.0
1294	0.0	1.0	0.0	0.0
860	0.0	1.0	0.0	0.0
1126	0.0	1.0	0.0	0.0

	Condition1_RRAe	Condition1_RRAn	Condition1_RRNe	Condition1_RRNn \
48	0.0	0.0	0.0	0.0
155	0.0	0.0	0.0	0.0
756	0.0	0.0	0.0	0.0
1070	0.0	0.0	0.0	0.0
303	0.0	0.0	0.0	0.0
...	...	...	...	...
1095	0.0	0.0	0.0	0.0
1130	0.0	0.0	0.0	0.0
1294	0.0	0.0	0.0	0.0
860	0.0	0.0	0.0	0.0
1126	0.0	0.0	0.0	0.0

	Condition2_Artery	Condition2_Feedr	Condition2_Norm	Condition2_PosA \
48	0.0	0.0	1.0	0.0
155	0.0	0.0	1.0	0.0
756	0.0	0.0	1.0	0.0
1070	0.0	0.0	1.0	0.0
303	0.0	0.0	1.0	0.0
...	...	...	...	...
1095	0.0	0.0	1.0	0.0
1130	0.0	0.0	1.0	0.0
1294	0.0	0.0	1.0	0.0
860	0.0	0.0	1.0	0.0
1126	0.0	0.0	1.0	0.0

	Condition2_PosN	Condition2_RRAe	Condition2_RRAn	Condition2_RRNn \
48	0.0	0.0	0.0	0.0
155	0.0	0.0	0.0	0.0
756	0.0	0.0	0.0	0.0
1070	0.0	0.0	0.0	0.0
303	0.0	0.0	0.0	0.0
...	...	...	...	...
1095	0.0	0.0	0.0	0.0
1130	0.0	0.0	0.0	0.0
1294	0.0	0.0	0.0	0.0
860	0.0	0.0	0.0	0.0
1126	0.0	0.0	0.0	0.0

	BldgType_1Fam	BldgType_2fmCon	BldgType_Duplex	BldgType_Twnhs \
48	1.0	0.0	0.0	0.0
155	1.0	0.0	0.0	0.0
756	1.0	0.0	0.0	0.0
1070	1.0	0.0	0.0	0.0
303	1.0	0.0	0.0	0.0
...	...	...	...	...
1095	0.0	1.0	0.0	0.0
1130	0.0	0.0	0.0	0.0
1294	1.0	0.0	0.0	0.0
860	1.0	0.0	0.0	0.0
1126	1.0	0.0	0.0	0.0

