RMarkdown DSC 520 - Project

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Nov 20th 2020

R Markdown

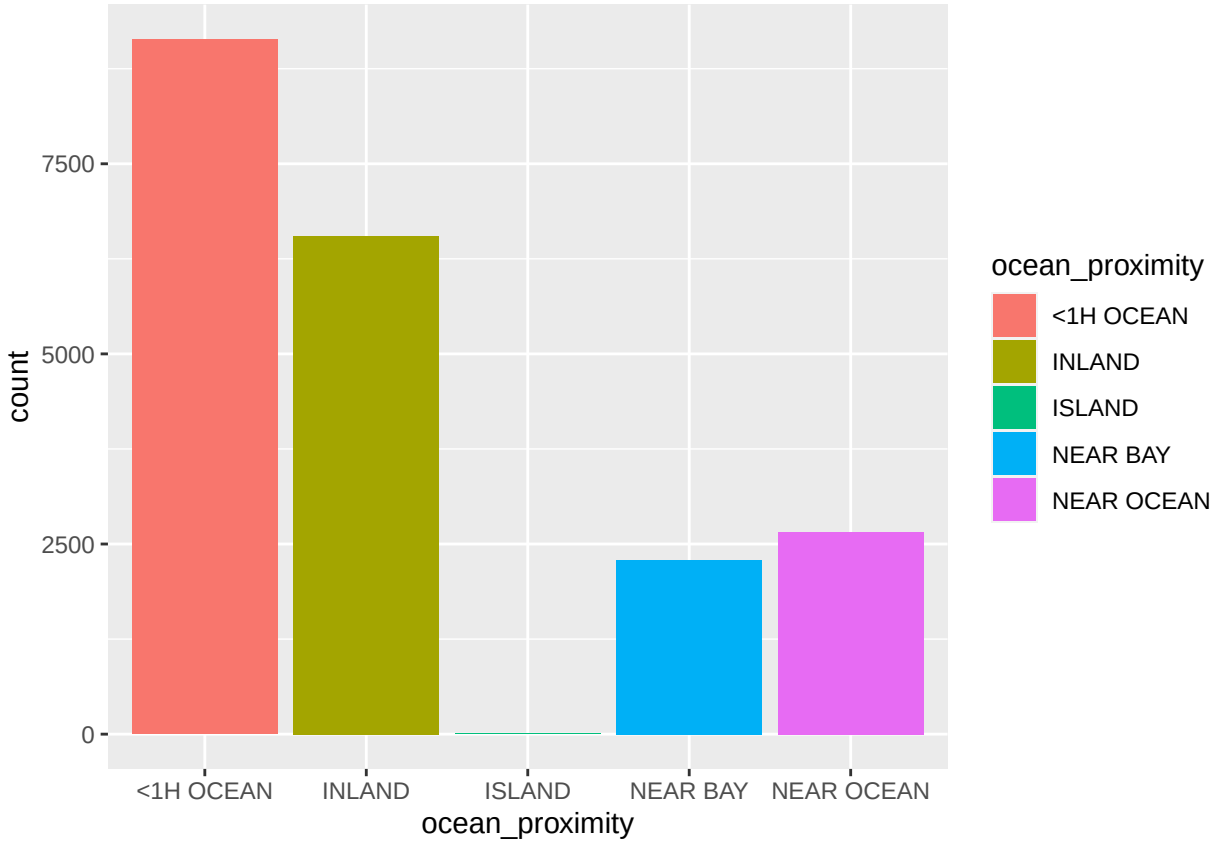
```
library(ggplot2)

library(car)