	BldgType_TwnhsE	HouseStyle_1.5Fin	HouseStyle_1.5Unf \
48	0.0	0.0	0.0
155	0.0	0.0	0.0
756	0.0	0.0	0.0
1070	0.0	0.0	0.0
303	0.0	0.0	0.0

```
...        ...        ...        ...
1095       0.0        1.0        0.0
1130       1.0        0.0        0.0
1294       0.0        1.0        0.0
860        0.0        0.0        0.0
1126       0.0        0.0        0.0

      HouseStyle_1Story  HouseStyle_2.5Fin  HouseStyle_2.5Unf  \
48                  0.0                0.0                0.0
155                 0.0                0.0                0.0
756                 0.0                0.0                0.0
1070                1.0                0.0                0.0
303                 0.0                0.0                0.0
...                 ...                ...                ...
1095                0.0                0.0                0.0
1130                1.0                0.0                0.0
1294                0.0                0.0                0.0
860                 1.0                0.0                0.0
1126                1.0                0.0                0.0

      HouseStyle_2Story  HouseStyle_SFoyer  HouseStyle_SLvl  RoofStyle_Flat  \
48                  1.0                0.0              0.0             0.0
155                 1.0                0.0              0.0             0.0
756                 1.0                0.0              0.0             0.0
1070                0.0                0.0              0.0             0.0
303                 1.0                0.0              0.0             0.0
...                 ...                ...              ...             ...
1095                0.0                0.0              0.0             0.0
1130                0.0                0.0              0.0             0.0
1294                0.0                0.0              0.0             0.0
860                 0.0                0.0              0.0             0.0
1126                0.0                0.0              0.0             0.0

      RoofStyle_Gable  RoofStyle_Gambrel  RoofStyle_Hip  RoofStyle_Mansard  \
48                1.0                0.0            0.0                0.0
155               1.0                0.0            0.0                0.0
756               1.0                0.0            0.0                0.0
1070              1.0                0.0            0.0                0.0
303               1.0                0.0            0.0                0.0
...               ...                ...            ...                ...
1095              1.0                0.0            0.0                0.0
1130              0.0                0.0            1.0                0.0
1294              0.0                0.0            1.0                0.0
860               1.0                0.0            0.0                0.0
1126              1.0                0.0            0.0                0.0

      RoofStyle_Shed  RoofMatl_CompShg  RoofMatl_Metal  RoofMatl_Roll  \
48               0.0               1.0             0.0            0.0
155              0.0               1.0             0.0            0.0
756              0.0               1.0             0.0            0.0
1070             0.0               1.0             0.0            0.0
303              0.0               1.0             0.0            0.0
...              ...               ...             ...            ...
1095             0.0               1.0             0.0            0.0
1130             0.0               1.0             0.0            0.0
1294             0.0               1.0             0.0            0.0
860              0.0               1.0             0.0            0.0
1126             0.0               1.0             0.0            0.0

      RoofMatl_Tar&Grv  RoofMatl_WdShake  RoofMatl_WdShngl  \
48                 0.0               0.0               0.0
155                0.0               0.0               0.0
756                0.0               0.0               0.0
1070               0.0               0.0               0.0
303                0.0               0.0               0.0
...                ...               ...               ...
```

```
1095               0.0                0.0                0.0
1130               0.0                0.0                0.0
1294               0.0                0.0                0.0
860                0.0                0.0                0.0
1126               0.0                0.0                0.0

      Exterior1st_AsbShng  Exterior1st_BrkComm  Exterior1st_BrkFace  \
48                    0.0                  0.0                  0.0
155                   0.0                  0.0                  0.0
756                   0.0                  0.0                  0.0
1070                  0.0                  0.0                  1.0
303                   0.0                  0.0                  0.0
...                   ...                  ...                  ...
1095                  0.0                  0.0                  0.0
1130                  0.0                  0.0                  0.0
1294                  0.0                  0.0                  0.0
860                   0.0                  0.0                  0.0
1126                  0.0                  0.0                  0.0

      Exterior1st_CBlock  Exterior1st_CemntBd  Exterior1st_HdBoard  \
48                   0.0                  0.0                  0.0
155                  0.0                  0.0                  0.0
756                  0.0                  0.0                  0.0
1070                 0.0                  0.0                  0.0
303                  0.0                  0.0                  0.0
...                  ...                  ...                  ...
1095                 0.0                  0.0                  0.0
1130                 0.0                  1.0                  0.0
1294                 0.0                  0.0                  0.0
860                  0.0                  0.0                  1.0
1126                 0.0                  0.0                  1.0

      Exterior1st_ImStucc  Exterior1st_MetalSd  Exterior1st_Plywood  \
48                    0.0                  0.0                  0.0
155                   0.0                  0.0                  0.0
756                   0.0                  1.0                  0.0
1070                  0.0                  0.0                  0.0
303                   0.0                  0.0                  0.0
...                   ...                  ...                  ...
1095                  0.0                  1.0                  0.0
1130                  0.0                  0.0                  0.0
1294                  0.0                  0.0                  0.0
860                   0.0                  0.0                  0.0
1126                  0.0                  0.0                  0.0

      Exterior1st_Stone  Exterior1st_Stucco  Exterior1st_VinylSd  \
48                  0.0                 0.0                  1.0
155                 0.0                 0.0                  1.0
756                 0.0                 0.0                  0.0
1070                0.0                 0.0                  0.0
303                 0.0                 0.0                  1.0
...                 ...                 ...                  ...
1095                0.0                 0.0                  0.0
1130                0.0                 0.0                  0.0
1294                0.0                 0.0                  1.0
860                 0.0                 0.0                  0.0
1126                0.0                 0.0                  0.0

      Exterior1st_Wd Sdng  Exterior1st_WdShing  Exterior2nd_AsbShng  \
48                    0.0                  0.0                  0.0
155                   0.0                  0.0                  0.0
756                   0.0                  0.0                  0.0
1070                  0.0                  0.0                  0.0
303                   0.0                  0.0                  0.0
...                   ...                  ...                  ...
1095                  0.0                  0.0                  0.0
```

```
1130                0.0                     0.0                     0.0
1294                0.0                     0.0                     0.0
860                 0.0                     0.0                     0.0
1126                0.0                     0.0                     0.0

      Exterior2nd_AsphShn  Exterior2nd_Brk Cmn  Exterior2nd_BrkFace  \
48                    0.0                  0.0                  0.0
155                   0.0                  0.0                  0.0
756                   0.0                  0.0                  0.0
1070                  0.0                  0.0                  0.0
303                   0.0                  0.0                  0.0
...                   ...                  ...                  ...
1095                  0.0                  0.0                  0.0
1130                  0.0                  0.0                  0.0
1294                  0.0                  0.0                  0.0
860                   0.0                  0.0                  0.0
1126                  0.0                  0.0                  0.0

      Exterior2nd_CBlock  Exterior2nd_CmentBd  Exterior2nd_HdBoard  \
48                   0.0                  0.0                  0.0
155                  0.0                  0.0                  0.0
756                  0.0                  0.0                  0.0
1070                 0.0                  0.0                  0.0
303                  0.0                  0.0                  0.0
...                  ...                  ...                  ...
1095                 0.0                  0.0                  0.0
1130                 0.0                  1.0                  0.0
1294                 0.0                  0.0                  0.0
860                  0.0                  0.0                  1.0
1126                 0.0                  0.0                  0.0

      Exterior2nd_ImStucc  Exterior2nd_MetalSd  Exterior2nd_Other  \
48                    0.0                  0.0                0.0
155                   0.0                  0.0                0.0
756                   0.0                  1.0                0.0
1070                  0.0                  0.0                0.0
303                   0.0                  0.0                0.0
...                   ...                  ...                ...
1095                  0.0                  1.0                0.0
1130                  0.0                  0.0                0.0
1294                  0.0                  0.0                0.0
860                   0.0                  0.0                0.0
1126                  0.0                  0.0                0.0

      Exterior2nd_Plywood  Exterior2nd_Stone  Exterior2nd_Stucco  \
48                    0.0                0.0                 0.0
155                   0.0                0.0                 0.0
756                   0.0                0.0                 0.0
1070                  0.0                0.0                 0.0
303                   0.0                0.0                 0.0
...                   ...                ...                 ...
1095                  0.0                0.0                 0.0
1130                  0.0                0.0                 0.0
1294                  0.0                0.0                 0.0
860                   0.0                0.0                 0.0
1126                  1.0                0.0                 0.0

      Exterior2nd_VinylSd  Exterior2nd_Wd Sdng  Exterior2nd_Wd Shng  \
48                    1.0                  0.0                  0.0
155                   1.0                  0.0                  0.0
756                   0.0                  0.0                  0.0
1070                  0.0                  1.0                  0.0
303                   1.0                  0.0                  0.0
...                   ...                  ...                  ...
1095                  0.0                  0.0                  0.0
1130                  0.0                  0.0                  0.0
```

```
1294                1.0                0.0                0.0
860                 0.0                0.0                0.0
1126                0.0                0.0                0.0

      MasVnrType_BrkCmn  MasVnrType_BrkFace  MasVnrType_None  \
48                  0.0                 0.0              1.0
155                 0.0                 1.0              0.0
756                 0.0                 0.0              1.0
1070                0.0                 0.0              1.0
303                 0.0                 0.0              1.0
...                 ...                 ...              ...
1095                0.0                 0.0              1.0
1130                0.0                 0.0              0.0
1294                0.0                 1.0              0.0
860                 0.0                 0.0              1.0
1126                0.0                 0.0              1.0

      MasVnrType_Stone  ExterQual_Ex  ExterQual_Fa  ExterQual_Gd  \
48                 0.0           0.0           0.0           0.0
155                0.0           0.0           0.0           1.0
756                0.0           0.0           0.0           1.0
1070               0.0           0.0           0.0           0.0
303                0.0           0.0           0.0           1.0
...                ...           ...           ...           ...
1095               0.0           0.0           0.0           0.0
1130               1.0           1.0           0.0           0.0
1294               0.0           0.0           0.0           1.0
860                0.0           0.0           0.0           0.0
1126               0.0           0.0           0.0           0.0

      ExterQual_TA  ExterCond_Ex  ExterCond_Fa  ExterCond_Gd  ExterCond_Po  \
48             1.0           0.0           0.0           0.0           0.0
155            0.0           0.0           0.0           0.0           0.0
756            0.0           0.0           0.0           0.0           0.0
1070           1.0           0.0           0.0           0.0           0.0
303            0.0           0.0           0.0           0.0           0.0
...            ...           ...           ...           ...           ...
1095           1.0           0.0           1.0           0.0           0.0
1130           0.0           0.0           0.0           0.0           0.0
1294           0.0           0.0           0.0           0.0           0.0
860            1.0           0.0           0.0           0.0           0.0
1126           1.0           0.0           0.0           0.0           0.0

      ExterCond_TA  Foundation_BrkTil  Foundation_CBlock  Foundation_PConc  \
48             1.0                0.0                0.0               1.0
155            1.0                0.0                0.0               1.0
756            1.0                0.0                0.0               1.0
1070           1.0                0.0                1.0               0.0
303            1.0                0.0                0.0               1.0
...            ...                ...                ...               ...
1095           0.0                1.0                0.0               0.0
1130           1.0                0.0                0.0               1.0
1294           1.0                0.0                0.0               1.0
860            1.0                0.0                1.0               0.0
1126           1.0                0.0                1.0               0.0

      Foundation_Stone  Foundation_Wood  BsmtQual_Ex  BsmtQual_Fa  \
48                 0.0              0.0          0.0          0.0
155                0.0              0.0          1.0          0.0
756                0.0              0.0          0.0          0.0
1070               0.0              0.0          0.0          0.0
303                0.0              0.0          0.0          0.0
...                ...              ...          ...          ...
1095               0.0              0.0          0.0          0.0
1130               0.0              0.0          1.0          0.0
1294               0.0              0.0          0.0          0.0
```

```
860                 0.0              0.0           0.0           0.0
1126                0.0              0.0           0.0           0.0

      BsmtQual_Gd  BsmtQual_TA  BsmtCond_Fa  BsmtCond_Gd  BsmtCond_Po  \
48            1.0          0.0          0.0          0.0          0.0
155           0.0          0.0          0.0          0.0          0.0
756           1.0          0.0          0.0          0.0          0.0
1070          0.0          1.0          0.0          0.0          0.0
303           1.0          0.0          0.0          0.0          0.0
...           ...          ...          ...          ...          ...
1095          1.0          0.0          0.0          0.0          0.0
1130          0.0          0.0          0.0          0.0          0.0
1294          1.0          0.0          0.0          0.0          0.0
860           0.0          1.0          0.0          0.0          0.0
1126          0.0          1.0          0.0          0.0          0.0

      BsmtCond_TA  BsmtExposure_Av  BsmtExposure_Gd  BsmtExposure_Mn  \
48            1.0              1.0              0.0              0.0
155           1.0              1.0              0.0              0.0
756           1.0              1.0              0.0              0.0
1070          1.0              0.0              0.0              0.0
303           1.0              0.0              0.0              0.0
...           ...              ...              ...              ...
1095          1.0              0.0              0.0              0.0
1130          1.0              0.0              1.0              0.0
1294          1.0              1.0              0.0              0.0
860           1.0              0.0              0.0              0.0
1126          1.0              0.0              0.0              0.0

      BsmtExposure_No  BsmtFinType1_ALQ  BsmtFinType1_BLQ  BsmtFinType1_GLQ  \
48                0.0               0.0               0.0               1.0
155               0.0               0.0               0.0               1.0
756               0.0               0.0               0.0               1.0
1070              1.0               0.0               0.0               0.0
303               1.0               0.0               0.0               1.0
...               ...               ...               ...               ...
1095              1.0               0.0               1.0               0.0
1130              0.0               0.0               0.0               1.0
1294              0.0               0.0               0.0               1.0
860               1.0               1.0               0.0               0.0
1126              1.0               1.0               0.0               0.0

      BsmtFinType1_LwQ  BsmtFinType1_Rec  BsmtFinType1_Unf  BsmtFinType2_ALQ  \
48                 0.0               0.0               0.0               0.0
155                0.0               0.0               0.0               0.0
756                0.0               0.0               0.0               0.0
1070               1.0               0.0               0.0               0.0
303                0.0               0.0               0.0               0.0
...                ...               ...               ...               ...
1095               0.0               0.0               0.0               0.0
1130               0.0               0.0               0.0               0.0
1294               0.0               0.0               0.0               0.0
860                0.0               0.0               0.0               0.0
1126               0.0               0.0               0.0               0.0

      BsmtFinType2_BLQ  BsmtFinType2_GLQ  BsmtFinType2_LwQ  BsmtFinType2_Rec  \
48                 0.0               0.0               0.0               0.0
155                0.0               0.0               0.0               0.0
756                0.0               0.0               0.0               0.0
1070               0.0               0.0               0.0               0.0
303                0.0               0.0               0.0               0.0
...                ...               ...               ...               ...
1095               0.0               0.0               0.0               0.0
1130               0.0               0.0               0.0               0.0
1294               0.0               0.0               0.0               0.0
860                0.0               0.0               0.0               0.0
```

```
1126               0.0                 0.0                 0.0                 0.0

      BsmtFinType2_Unf  Heating_GasA  Heating_GasW  Heating_Grav  \
48                 1.0           1.0           0.0           0.0
155                1.0           1.0           0.0           0.0
756                1.0           1.0           0.0           0.0
1070               1.0           1.0           0.0           0.0
303                1.0           1.0           0.0           0.0
...                ...           ...           ...           ...
1095               1.0           0.0           0.0           1.0
1130               1.0           1.0           0.0           0.0
1294               1.0           1.0           0.0           0.0
860                1.0           1.0           0.0           0.0
1126               1.0           1.0           0.0           0.0

      Heating_OthW  HeatingQC_Ex  HeatingQC_Fa  HeatingQC_Gd  HeatingQC_Po  \
48             0.0           0.0           0.0           1.0           0.0
155            0.0           1.0           0.0           0.0           0.0
756            0.0           1.0           0.0           0.0           0.0
1070           0.0           0.0           0.0           0.0           0.0
303            0.0           1.0           0.0           0.0           0.0
...            ...           ...           ...           ...           ...
1095           0.0           0.0           1.0           0.0           0.0
1130           0.0           1.0           0.0           0.0           0.0
1294           0.0           1.0           0.0           0.0           0.0
860            0.0           0.0           0.0           0.0           0.0
1126           0.0           0.0           0.0           0.0           0.0

      HeatingQC_TA  CentralAir_N  CentralAir_Y  Electrical_FuseA  \
48             0.0           0.0           1.0               0.0
155            0.0           0.0           1.0               0.0
756            0.0           0.0           1.0               0.0
1070           1.0           0.0           1.0               1.0
303            0.0           0.0           1.0               0.0
...            ...           ...           ...               ...
1095           0.0           1.0           0.0               1.0
1130           0.0           0.0           1.0               0.0
1294           0.0           0.0           1.0               0.0
860            1.0           0.0           1.0               0.0
1126           1.0           0.0           1.0               0.0

      Electrical_FuseF  Electrical_FuseP  Electrical_Mix  Electrical_SBrkr  \
48                 0.0               0.0             0.0               1.0
155                0.0               0.0             0.0               1.0
756                0.0               0.0             0.0               1.0
1070               0.0               0.0             0.0               0.0
303                0.0               0.0             0.0               1.0
...                ...               ...             ...               ...
1095               0.0               0.0             0.0               0.0
1130               0.0               0.0             0.0               1.0
1294               0.0               0.0             0.0               1.0
860                0.0               0.0             0.0               1.0
1126               0.0               0.0             0.0               1.0

      KitchenQual_Ex  KitchenQual_Fa  KitchenQual_Gd  KitchenQual_TA  \
48               0.0             0.0             0.0             1.0
155              1.0             0.0             0.0             0.0
756              0.0             0.0             0.0             1.0
1070             0.0             0.0             0.0             1.0
303              0.0             0.0             1.0             0.0
...              ...             ...             ...             ...
1095             0.0             1.0             0.0             0.0
1130             0.0             0.0             1.0             0.0
1294             0.0             0.0             1.0             0.0
860              0.0             0.0             0.0             1.0
1126             0.0             0.0             0.0             1.0
```

```
      Functional_Maj1  Functional_Maj2  Functional_Min1  Functional_Min2  \
48                0.0              0.0              0.0              0.0   
155               0.0              0.0              0.0              0.0   
756               0.0              0.0              0.0              0.0   
1070              0.0              0.0              0.0              0.0   
303               0.0              0.0              0.0              0.0   
...               ...              ...              ...              ...   
1095              0.0              0.0              0.0              0.0   
1130              0.0              0.0              0.0              0.0   
1294              0.0              0.0              0.0              0.0   
860               0.0              0.0              0.0              0.0   
1126              0.0              0.0              0.0              0.0   

      Functional_Mod  Functional_Sev  Functional_Typ  FireplaceQu_Ex  \
48               0.0             0.0             1.0             0.0   
155              0.0             0.0             1.0             0.0   
756              0.0             0.0             1.0             0.0   
1070             0.0             0.0             1.0             0.0   
303              0.0             0.0             1.0             0.0   
...              ...             ...             ...             ...   
1095             0.0             0.0             1.0             0.0   
1130             0.0             0.0             1.0             0.0   
1294             0.0             0.0             1.0             1.0   
860              0.0             0.0             1.0             0.0   
1126             0.0             0.0             1.0             0.0   

      FireplaceQu_Fa  FireplaceQu_Gd  FireplaceQu_None  FireplaceQu_Po  \
48               0.0             0.0               1.0             0.0   
155              0.0             1.0               0.0             0.0   
756              0.0             0.0               0.0             0.0   
1070             0.0             0.0               1.0             0.0   
303              0.0             1.0               0.0             0.0   
...              ...             ...               ...             ...   
1095             0.0             0.0               1.0             0.0   
1130             0.0             1.0               0.0             0.0   
1294             0.0             0.0               0.0             0.0   
860              0.0             0.0               1.0             0.0   
1126             0.0             0.0               1.0             0.0   

      FireplaceQu_TA  GarageType_2Types  GarageType_Attchd  \
48               0.0                0.0                1.0   
155              0.0                0.0                0.0   
756              1.0                0.0                1.0   
1070             0.0                0.0                1.0   
303              0.0                0.0                1.0   
...              ...                ...                ...   
1095             0.0                0.0                0.0   
1130             0.0                0.0                1.0   
1294             0.0                0.0                1.0   
860              0.0                0.0                0.0   
1126             0.0                0.0                1.0   

      GarageType_Basment  GarageType_BuiltIn  GarageType_CarPort  \
48                   0.0                 0.0                 0.0   
155                  0.0                 1.0                 0.0   
756                  0.0                 0.0                 0.0   
1070                 0.0                 0.0                 0.0   
303                  0.0                 0.0                 0.0   
...                  ...                 ...                 ...   
1095                 0.0                 0.0                 0.0   
1130                 0.0                 0.0                 0.0   
1294                 0.0                 0.0                 0.0   
860                  0.0                 0.0                 0.0   
1126                 0.0                 0.0                 0.0   
```

```
      GarageType_Detchd  GarageType_None  PavedDrive_N  PavedDrive_P  \
48                  0.0              0.0           0.0           0.0
155                 0.0              0.0           0.0           0.0
756                 0.0              0.0           0.0           0.0
1070                0.0              0.0           0.0           0.0
303                 0.0              0.0           0.0           0.0
...                 ...              ...           ...           ...
1095                1.0              0.0           0.0           0.0
1130                0.0              0.0           0.0           0.0
1294                0.0              0.0           0.0           0.0
860                 1.0              0.0           0.0           0.0
1126                0.0              0.0           0.0           0.0

      PavedDrive_Y  SaleType_COD  SaleType_CWD  SaleType_Con  SaleType_ConLD  \
48             1.0           0.0           0.0           0.0             0.0
155            1.0           0.0           0.0           0.0             0.0
756            1.0           0.0           0.0           0.0             0.0
1070           1.0           0.0           0.0           0.0             0.0
303            1.0           0.0           0.0           0.0             0.0
...            ...           ...           ...           ...             ...
1095           1.0           0.0           0.0           0.0             0.0
1130           1.0           0.0           0.0           0.0             0.0
1294           1.0           0.0           0.0           0.0             0.0
860            1.0           0.0           0.0           0.0             0.0
1126           1.0           0.0           0.0           0.0             0.0

      SaleType_ConLI  SaleType_ConLw  SaleType_New  SaleType_Oth  SaleType_WD  \
48               0.0             0.0           0.0           0.0          1.0
155              0.0             0.0           0.0           0.0          1.0
756              0.0             0.0           0.0           0.0          1.0
1070             0.0             0.0           0.0           0.0          1.0
303              0.0             0.0           0.0           0.0          1.0
...              ...             ...           ...           ...          ...
1095             0.0             0.0           0.0           0.0          1.0
1130             0.0             0.0           1.0           0.0          0.0
1294             0.0             0.0           0.0           0.0          1.0
860              0.0             0.0           0.0           0.0          1.0
1126             0.0             0.0           0.0           0.0          1.0

      SaleCondition_Abnorml  SaleCondition_AdjLand  SaleCondition_Alloca  \
48                      0.0                    0.0                   0.0
155                     0.0                    0.0                   0.0
756                     0.0                    0.0                   0.0
1070                    0.0                    0.0                   0.0
303                     0.0                    0.0                   0.0
...                     ...                    ...                   ...
1095                    0.0                    0.0                   0.0
1130                    0.0                    0.0                   0.0
1294                    0.0                    0.0                   0.0
860                     0.0                    0.0                   0.0
1126                    0.0                    0.0                   0.0

      SaleCondition_Family  SaleCondition_Normal  SaleCondition_Partial
48                     0.0                   1.0                    0.0
155                    0.0                   1.0                    0.0
756                    0.0                   1.0                    0.0
1070                   0.0                   1.0                    0.0
303                    0.0                   1.0                    0.0
...                    ...                   ...                    ...
1095                   0.0                   1.0                    0.0
1130                   0.0                   0.0                    1.0
1294                   0.0                   1.0                    0.0
860                    0.0                   1.0                    0.0
1126                   0.0                   1.0                    0.0

[1118 rows x 254 columns]
```

```
Testing Features:
      MSSubClass  LotFrontage  LotArea  OverallQual  OverallCond  YearBuilt  \
78           120    32.000000     4500            6            5       1998
478          160    21.000000     1890            6            5       1973
354           60    69.655724     8121            6            5       2000
594           20    71.000000     7064            5            6       1977
1255          60   108.000000    14774            9            5       1999
...          ...          ...      ...          ...          ...        ...
435           70    34.000000     4571            5            5       1916
538           60    77.000000    11198            9            5       2005
350           20    69.655724     9500            6            5       1963
1159          30    50.000000     9340            4            6       1941
894           20   313.000000    27650            7            7       1960

      YearRemodAdd  MasVnrArea  BsmtFinSF1  BsmtFinSF2  BsmtUnfSF  \
78            1998       443.0        1201           0         36
478           1973       285.0         356           0        316
354           2000         0.0           0           0        953
594           1977       153.0         560           0        420
1255          1999       165.0           0           0       1393
...            ...         ...         ...         ...        ...
435           1950         0.0           0           0        624
538           2007       245.0           0           0       1122
350           1963       247.0         609           0        785
1159          1950         0.0         344           0        328
894           2007         0.0         425           0        160

      TotalBsmtSF  1stFlrSF  2ndFlrSF  LowQualFinSF  GrLivArea  BsmtFullBath  \
78           1237      1337         0             0       1337             1
478           672       672       546             0       1218             0
354           953       953       711             0       1664             0
594           980       980         0             0        980             0
1255         1393      1422      1177             0       2599             0
...           ...       ...       ...           ...        ...           ...
435           624       624       720             0       1344             0
538          1122      1134      1370             0       2504             0
350          1394      1394         0             0       1394             1
1159          672       672         0             0        672             1
894           585      2069         0             0       2069             1

      BsmtHalfBath  FullBath  HalfBath  BedroomAbvGr  KitchenAbvGr  \
78               0         2         0             2             1
478              0         1         1             3             1
354              0         2         1             3             1
594              0         1         0             3             1
1255             0         2         1             4             1
...            ...       ...       ...           ...           ...
435              0         1         0             4             1
538              0         2         1             4             1
350              0         1         1             3             1
1159             0         1         0             2             1
894              0         2         0             4             1

      TotRmsAbvGrd  Fireplaces  GarageCars  GarageArea  WoodDeckSF  \
78               5           0           2         405           0
478              7           0           1         264         144
354              7           1           2         460         100
594              6           0           2         484         192
1255            10           1           3         779         668
...            ...         ...         ...         ...         ...
435              7           0           3         513           0
538             11           1           3         656         144
350              6           2           2         514           0
1159             4           0           1         234           0