```

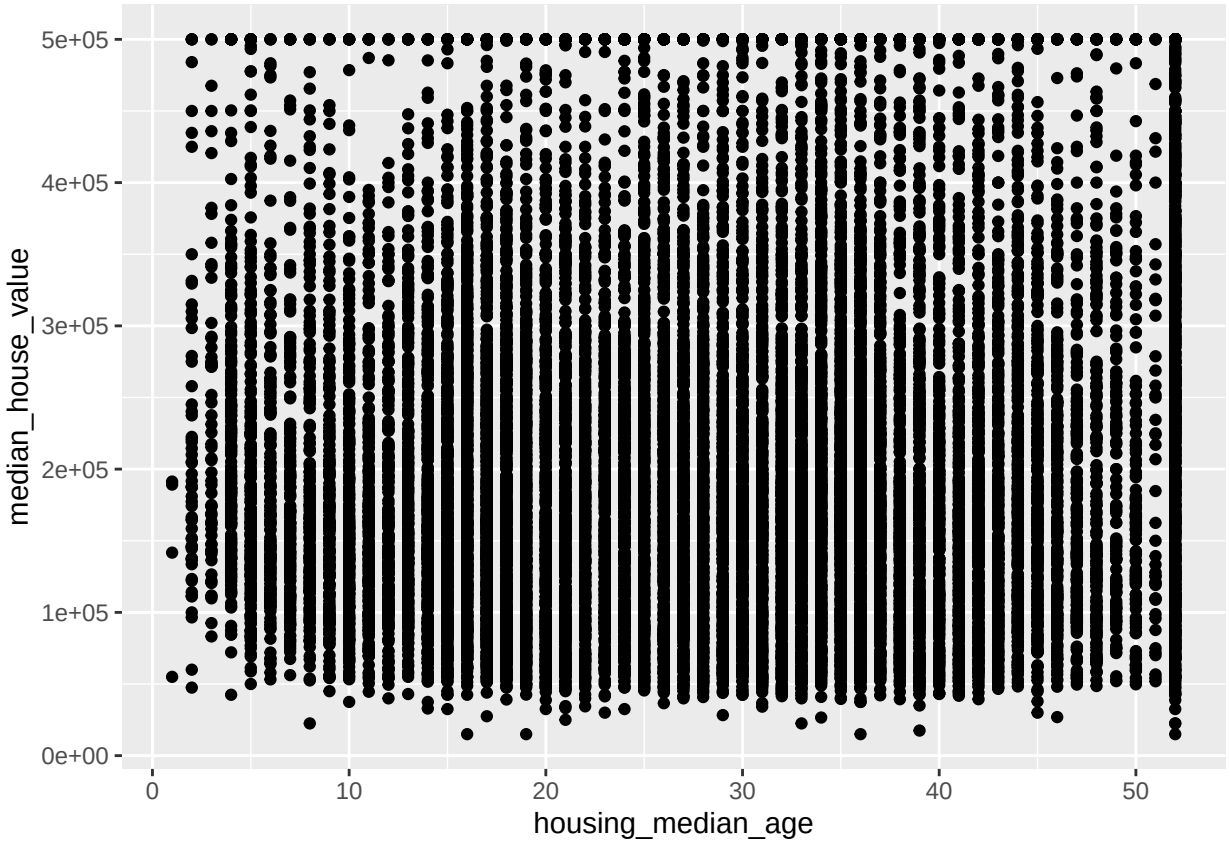
```
## Loading required package: carData
```

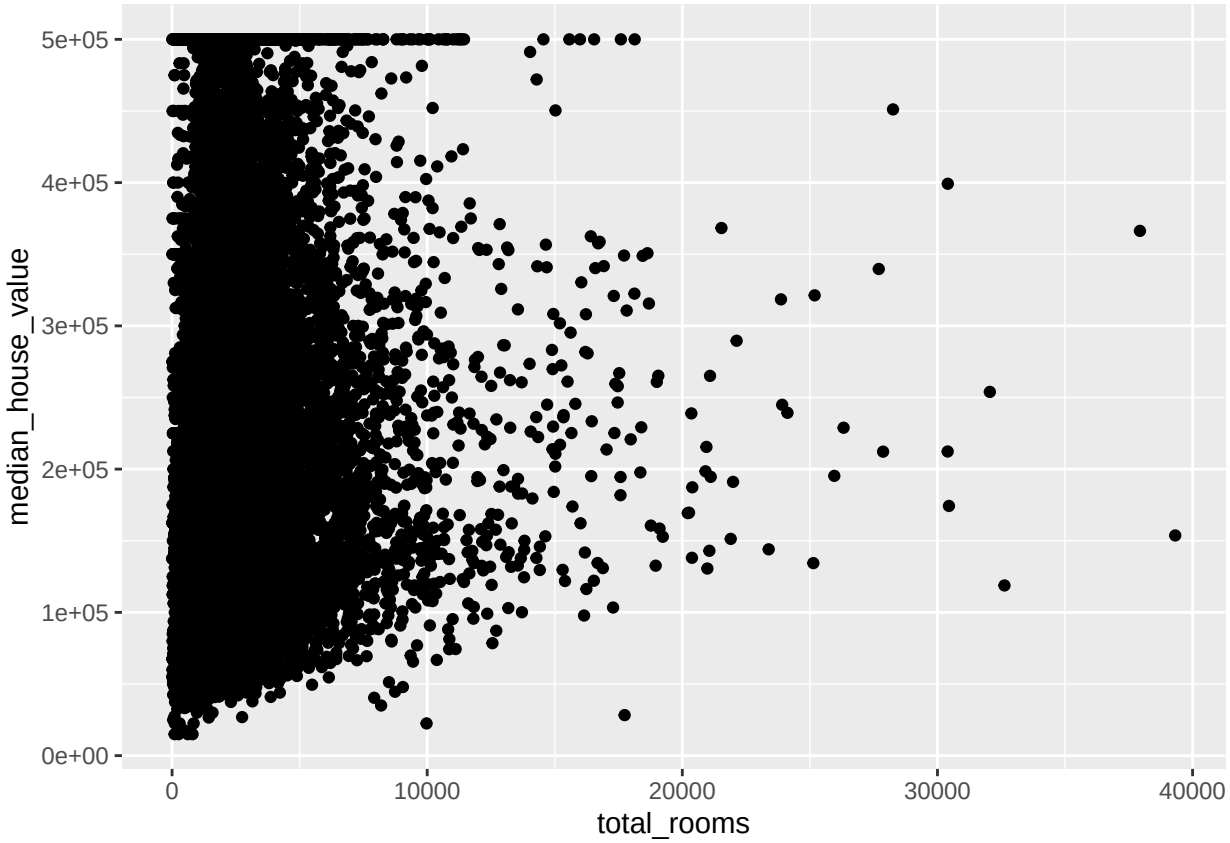
initial reading of California Housing prices csv