894              9           1           2         505           0
```

```
      OpenPorchSF  EnclosedPorch  3SsnPorch  ScreenPorch  PoolArea  MiscVal  \
78            199              0          0            0         0        0
478            28              0          0            0         0        0
354            40              0          0            0         0        0
594             0              0          0            0         0        0
1255           30              0          0            0         0        0
...           ...            ...        ...          ...       ...      ...
435             0             96          0            0         0        0
538            39              0          0            0         0        0
350            76              0          0          185         0        0
1159          113              0          0            0         0        0
894             0              0          0            0         0        0

      MoSold  YrSold  GrandArea  MSZoning_C (all)  MSZoning_FV  MSZoning_RH  \
78         3    2006       2574               0.0          0.0          0.0
478        5    2007       1890               0.0          0.0          0.0
354        1    2006       2617               0.0          0.0          0.0
594        7    2009       1960               0.0          0.0          0.0
1255       5    2010       3992               0.0          0.0          0.0
...      ...     ...        ...               ...          ...          ...
435        5    2008       1968               0.0          0.0          0.0
538        6    2008       3626               0.0          0.0          0.0
350        7    2009       2788               0.0          0.0          0.0
1159       8    2009       1344               0.0          0.0          0.0
894       11    2008       2654               0.0          0.0          0.0

      MSZoning_RL  MSZoning_RM  LotShape_IR1  LotShape_IR2  LotShape_IR3  \
78            0.0          1.0           0.0           0.0           0.0
478           0.0          1.0           0.0           0.0           0.0
354           1.0          0.0           1.0           0.0           0.0
594           1.0          0.0           0.0           0.0           0.0
1255          1.0          0.0           1.0           0.0           0.0
...           ...          ...           ...           ...           ...
435           0.0          1.0           0.0           0.0           0.0
538           1.0          0.0           1.0           0.0           0.0
350           1.0          0.0           1.0           0.0           0.0
1159          1.0          0.0           0.0           0.0           0.0
894           1.0          0.0           0.0           1.0           0.0

      LotShape_Reg  LandContour_Bnk  LandContour_HLS  LandContour_Low  \
78             1.0              0.0              0.0              0.0
478            1.0              0.0              0.0              0.0
354            0.0              0.0              0.0              0.0
594            1.0              0.0              0.0              0.0
1255           0.0              0.0              0.0              0.0
...            ...              ...              ...              ...
435            1.0              0.0              0.0              0.0
538            0.0              0.0              0.0              0.0
350            0.0              0.0              0.0              0.0
1159           1.0              0.0              0.0              0.0
894            0.0              0.0              1.0              0.0

      LandContour_Lvl  LotConfig_Corner  LotConfig_CulDSac  LotConfig_FR2  \
78                1.0               0.0                0.0            1.0
478               1.0               0.0                0.0            0.0
354               1.0               0.0                0.0            0.0
594               1.0               0.0                0.0            0.0
1255              1.0               1.0                0.0            0.0
...               ...               ...                ...            ...
435               1.0               0.0                0.0            0.0
538               1.0               0.0                0.0            0.0
350               1.0               0.0                0.0            0.0
1159              1.0               0.0                0.0            0.0
894               0.0               0.0                0.0            0.0

      LotConfig_FR3  LotConfig_Inside  LandSlope_Gtl  LandSlope_Mod  \
```

```
78              0.0             0.0             1.0             0.0
478             0.0             1.0             1.0             0.0
354             0.0             1.0             1.0             0.0
594             0.0             1.0             1.0             0.0
1255            0.0             0.0             1.0             0.0
...             ...             ...             ...             ...
435             0.0             1.0             1.0             0.0
538             0.0             1.0             1.0             0.0
350             0.0             1.0             1.0             0.0
1159            0.0             1.0             1.0             0.0
894             0.0             1.0             0.0             1.0

      LandSlope_Sev  Neighborhood_Blmngtn  Neighborhood_Blueste  \
78              0.0                   0.0                   0.0
478             0.0                   0.0                   0.0
354             0.0                   0.0                   0.0
594             0.0                   0.0                   0.0
1255            0.0                   0.0                   0.0
...             ...                   ...                   ...
435             0.0                   0.0                   0.0
538             0.0                   0.0                   0.0
350             0.0                   0.0                   0.0
1159            0.0                   0.0                   0.0
894             0.0                   0.0                   0.0

      Neighborhood_BrDale  Neighborhood_BrkSide  Neighborhood_ClearCr  \
78                    0.0                   0.0                   0.0
478                   1.0                   0.0                   0.0
354                   0.0                   0.0                   0.0
594                   0.0                   0.0                   0.0
1255                  0.0                   0.0                   0.0
...                   ...                   ...                   ...
435                   0.0                   0.0                   0.0
538                   0.0                   0.0                   0.0
350                   0.0                   0.0                   0.0
1159                  0.0                   0.0                   0.0
894                   0.0                   0.0                   0.0

      Neighborhood_CollgCr  Neighborhood_Crawfor  Neighborhood_Edwards  \
78                     0.0                   0.0                   0.0
478                    0.0                   0.0                   0.0
354                    0.0                   0.0                   0.0
594                    0.0                   0.0                   0.0
1255                   0.0                   0.0                   0.0
...                    ...                   ...                   ...
435                    0.0                   0.0                   0.0
538                    0.0                   0.0                   0.0
350                    0.0                   0.0                   0.0
1159                   0.0                   0.0                   1.0
894                    0.0                   0.0                   0.0

      Neighborhood_Gilbert  Neighborhood_IDOTRR  Neighborhood_MeadowV  \
78                     0.0                  0.0                   0.0
478                    0.0                  0.0                   0.0
354                    1.0                  0.0                   0.0
594                    0.0                  0.0                   0.0
1255                   0.0                  0.0                   0.0
...                    ...                  ...                   ...
435                    0.0                  0.0                   0.0
538                    0.0                  0.0                   0.0
350                    0.0                  0.0                   0.0
1159                   0.0                  0.0                   0.0
894                    0.0                  0.0                   0.0

      Neighborhood_Mitchel  Neighborhood_NAmes  Neighborhood_NPkVill  \
78                     1.0                 0.0                   0.0
```

```
478                 0.0                 0.0                 0.0
354                 0.0                 0.0                 0.0
594                 0.0                 0.0                 0.0
1255                0.0                 0.0                 0.0
...                 ...                 ...                 ...
435                 0.0                 0.0                 0.0
538                 0.0                 0.0                 0.0
350                 0.0                 1.0                 0.0
1159                0.0                 0.0                 0.0
894                 0.0                 1.0                 0.0

      Neighborhood_NWAmes  Neighborhood_NoRidge  Neighborhood_NridgHt  \
78                    0.0                   0.0                   0.0
478                   0.0                   0.0                   0.0
354                   0.0                   0.0                   0.0
594                   0.0                   0.0                   0.0
1255                  0.0                   1.0                   0.0
...                   ...                   ...                   ...
435                   0.0                   0.0                   0.0
538                   0.0                   0.0                   0.0
350                   0.0                   0.0                   0.0
1159                  0.0                   0.0                   0.0
894                   0.0                   0.0                   0.0

      Neighborhood_OldTown  Neighborhood_SWISU  Neighborhood_Sawyer  \
78                     0.0                 0.0                  0.0
478                    0.0                 0.0                  0.0
354                    0.0                 0.0                  0.0
594                    0.0                 0.0                  1.0
1255                   0.0                 0.0                  0.0
...                    ...                 ...                  ...
435                    1.0                 0.0                  0.0
538                    0.0                 0.0                  0.0
350                    0.0                 0.0                  0.0
1159                   0.0                 0.0                  0.0
894                    0.0                 0.0                  0.0

      Neighborhood_SawyerW  Neighborhood_Somerst  Neighborhood_StoneBr  \
78                     0.0                   0.0                   0.0
478                    0.0                   0.0                   0.0
354                    0.0                   0.0                   0.0
594                    0.0                   0.0                   0.0
1255                   0.0                   0.0                   0.0
...                    ...                   ...                   ...
435                    0.0                   0.0                   0.0
538                    0.0                   0.0                   1.0
350                    0.0                   0.0                   0.0
1159                   0.0                   0.0                   0.0
894                    0.0                   0.0                   0.0

      Neighborhood_Timber  Neighborhood_Veenker  Condition1_Artery  \
78                    0.0                   0.0                0.0
478                   0.0                   0.0                0.0
354                   0.0                   0.0                0.0
594                   0.0                   0.0                0.0
1255                  0.0                   0.0                0.0
...                   ...                   ...                ...
435                   0.0                   0.0                0.0
538                   0.0                   0.0                0.0
350                   0.0                   0.0                0.0
1159                  0.0                   0.0                0.0
894                   0.0                   0.0                0.0

      Condition1_Feedr  Condition1_Norm  Condition1_PosA  Condition1_PosN  \
78                 0.0              1.0              0.0              0.0
478                0.0              1.0              0.0              0.0
```

```
354                0.0             1.0              0.0              0.0
594                0.0             1.0              0.0              0.0
1255               0.0             1.0              0.0              0.0
...                ...             ...              ...              ...
435                0.0             1.0              0.0              0.0
538                0.0             1.0              0.0              0.0
350                0.0             1.0              0.0              0.0
1159               0.0             1.0              0.0              0.0
894                0.0             0.0              1.0              0.0

      Condition1_RRAe  Condition1_RRAn  Condition1_RRNe  Condition1_RRNn  \
78                0.0              0.0              0.0              0.0
478               0.0              0.0              0.0              0.0
354               0.0              0.0              0.0              0.0
594               0.0              0.0              0.0              0.0
1255              0.0              0.0              0.0              0.0
...               ...              ...              ...              ...
435               0.0              0.0              0.0              0.0
538               0.0              0.0              0.0              0.0
350               0.0              0.0              0.0              0.0
1159              0.0              0.0              0.0              0.0
894               0.0              0.0              0.0              0.0

      Condition2_Artery  Condition2_Feedr  Condition2_Norm  Condition2_PosA  \
78                  0.0               0.0              1.0              0.0
478                 0.0               0.0              1.0              0.0
354                 0.0               0.0              1.0              0.0
594                 0.0               0.0              1.0              0.0
1255                0.0               0.0              1.0              0.0
...                 ...               ...              ...              ...
435                 0.0               0.0              1.0              0.0
538                 0.0               0.0              1.0              0.0
350                 0.0               0.0              1.0              0.0
1159                0.0               0.0              1.0              0.0
894                 0.0               0.0              1.0              0.0

      Condition2_PosN  Condition2_RRAe  Condition2_RRAn  Condition2_RRNn  \
78                0.0              0.0              0.0              0.0
478               0.0              0.0              0.0              0.0
354               0.0              0.0              0.0              0.0
594               0.0              0.0              0.0              0.0
1255              0.0              0.0              0.0              0.0
...               ...              ...              ...              ...
435               0.0              0.0              0.0              0.0
538               0.0              0.0              0.0              0.0
350               0.0              0.0              0.0              0.0
1159              0.0              0.0              0.0              0.0
894               0.0              0.0              0.0              0.0

      BldgType_1Fam  BldgType_2fmCon  BldgType_Duplex  BldgType_Twnhs  \
78              0.0              0.0              0.0             0.0
478             0.0              0.0              0.0             1.0
354             1.0              0.0              0.0             0.0
594             1.0              0.0              0.0             0.0
1255            1.0              0.0              0.0             0.0
...             ...              ...              ...             ...
435             1.0              0.0              0.0             0.0
538             1.0              0.0              0.0             0.0
350             1.0              0.0              0.0             0.0
1159            1.0              0.0              0.0             0.0
894             1.0              0.0              0.0             0.0

      BldgType_TwnhsE  HouseStyle_1.5Fin  HouseStyle_1.5Unf  \
78                1.0                0.0                0.0
478               0.0                0.0                0.0
354               0.0                0.0                0.0
```

```
594             0.0                 0.0                 0.0
1255            0.0                 0.0                 0.0
...             ...                 ...                 ...
435             0.0                 0.0                 0.0
538             0.0                 0.0                 0.0
350             0.0                 0.0                 0.0
1159            0.0                 0.0                 0.0
894             0.0                 0.0                 0.0

      HouseStyle_1Story  HouseStyle_2.5Fin  HouseStyle_2.5Unf  \
78                  1.0                0.0                0.0
478                 0.0                0.0                0.0
354                 0.0                0.0                0.0
594                 1.0                0.0                0.0
1255                0.0                0.0                0.0
...                 ...                ...                ...
435                 0.0                0.0                0.0
538                 0.0                0.0                0.0
350                 1.0                0.0                0.0
1159                1.0                0.0                0.0
894                 1.0                0.0                0.0

      HouseStyle_2Story  HouseStyle_SFoyer  HouseStyle_SLvl  RoofStyle_Flat  \
78                  0.0                0.0              0.0             0.0
478                 1.0                0.0              0.0             0.0
354                 1.0                0.0              0.0             0.0
594                 0.0                0.0              0.0             0.0
1255                1.0                0.0              0.0             0.0
...                 ...                ...              ...             ...
435                 1.0                0.0              0.0             0.0
538                 1.0                0.0              0.0             0.0
350                 0.0                0.0              0.0             0.0
1159                0.0                0.0              0.0             0.0
894                 0.0                0.0              0.0             1.0

      RoofStyle_Gable  RoofStyle_Gambrel  RoofStyle_Hip  RoofStyle_Mansard  \
78                0.0                0.0            1.0                0.0
478               1.0                0.0            0.0                0.0
354               1.0                0.0            0.0                0.0
594               1.0                0.0            0.0                0.0
1255              1.0                0.0            0.0                0.0
...               ...                ...            ...                ...
435               1.0                0.0            0.0                0.0
538               0.0                0.0            1.0                0.0
350               1.0                0.0            0.0                0.0
1159              0.0                0.0            1.0                0.0
894               0.0                0.0            0.0                0.0

      RoofStyle_Shed  RoofMatl_CompShg  RoofMatl_Metal  RoofMatl_Roll  \
78               0.0               1.0             0.0            0.0
478              0.0               1.0             0.0            0.0
354              0.0               1.0             0.0            0.0
594              0.0               1.0             0.0            0.0
1255             0.0               1.0             0.0            0.0
...              ...               ...             ...            ...
435              0.0               1.0             0.0            0.0
538              0.0               1.0             0.0            0.0
350              0.0               1.0             0.0            0.0
1159             0.0               1.0             0.0            0.0
894              0.0               0.0             0.0            0.0

      RoofMatl_Tar&Grv  RoofMatl_WdShake  RoofMatl_WdShngl  \
78                 0.0               0.0               0.0
478                0.0               0.0               0.0
354                0.0               0.0               0.0
594                0.0               0.0               0.0
```

```
1255           0.0            0.0            0.0
...            ...            ...            ...
435            0.0            0.0            0.0
538            0.0            0.0            0.0
350            0.0            0.0            0.0
1159           0.0            0.0            0.0
894            1.0            0.0            0.0

      Exterior1st_AsbShng  Exterior1st_BrkComm  Exterior1st_BrkFace  \
78                    0.0                  0.0                  0.0
478                   0.0                  0.0                  0.0
354                   0.0                  0.0                  0.0
594                   0.0                  0.0                  0.0
1255                  0.0                  0.0                  0.0
...                   ...                  ...                  ...
435                   1.0                  0.0                  0.0
538                   0.0                  0.0                  0.0
350                   0.0                  0.0                  0.0
1159                  0.0                  0.0                  0.0
894                   0.0                  0.0                  0.0

      Exterior1st_CBlock  Exterior1st_CemntBd  Exterior1st_HdBoard  \
78                   0.0                  0.0                  0.0
478                  0.0                  0.0                  1.0
354                  0.0                  0.0                  0.0
594                  0.0                  0.0                  0.0
1255                 0.0                  0.0                  0.0
...                  ...                  ...                  ...
435                  0.0                  0.0                  0.0
538                  0.0                  0.0                  0.0
350                  0.0                  0.0                  0.0
1159                 0.0                  0.0                  0.0
894                  0.0                  0.0                  0.0

      Exterior1st_ImStucc  Exterior1st_MetalSd  Exterior1st_Plywood  \
78                    0.0                  0.0                  0.0
478                   0.0                  0.0                  0.0
354                   0.0                  0.0                  0.0
594                   0.0                  0.0                  1.0
1255                  0.0                  0.0                  0.0
...                   ...                  ...                  ...
435                   0.0                  0.0                  0.0
538                   0.0                  0.0                  0.0
350                   0.0                  0.0                  1.0
1159                  0.0                  1.0                  0.0
894                   0.0                  0.0                  0.0

      Exterior1st_Stone  Exterior1st_Stucco  Exterior1st_VinylSd  \
78                  0.0                 0.0                  1.0
478                 0.0                 0.0                  0.0
354                 0.0                 0.0                  1.0
594                 0.0                 0.0                  0.0
1255                0.0                 0.0                  1.0
...                 ...                 ...                  ...
435                 0.0                 0.0                  0.0
538                 0.0                 0.0                  1.0
350                 0.0                 0.0                  0.0
1159                0.0                 0.0                  0.0
894                 0.0                 0.0                  0.0

      Exterior1st_Wd Sdng  Exterior1st_WdShing  Exterior2nd_AsbShng  \
78                    0.0                  0.0                  0.0
478                   0.0                  0.0                  0.0
354                   0.0                  0.0                  0.0
594                   0.0                  0.0                  0.0
1255                  0.0                  0.0                  0.0
```

```
...                  ...                 ...                  ...
435                  0.0                 0.0                  1.0
538                  0.0                 0.0                  0.0
350                  0.0                 0.0                  0.0
1159                 0.0                 0.0                  0.0
894                  1.0                 0.0                  0.0

      Exterior2nd_AsphShn  Exterior2nd_Brk Cmn  Exterior2nd_BrkFace  \
78                    0.0                  0.0                  0.0
478                   0.0                  0.0                  0.0
354                   0.0                  0.0                  0.0
594                   0.0                  0.0                  0.0
1255                  0.0                  0.0                  0.0
...                   ...                  ...                  ...
435                   0.0                  0.0                  0.0
538                   0.0                  0.0                  0.0
350                   0.0                  0.0                  0.0
1159                  0.0                  0.0                  0.0
894                   0.0                  0.0                  0.0

      Exterior2nd_CBlock  Exterior2nd_CmentBd  Exterior2nd_HdBoard  \
78                   0.0                  0.0                  0.0
478                  0.0                  0.0                  1.0
354                  0.0                  0.0                  0.0
594                  0.0                  0.0                  0.0
1255                 0.0                  0.0                  0.0
...                  ...                  ...                  ...
435                  0.0                  0.0                  0.0
538                  0.0                  0.0                  0.0
350                  0.0                  0.0                  0.0
1159                 0.0                  0.0                  0.0
894                  0.0                  0.0                  0.0

      Exterior2nd_ImStucc  Exterior2nd_MetalSd  Exterior2nd_Other  \
78                    0.0                  0.0                0.0
478                   0.0                  0.0                0.0
354                   0.0                  0.0                0.0
594                   0.0                  0.0                0.0
1255                  0.0                  0.0                0.0
...                   ...                  ...                ...
435                   0.0                  0.0                0.0
538                   0.0                  0.0                0.0
350                   0.0                  0.0                0.0
1159                  0.0                  1.0                0.0
894                   0.0                  0.0                0.0

      Exterior2nd_Plywood  Exterior2nd_Stone  Exterior2nd_Stucco  \
78                    0.0                0.0                 0.0
478                   0.0                0.0                 0.0
354                   0.0                0.0                 0.0
594                   1.0                0.0                 0.0
1255                  0.0                0.0                 0.0
...                   ...                ...                 ...
435                   0.0                0.0                 0.0
538                   0.0                0.0                 0.0
350                   1.0                0.0                 0.0
1159                  0.0                0.0                 0.0
894                   0.0                0.0                 0.0

      Exterior2nd_VinylSd  Exterior2nd_Wd Sdng  Exterior2nd_Wd Shng  \
78                    1.0                  0.0                  0.0
478                   0.0                  0.0                  0.0
354                   1.0                  0.0                  0.0
594                   0.0                  0.0                  0.0
1255                  1.0                  0.0                  0.0
...                   ...                  ...                  ...
```

```
435             0.0                 0.0                0.0
538             1.0                 0.0                0.0
350             0.0                 0.0                0.0
1159            0.0                 0.0                0.0
894             0.0                 1.0                0.0

      MasVnrType_BrkCmn  MasVnrType_BrkFace  MasVnrType_None  \
78                  0.0                 1.0              0.0
478                 0.0                 1.0              0.0
354                 0.0                 0.0              1.0
594                 0.0                 1.0              0.0
1255                0.0                 1.0              0.0
...                 ...                 ...              ...
435                 0.0                 0.0              1.0
538                 0.0                 1.0              0.0
350                 0.0                 1.0              0.0
1159                0.0                 0.0              1.0
894                 0.0                 0.0              1.0

      MasVnrType_Stone  ExterQual_Ex  ExterQual_Fa  ExterQual_Gd  \
78                 0.0           0.0           0.0           0.0
478                0.0           0.0           0.0           0.0
354                0.0           0.0           0.0           0.0
594                0.0           0.0           0.0           0.0
1255               0.0           0.0           0.0           1.0
...                ...           ...           ...           ...
435                0.0           0.0           0.0           0.0
538                0.0           0.0           0.0           1.0
350                0.0           0.0           0.0           0.0
1159               0.0           0.0           0.0           0.0
894                0.0           0.0           0.0           0.0

      ExterQual_TA  ExterCond_Ex  ExterCond_Fa  ExterCond_Gd  ExterCond_Po  \
78             1.0           0.0           0.0           1.0           0.0
478            1.0           0.0           0.0           0.0           0.0
354            1.0           0.0           0.0           0.0           0.0
594            1.0           0.0           0.0           0.0           0.0
1255           0.0           0.0           0.0           0.0           0.0
...            ...           ...           ...           ...           ...
435            1.0           0.0           0.0           0.0           0.0
538            0.0           0.0           0.0           0.0           0.0
350            1.0           0.0           0.0           0.0           0.0
1159           1.0           0.0           0.0           0.0           0.0
894            1.0           0.0           0.0           0.0           0.0

      ExterCond_TA  Foundation_BrkTil  Foundation_CBlock  Foundation_PConc  \
78             0.0                0.0                0.0               1.0
478            1.0                0.0                1.0               0.0
354            1.0                0.0                0.0               1.0
594            1.0                0.0                1.0               0.0
1255           1.0                0.0                0.0               1.0
...            ...                ...                ...               ...
435            1.0                1.0                0.0               0.0
538            1.0                0.0                0.0               1.0
350            1.0                0.0                1.0               0.0
1159           1.0                0.0                1.0               0.0
894            1.0                0.0                1.0               0.0

      Foundation_Stone  Foundation_Wood  BsmtQual_Ex  BsmtQual_Fa  \
78                 0.0              0.0          1.0          0.0
478                0.0              0.0          0.0          0.0
354                0.0              0.0          0.0          0.0
594                0.0              0.0          0.0          0.0
1255               0.0              0.0          0.0          0.0
...                ...              ...          ...          ...
435                0.0              0.0          0.0          0.0
```

```
538             0.0               0.0           0.0           0.0
350             0.0               0.0           0.0           0.0
1159            0.0               0.0           0.0           0.0
894             0.0               0.0           0.0           0.0

      BsmtQual_Gd  BsmtQual_TA  BsmtCond_Fa  BsmtCond_Gd  BsmtCond_Po  \
78            0.0          0.0          0.0          1.0          0.0
478           0.0          1.0          0.0          0.0          0.0
354           1.0          0.0          0.0          0.0          0.0
594           0.0          1.0          0.0          0.0          0.0
1255          1.0          0.0          0.0          0.0          0.0
...           ...          ...          ...          ...          ...
435           0.0          1.0          0.0          0.0          0.0
538           1.0          0.0          0.0          1.0          0.0
350           1.0          0.0          0.0          0.0          0.0
1159          0.0          1.0          0.0          0.0          0.0
894           1.0          0.0          0.0          0.0          0.0

      BsmtCond_TA  BsmtExposure_Av  BsmtExposure_Gd  BsmtExposure_Mn  \
78            0.0              0.0              0.0              0.0
478           1.0              0.0              0.0              0.0
354           1.0              0.0              0.0              0.0
594           1.0              0.0              0.0              0.0
1255          1.0              0.0              0.0              0.0
...           ...              ...              ...              ...
435           1.0              0.0              0.0              0.0
538           0.0              0.0              0.0              0.0
350           1.0              0.0              0.0              0.0
1159          1.0              0.0              0.0              0.0
894           1.0              0.0              1.0              0.0

      BsmtExposure_No  BsmtFinType1_ALQ  BsmtFinType1_BLQ  BsmtFinType1_GLQ  \
78                1.0               0.0               0.0               1.0
478               1.0               0.0               1.0               0.0
354               1.0               0.0               0.0               0.0
594               1.0               0.0               1.0               0.0
1255              1.0               0.0               0.0               0.0
...               ...               ...               ...               ...
435               1.0               0.0               0.0               0.0
538               1.0               0.0               0.0               0.0
350               1.0               0.0               1.0               0.0
1159              1.0               0.0               0.0               0.0
894               0.0               0.0               0.0               1.0

      BsmtFinType1_LwQ  BsmtFinType1_Rec  BsmtFinType1_Unf  BsmtFinType2_ALQ  \
78                 0.0               0.0               0.0               0.0
478                0.0               0.0               0.0               0.0
354                0.0               0.0               1.0               0.0
594                0.0               0.0               0.0               0.0
1255               0.0               0.0               1.0               0.0
...                ...               ...               ...               ...
435                0.0               0.0               1.0               0.0
538                0.0               0.0               1.0               0.0
350                0.0               0.0               0.0               0.0
1159               0.0               1.0               0.0               0.0
894                0.0               0.0               0.0               0.0

      BsmtFinType2_BLQ  BsmtFinType2_GLQ  BsmtFinType2_LwQ  BsmtFinType2_Rec  \
78                 0.0               0.0               0.0               0.0
478                0.0               0.0               0.0               0.0
354                0.0               0.0               0.0               0.0
594                0.0               0.0               0.0               0.0
1255               0.0               0.0               0.0               0.0
...                ...               ...               ...               ...
435                0.0               0.0               0.0               0.0
538                0.0               0.0               0.0               0.0
```

350	0.0	0.0	0.0	0.0
1159	0.0	0.0	0.0	0.0
894	0.0	0.0	0.0	0.0

	BsmtFinType2_Unf	Heating_GasA	Heating_GasW	Heating_Grav \
78	1.0	1.0	0.0	0.0
478	1.0	1.0	0.0	0.0
354	1.0	1.0	0.0	0.0
594	1.0	1.0	0.0	0.0
1255	1.0	1.0	0.0	0.0
...	...	...	...	...
435	1.0	1.0	0.0	0.0
538	1.0	1.0	0.0	0.0
350	1.0	1.0	0.0	0.0
1159	1.0	1.0	0.0	0.0
894	1.0	1.0	0.0	0.0

	Heating_OthW	HeatingQC_Ex	HeatingQC_Fa	HeatingQC_Gd	HeatingQC_Po \
78	0.0	1.0	0.0	0.0	0.0
478	0.0	0.0	0.0	0.0	0.0
354	0.0	1.0	0.0	0.0	0.0
594	0.0	0.0	0.0	0.0	0.0
1255	0.0	1.0	0.0	0.0	0.0
...	...	...	...	...	...
435	0.0	0.0	1.0	0.0	0.0
538	0.0	1.0	0.0	0.0	0.0
350	0.0	0.0	0.0	1.0	0.0
1159	0.0	0.0	0.0	0.0	0.0
894	0.0	1.0	0.0	0.0	0.0

	HeatingQC_TA	CentralAir_N	CentralAir_Y	Electrical_FuseA \
78	0.0	0.0	1.0	0.0
478	1.0	0.0	1.0	0.0
354	0.0	0.0	1.0	0.0
594	1.0	0.0	1.0	0.0
1255	0.0	0.0	1.0	0.0
...	...	...	...	...
435	0.0	1.0	0.0	0.0
538	0.0	0.0	1.0	0.0
350	0.0	0.0	1.0	0.0
1159	1.0	0.0	1.0	0.0
894	0.0	0.0	1.0	0.0

	Electrical_FuseF	Electrical_FuseP	Electrical_Mix	Electrical_SBrkr \
78	0.0	0.0	0.0	1.0
478	0.0	0.0	0.0	1.0
354	0.0	0.0	0.0	1.0
594	0.0	0.0	0.0	1.0
1255	0.0	0.0	0.0	1.0
...	...	...	...	...
435	0.0	0.0	0.0	1.0
538	0.0	0.0	0.0	1.0
350	0.0	0.0	0.0	1.0
1159	0.0	0.0	0.0	1.0
894	0.0	0.0	0.0	1.0

	KitchenQual_Ex	KitchenQual_Fa	KitchenQual_Gd	KitchenQual_TA \
78	0.0	0.0	0.0	1.0
478	0.0	0.0	0.0	1.0
354	0.0	0.0	0.0	1.0
594	0.0	0.0	0.0	1.0
1255	0.0	0.0	1.0	0.0
...	...	...	...	...
435	0.0	0.0	0.0	1.0
538	1.0	0.0	0.0	0.0
350	0.0	0.0	0.0	1.0

```
1159           0.0            0.0            0.0            1.0
894            0.0            0.0            1.0            0.0

      Functional_Maj1  Functional_Maj2  Functional_Min1  Functional_Min2  \
78                0.0              0.0              0.0              0.0
478               0.0              0.0              0.0              0.0
354               0.0              0.0              0.0              0.0
594               0.0              0.0              0.0              0.0
1255              0.0              0.0              0.0              0.0
...               ...              ...              ...              ...
435               0.0              0.0              0.0              0.0
538               0.0              0.0              0.0              0.0
350               0.0              0.0              0.0              0.0
1159              0.0              0.0              0.0              0.0
894               0.0              0.0              0.0              0.0

      Functional_Mod  Functional_Sev  Functional_Typ  FireplaceQu_Ex  \
78               0.0             0.0             1.0             0.0
478              0.0             0.0             1.0             0.0
354              0.0             0.0             1.0             0.0
594              0.0             0.0             1.0             0.0
1255             0.0             0.0             1.0             0.0
...              ...             ...             ...             ...
435              0.0             0.0             1.0             0.0
538              0.0             0.0             1.0             0.0
350              0.0             0.0             1.0             0.0
1159             0.0             0.0             1.0             0.0
894              0.0             0.0             1.0             0.0

      FireplaceQu_Fa  FireplaceQu_Gd  FireplaceQu_None  FireplaceQu_Po  \
78               0.0             0.0               1.0             0.0
478              0.0             0.0               1.0             0.0
354              0.0             0.0               0.0             0.0
594              0.0             0.0               1.0             0.0
1255             0.0             0.0               0.0             0.0
...              ...             ...               ...             ...
435              0.0             0.0               1.0             0.0
538              0.0             1.0               0.0             0.0
350              0.0             1.0               0.0             0.0
1159             0.0             0.0               1.0             0.0
894              0.0             1.0               0.0             0.0

      FireplaceQu_TA  GarageType_2Types  GarageType_Attchd  \
78               0.0                0.0                1.0
478              0.0                0.0                0.0
354              1.0                0.0                1.0
594              0.0                0.0                0.0
1255             1.0                0.0                0.0
...              ...                ...                ...
435              0.0                0.0                0.0
538              0.0                0.0                0.0
350              0.0                0.0                1.0
1159             0.0                0.0                1.0
894              0.0                0.0                1.0

      GarageType_Basment  GarageType_BuiltIn  GarageType_CarPort  \
78                   0.0                 0.0                 0.0
478                  0.0                 0.0                 0.0
354                  0.0                 0.0                 0.0
594                  0.0                 0.0                 0.0
1255                 0.0                 1.0                 0.0
...                  ...                 ...                 ...
435                  0.0                 0.0                 0.0
538                  0.0                 1.0                 0.0
350                  0.0                 0.0                 0.0
1159                 0.0                 0.0                 0.0
```

```
894                0.0                 0.0                 0.0

      GarageType_Detchd  GarageType_None  PavedDrive_N  PavedDrive_P  \
78                  0.0              0.0           0.0           0.0
478                 1.0              0.0           0.0           0.0
354                 0.0              0.0           0.0           0.0
594                 1.0              0.0           0.0           0.0
1255                0.0              0.0           0.0           0.0
...                 ...              ...           ...           ...
435                 1.0              0.0           0.0           0.0
538                 0.0              0.0           0.0           0.0
350                 0.0              0.0           0.0           0.0
1159                0.0              0.0           1.0           0.0
894                 0.0              0.0           0.0           0.0

      PavedDrive_Y  SaleType_COD  SaleType_CWD  SaleType_Con  SaleType_ConLD  \
78             1.0           0.0           0.0           0.0             0.0
478            1.0           0.0           0.0           0.0             0.0
354            1.0           0.0           0.0           0.0             0.0
594            1.0           0.0           0.0           0.0             0.0
1255           1.0           0.0           0.0           0.0             0.0
...            ...           ...           ...           ...             ...
435            1.0           1.0           0.0           0.0             0.0
538            1.0           0.0           0.0           0.0             0.0
350            1.0           0.0           0.0           0.0             0.0
1159           0.0           0.0           0.0           0.0             0.0
894            1.0           0.0           0.0           0.0             0.0

      SaleType_ConLI  SaleType_ConLw  SaleType_New  SaleType_Oth  SaleType_WD  \
78               0.0             0.0           0.0           0.0          1.0
478              0.0             0.0           0.0           0.0          1.0
354              0.0             0.0           0.0           0.0          1.0
594              0.0             0.0           0.0           0.0          1.0
1255             0.0             0.0           0.0           0.0          1.0
...              ...             ...           ...           ...          ...
435              0.0             0.0           0.0           0.0          0.0
538              0.0             0.0           0.0           0.0          1.0
350              0.0             0.0           0.0           0.0          1.0
1159             0.0             0.0           0.0           0.0          1.0
894              0.0             0.0           0.0           0.0          1.0

      SaleCondition_Abnorml  SaleCondition_AdjLand  SaleCondition_Alloca  \
78                      0.0                    0.0                   0.0
478                     0.0                    0.0                   0.0
354                     0.0                    0.0                   0.0
594                     0.0                    0.0                   0.0
1255                    0.0                    0.0                   0.0
...                     ...                    ...                   ...
435                     1.0                    0.0                   0.0
538                     0.0                    0.0                   0.0
350                     0.0                    0.0                   0.0
1159                    0.0                    0.0                   0.0
894                     0.0                    0.0                   0.0

      SaleCondition_Family  SaleCondition_Normal  SaleCondition_Partial
78                     0.0                   1.0                    0.0
478                    0.0                   1.0                    0.0
354                    0.0                   1.0                    0.0
594                    0.0                   1.0                    0.0
1255                   0.0                   1.0                    0.0
...                    ...                   ...                    ...
435                    0.0                   0.0                    0.0
538                    0.0                   1.0                    0.0
350                    0.0                   1.0                    0.0
1159                   0.0                   1.0                    0.0
894                    0.0                   1.0                    0.0
```

```
[280 rows x 254 columns]
Training Labels:
 48       177000
155      412500
756      269790
1070     133700
303      188500
          ...
1095      80000
1130     392500
1294     410000
860      110000
1126     119500
Name: SalePrice, Length: 1118, dtype: int64
Testing Labels:
 78       153500
478      113000
354      172400
594      135000
1255     333168
          ...
435       98000
538      325000
350      159000
1159     113000
894      242000
Name: SalePrice, Length: 280, dtype: int64
```

Models

Following are the two regression models developed for this project,

1. XGBoost

2. Artificial Neural networks

XGBoost model

After splitting the dataset, XGBoost model libraries are imported and and using XGBRegressor class the model is fit and predicted.
The MSE and R Squared is also calculated.

In [21]:

```
import xgboost as xgb
from sklearn.model_selection import train_test_split
from sklearn.metrics import mean_squared_error
import pandas as pd
import numpy as np



# Initialize the XGBoost Regressor
xg_reg = xgb.XGBRegressor(objective='reg:squarederror',   # Regression task
                          n_estimators=100,               # Number of boosting rounds (tr
                          learning_rate=0.1,              # Step size shrinkage
                          max_depth=3)                    # Maximum tree depth
```

```
# Fit the model to training data
xg_reg.fit(X_train, y_train)


# Make predictions on the test set
# Predict on test data
y_pred = xg_reg.predict(X_test)


# Calculate Mean Squared Error
mse = mean_squared_error(y_test, y_pred)
print(f"Mean Squared Error: {mse}")

# Calculate R-squared
r_squared = xg_reg.score(X_test, y_test)
print(f"R-squared: {r_squared}")
```

```
Mean Squared Error: 739680079.3796469
R-squared: 0.8952285051345825
```

As a part of my learning, GridSearchCV has been used and best parameters are found.

In [22]:
```
from sklearn.model_selection import GridSearchCV

# Define the hyperparameter grid
param_grid = {
    'learning_rate': [0.01, 0.1, 0.2,0.3],
    'n_estimators': [100, 200,300],
    'max_depth': [3, 4, 5],
}

# Initialize GridSearchCV with XGBRegressor
grid_search = GridSearchCV(estimator=xgb.XGBRegressor(objective='reg:squarederror'),
                           param_grid=param_grid, cv=3, scoring='neg_mean_squared_error'

# Fit the grid search to the data
grid_search.fit(X_train, y_train)

# Best parameters
print("Best Parameters:", grid_search.best_params_)
```

```
Best Parameters: {'learning_rate': 0.2, 'max_depth': 3, 'n_estimators': 300}
```

Same XGBoost model has been run once again with the best parameters as found above.

In [23]:
```
# Initialize the XGBoost Regressor
xg_reg_cv = xgb.XGBRegressor(objective='reg:squarederror',  # Regression task
                          n_estimators=300,              # Number of boosting rounds (tr
                          learning_rate=0.2,             # Step size shrinkage
                          max_depth=3)                   # Maximum tree depth


# Fit the model to training data
xg_reg_cv.fit(X_train, y_train)


# Make predictions on the test set
# Predict on test data
y_pred_cv = xg_reg_cv.predict(X_test)


# Calculate Mean Squared Error
mse_cv = mean_squared_error(y_test, y_pred)
print(f"Mean Squared Error: {mse_cv}")
```

```
# Calculate R-squared
r_squared_cv = xg_reg_cv.score(X_test, y_test)
print(f"R-squared: {r_squared_cv}")
```

```
Mean Squared Error: 739680079.3796469
R-squared: 0.8992318511009216
```

One another instance of the same model has been run using RFECV as a part of my learning.

In [25]:
```
from sklearn.feature_selection import RFECV

# Initialize XGBoost Regressor
xg_reg_RFECV = xgb.XGBRegressor(objective='reg:squarederror', n_estimators=100, learning

# RFECV for automatic feature selection
rfecv_RFECV = RFECV(estimator=xg_reg, step=1, cv=5, scoring='neg_mean_squared_error')
rfecv_RFECV.fit(X_train, y_train)

# Get selected features
selected_features_rfecv = X.columns[rfecv_RFECV.support_]
print(f'Selected Features (RFECV): {selected_features_rfecv}')

# Train model with selected features
X_train_selected = X_train[selected_features_rfecv]
X_test_selected = X_test[selected_features_rfecv]

xg_reg_RFECV.fit(X_train_selected, y_train)
y_pred = xg_reg_RFECV.predict(X_test_selected)

# Calculate Mean Squared Error
mse_rfecv = mean_squared_error(y_test, y_pred)
print(f'Mean Squared Error (RFECV): {mse_rfecv}')

# Calculate R-squared
r_squared_RFECV = xg_reg_RFECV.score(X_test_selected, y_test)
print(f"R-squared: {r_squared_RFECV}")

rmse = np.sqrt(mse_rfecv)
print (rmse)
```

```
Selected Features (RFECV): Index(['LotArea', 'OverallQual', 'OverallCond', 'YearBuilt',
'YearRemodAdd',
       'MasVnrArea', 'BsmtFinSF1', 'TotalBsmtSF', '2ndFlrSF', 'GrLivArea',
       'BsmtFullBath', 'FullBath', 'HalfBath', 'KitchenAbvGr', 'TotRmsAbvGrd',
       'Fireplaces', 'GarageCars', 'GarageArea', 'WoodDeckSF', 'MoSold',
       'GrandArea', 'MSZoning_RL', 'LandSlope_Mod', 'Neighborhood_CollgCr',
       'Neighborhood_Crawfor', 'Neighborhood_StoneBr', 'ExterQual_Ex',
       'ExterQual_TA', 'BsmtQual_Ex', 'BsmtExposure_Gd', 'BsmtFinType1_GLQ',
       'HeatingQC_Gd', 'CentralAir_N', 'KitchenQual_Ex', 'KitchenQual_Gd',
       'Functional_Typ', 'FireplaceQu_Gd', 'GarageType_Attchd',
       'GarageType_Detchd', 'SaleType_New', 'SaleCondition_Abnorml'],
      dtype='object')
Mean Squared Error (RFECV): 712265048.1892676
R-squared: 0.8991116881370544
26688.294216552462
```

GridSearchCV has been run once again with the combination of RFECV for my learning purpose

In [26]:
```
from sklearn.model_selection import GridSearchCV

# Define the hyperparameter grid
param_grid = {
    'learning_rate': [0.01, 0.1, 0.2,0.3],
    'n_estimators': [100, 200,300],
    'max_depth': [3, 4, 5],
```

```
}

# Initialize GridSearchCV with XGBRegressor
grid_search_RFECV = GridSearchCV(estimator=xgb.XGBRegressor(objective='reg:squarederror'
                           param_grid=param_grid, cv=3, scoring='neg_mean_squared_error'

# Fit the grid search to the data
grid_search_RFECV.fit(X_train_selected, y_train)

# Best parameters
print("Best Parameters:", grid_search_RFECV.best_params_)

# Initialize the XGBoost Regressor
xg_reg_RFECV = xgb.XGBRegressor(objective='reg:squarederror',  # Regression task
                          n_estimators=200,              # Number of boosting rounds (tr
                          learning_rate=0.2,             # Step size shrinkage
                          max_depth=3)                   # Maximum tree depth

# Make predictions on the test set
# Predict on test data
xg_reg_RFECV.fit(X_train_selected, y_train)
y_pred_RFECV = xg_reg_RFECV.predict(X_test_selected)


# Calculate Mean Squared Error
mse_RFECV = mean_squared_error(y_test, y_pred)
print(f"Mean Squared Error: {mse_RFECV}")

# Calculate R-squared
r_squared_RFECV = xg_reg_RFECV.score(X_test_selected, y_test)
print(f"R-squared: {r_squared_RFECV}")
```

```
Best Parameters: {'learning_rate': 0.2, 'max_depth': 3, 'n_estimators': 200}
Mean Squared Error: 712265048.1892676
R-squared: 0.8892741799354553
```

ANN model

Standard scaler has been applied to the train and test data, to have a mean of 0 and standard deviation of 1. It helps speed up the learning process by ensuring the network has a more stable and balanced gradient. An additional neural network model has been run.

In [27]:

```
import numpy as np
import pandas as pd
from sklearn.model_selection import train_test_split
from sklearn.preprocessing import StandardScaler
from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import Dense
from sklearn.metrics import mean_squared_error
from sklearn.metrics import r2_score

# Standardize the data (this is often useful for neural networks)
scaler = StandardScaler()
X_train_scaled = scaler.fit_transform(X_train)
X_test_scaled = scaler.transform(X_test)

# Build a simple neural network model for regression
model = Sequential()

# Input layer with 3 input features, one hidden layer with 64 neurons, and output layer
model.add(Dense(64, activation='relu', input_shape=(X_train_scaled.shape[1],)))
model.add(Dense(128, activation='relu'))  # 2nd hidden layer
```

```
model.add(Dense(64, activation='relu'))   # 3rd hidden layer
model.add(Dense(32, activation='relu'))   # 4th hidden layer
model.add(Dense(1))  # Output layer with 1 neuron (for continuous value prediction)

# Compile the model using Mean Squared Error (MSE) as the loss function and Adam optimiz
model.compile(optimizer='adam', loss='mean_squared_error')

# Train the model
model.fit(X_train_scaled, y_train, epochs=100, batch_size=32, verbose=1)

# Make predictions
y_pred = model.predict(X_test_scaled)

# Calculate and print the Root Mean Squared Error (RMSE)
rmse = np.sqrt(mean_squared_error(y_test, y_pred))
print(f"Root Mean Squared Error (RMSE): {rmse}")


# Calculate R-squared
r2 = r2_score(y_test, y_pred)

print(f"R-squared: {r2}")
```

```
C:\Users\Riaz\anaconda3\Lib\site-packages\keras\src\layers\core\dense.py:87: UserWarnin
g: Do not pass an `input_shape`/`input_dim` argument to a layer. When using Sequential m
odels, prefer using an `Input(shape)` object as the first layer in the model instead.
  super().__init__(activity_regularizer=activity_regularizer, **kwargs)
Epoch 1/100
35/35 ━━━━━━━━━━━━━━━━━━━━ 3s 3ms/step - loss: 38733680640.0000
Epoch 2/100
35/35 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - loss: 39961980928.0000
Epoch 3/100
35/35 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - loss: 39441084416.0000
Epoch 4/100
35/35 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - loss: 27071232000.0000
Epoch 5/100
35/35 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - loss: 10535130112.0000
Epoch 6/100
35/35 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - loss: 6200822784.0000
Epoch 7/100
35/35 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - loss: 3546874112.0000
Epoch 8/100
35/35 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - loss: 2108351232.0000
Epoch 9/100
35/35 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - loss: 1642377472.0000
Epoch 10/100
35/35 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - loss: 1227948032.0000
Epoch 11/100
35/35 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - loss: 1014454336.0000
Epoch 12/100
35/35 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - loss: 980015040.0000
Epoch 13/100
35/35 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - loss: 809232576.0000
Epoch 14/100
35/35 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - loss: 781222720.0000
Epoch 15/100
35/35 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - loss: 674652672.0000
Epoch 16/100
35/35 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - loss: 656052736.0000
Epoch 17/100
35/35 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - loss: 634472000.0000
Epoch 18/100
35/35 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - loss: 480466784.0000
Epoch 19/100
35/35 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - loss: 540717440.0000
```

```
Epoch 20/100
35/35 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - loss: 475730848.0000
Epoch 21/100
35/35 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - loss: 478371552.0000
Epoch 22/100
35/35 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - loss: 448959008.0000
Epoch 23/100
35/35 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - loss: 415411776.0000
Epoch 24/100
35/35 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - loss: 367201728.0000
Epoch 25/100
35/35 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - loss: 389466752.0000
Epoch 26/100
35/35 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - loss: 367920032.0000
Epoch 27/100
35/35 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - loss: 346098944.0000
Epoch 28/100
35/35 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - loss: 346544192.0000
Epoch 29/100
35/35 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - loss: 364562080.0000
Epoch 30/100
35/35 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - loss: 372335456.0000
Epoch 31/100
35/35 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - loss: 289689440.0000
Epoch 32/100
35/35 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - loss: 297819840.0000
Epoch 33/100
35/35 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - loss: 243877744.0000
Epoch 34/100
35/35 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - loss: 270862976.0000
Epoch 35/100
35/35 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - loss: 251725968.0000
Epoch 36/100
35/35 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - loss: 322231040.0000
Epoch 37/100
35/35 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - loss: 265979552.0000
Epoch 38/100
35/35 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - loss: 289109824.0000
Epoch 39/100
35/35 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - loss: 262039888.0000
Epoch 40/100
35/35 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - loss: 244107152.0000
Epoch 41/100
35/35 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - loss: 243650816.0000
Epoch 42/100
35/35 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - loss: 255338304.0000
Epoch 43/100
35/35 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - loss: 208358976.0000
Epoch 44/100
35/35 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - loss: 235003008.0000
Epoch 45/100
35/35 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - loss: 246282880.0000
Epoch 46/100
35/35 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - loss: 213298992.0000
Epoch 47/100
35/35 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - loss: 192490064.0000
Epoch 48/100
35/35 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - loss: 196573408.0000
Epoch 49/100
35/35 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - loss: 198204560.0000
Epoch 50/100
35/35 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - loss: 207491040.0000
Epoch 51/100
35/35 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - loss: 178342128.0000
Epoch 52/100
35/35 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - loss: 186717792.0000
```

```
Epoch 53/100
35/35 0s 2ms/step - loss: 223875824.0000
Epoch 54/100
35/35 0s 2ms/step - loss: 155992576.0000
Epoch 55/100
35/35 0s 2ms/step - loss: 222225248.0000
Epoch 56/100
35/35 0s 2ms/step - loss: 164092560.0000
Epoch 57/100
35/35 0s 3ms/step - loss: 183253840.0000
Epoch 58/100
35/35 0s 2ms/step - loss: 177960880.0000
Epoch 59/100
35/35 0s 3ms/step - loss: 167012288.0000
Epoch 60/100
35/35 0s 3ms/step - loss: 184324848.0000
Epoch 61/100
35/35 0s 2ms/step - loss: 180131824.0000
Epoch 62/100
35/35 0s 2ms/step - loss: 219963088.0000
Epoch 63/100
35/35 0s 2ms/step - loss: 159893456.0000
Epoch 64/100
35/35 0s 3ms/step - loss: 156727072.0000
Epoch 65/100
35/35 0s 3ms/step - loss: 137286368.0000
Epoch 66/100
35/35 0s 2ms/step - loss: 146315568.0000
Epoch 67/100
35/35 0s 3ms/step - loss: 146743552.0000
Epoch 68/100
35/35 0s 3ms/step - loss: 141036480.0000
Epoch 69/100
35/35 0s 3ms/step - loss: 171761152.0000
Epoch 70/100
35/35 0s 3ms/step - loss: 156288208.0000
Epoch 71/100
35/35 0s 2ms/step - loss: 157211872.0000
Epoch 72/100
35/35 0s 2ms/step - loss: 133620520.0000
Epoch 73/100
35/35 0s 3ms/step - loss: 169730544.0000
Epoch 74/100
35/35 0s 3ms/step - loss: 142623888.0000
Epoch 75/100
35/35 0s 3ms/step - loss: 155123120.0000
Epoch 76/100
35/35 0s 3ms/step - loss: 138146448.0000
Epoch 77/100
35/35 0s 2ms/step - loss: 133328832.0000
Epoch 78/100
35/35 0s 2ms/step - loss: 120216896.0000
Epoch 79/100
35/35 0s 2ms/step - loss: 137511248.0000
Epoch 80/100
35/35 0s 3ms/step - loss: 136124080.0000
Epoch 81/100
35/35 0s 4ms/step - loss: 126484968.0000
Epoch 82/100
35/35 0s 3ms/step - loss: 109866192.0000
Epoch 83/100
35/35 0s 2ms/step - loss: 116785064.0000
Epoch 84/100
35/35 0s 2ms/step - loss: 115543440.0000
Epoch 85/100
35/35 0s 2ms/step - loss: 126940600.0000
```

```
Epoch 86/100
35/35 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - loss: 144546592.0000
Epoch 87/100
35/35 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - loss: 111387008.0000
Epoch 88/100
35/35 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - loss: 98769080.0000
Epoch 89/100
35/35 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - loss: 116741600.0000
Epoch 90/100
35/35 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - loss: 142048272.0000
Epoch 91/100
35/35 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - loss: 96497160.0000
Epoch 92/100
35/35 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - loss: 130368592.0000
Epoch 93/100
35/35 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - loss: 143725472.0000
Epoch 94/100
35/35 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - loss: 98900160.0000
Epoch 95/100
35/35 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - loss: 117763896.0000
Epoch 96/100
35/35 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - loss: 105844224.0000
Epoch 97/100
35/35 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - loss: 89482872.0000
Epoch 98/100
35/35 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - loss: 86296432.0000
Epoch 99/100
35/35 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - loss: 98563528.0000
Epoch 100/100
35/35 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - loss: 130962592.0000
9/9 ━━━━━━━━━━━━━━━━━━━━ 0s 15ms/step
Root Mean Squared Error (RMSE): 34126.043177258194
R-squared: 0.8350428342819214
```

One another time the same ANN model has been run with the hyperparameter tuning

In [62]:

```python
#from tensorflow.keras.wrappers.scikit_learn import KerasRegressor
#%pip install tensorflow scikeras scikit-learn

from sklearn.model_selection import GridSearchCV,RandomizedSearchCV
#from tensorflow.keras.wrappers.scikit_learn import KerasRegressor
from scikeras.wrappers import KerasRegressor
from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import Dense

# Define a function to create the model (to use in grid search)
def create_model(neurons=64, hidden_layers=1):
    model_kerasregressor = Sequential()
    model_kerasregressor.add(Dense(neurons, input_dim=X_train_scaled.shape[1], activatio

    # Add the desired number of hidden layers
    for _ in range(hidden_layers):
        model_kerasregressor.add(Dense(neurons, activation='relu'))

    model_kerasregressor.add(Dense(1))  # Output layer for regression
    model_kerasregressor.compile(optimizer='adam', loss='mean_squared_error')
    return model_kerasregressor

# Wrap Keras model with KerasRegressor
model_kerasregressor = KerasRegressor(build_fn=create_model, epochs=50, batch_size=32, v
print (model_kerasregressor)
# Define the grid of hyperparameters to search
param_grid = {
    'model__neurons': [32, 64, 128],         # Different neuron counts
    'model__hidden_layers': [1, 2, 3],       # Number of hidden layers
```

```
    'batch_size': [16, 32, 64],       # Batch sizes to try
    'epochs': [50, 100, 150]          # Number of epochs to try
}

# Perform the grid search
grid_ann = RandomizedSearchCV(estimator=model_kerasregressor, param_distributions=param_
grid_result = grid_ann.fit(X_train_scaled, y_train)

# Get the best parameters
print(f"Best: {grid_result.best_score_} using {grid_result.best_params_}")
```

```
KerasRegressor(
        model=None
        build_fn=<function create_model at 0x0000021003DE4680>
        warm_start=False
        random_state=None
        optimizer=rmsprop
        loss=None
        metrics=None
        batch_size=32
        validation_batch_size=None
        verbose=0
        callbacks=None
        validation_split=0.0
        shuffle=True
        run_eagerly=False
        epochs=50
)
C:\Users\Riaz\anaconda3\Lib\site-packages\scikeras\wrappers.py:925: UserWarning: ``build
_fn`` will be renamed to ``model`` in a future release, at which point use of ``build_fn
`` will raise an Error instead.
  X, y = self._initialize(X, y)
C:\Users\Riaz\anaconda3\Lib\site-packages\keras\src\layers\core\dense.py:87: UserWarnin
g: Do not pass an `input_shape`/`input_dim` argument to a layer. When using Sequential m
odels, prefer using an `Input(shape)` object as the first layer in the model instead.
  super().__init__(activity_regularizer=activity_regularizer, **kwargs)
Best: -1264862090.065643 using {'model__neurons': 128, 'model__hidden_layers': 3, 'epoch
s': 150, 'batch_size': 64}
```

In [64]:

```
best_model = grid_result.best_estimator_
predictions = best_model.predict(X_test_scaled)

# Calculate and print the Root Mean Squared Error (RMSE)
rmse_randomsearchcv = np.sqrt(mean_squared_error(y_test, predictions))
print(f"Root Mean Squared Error (RMSE): {rmse_randomsearchcv}")



# Calculate R-squared
r2_randomsearchcv = r2_score(y_test, predictions)

print(f"R-squared: {r2_randomsearchcv}")
```

```
Root Mean Squared Error (RMSE): 30195.1942335079
R-squared: 0.8708558082580566
```

In [65]:

```
estimators = [
  ('knn', KNeighborsClassifier()),
   ('rf', RandomForestClassifier(n_estimators=10, random_state=42)),
   ('svr', LinearSVC(random_state=42))
]
```

```
R-squared: 0.8708558082580566
```

Result Evaluation

Standard regression evaluation metrics like MAE, MSE, RMSE, and R^2 will be used. Also, the feature importance of XGBRegressor will be explored.

Out of the two different models, XGboost offered a marginal higher performance over ANN,

XGboost Model
Best Parameters: {'learning_rate': 0.2, 'max_depth': 3, 'n_estimators': 200}
Mean Squared Error: 712265048.1892676
Root Mean Squared Error (RMSE): 26688.294216
R-squared: 0.8991116881370544

ANN Model
Best Parameters: -1264862090.065643 using {'model**neurons': 128, 'model**hidden_layers': 3, 'epochs': 150, 'batch_size': 64}
Mean Squared Error: 30195.1942335079
Root Mean Squared Error (RMSE): 30195.1942335079
R-squared: 0.8708558082580566

Root Mean Squared Error (RMSE) indicates the XGBoost model prediction is off of 26688 USD, the actual sale value of the house.

Coefficient of Determination is how well the input variables in a regression model explains the variance in the target variable. It varies from 0 to 1 and in the case of XGBoost model, the input variables are able to explain the 89% of the variance in target variable and the rest 11% is unexplained.

Conclusion

This is an individual project related to housing price prediction from historical prices.
Two different models has been created after performing data preparation and the models are evaluated.
Data visualization has also been completed to understand more about the data.
Please refer this Jupyter notebook with the original word document for easier understanding.