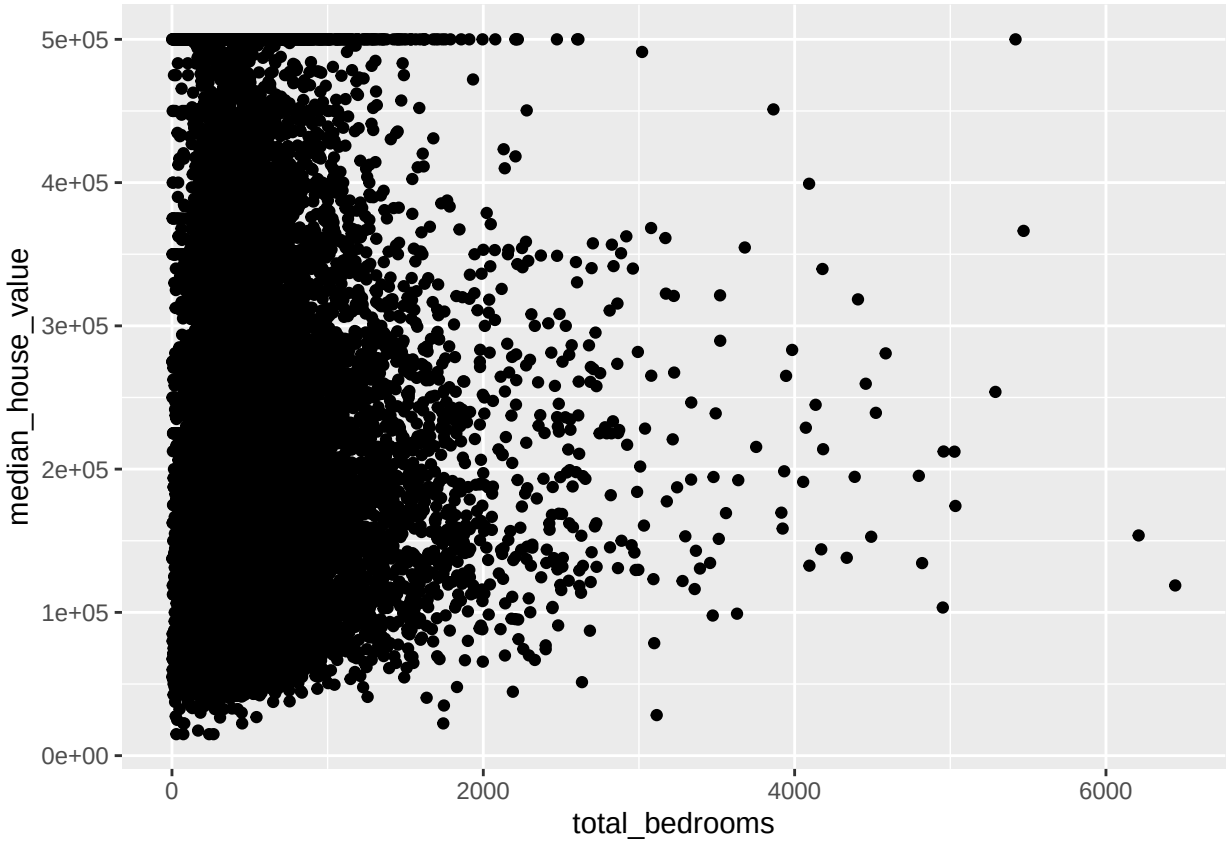
```
## 'data.frame':    20640 obs. of  10 variables:
##  $ longitude         : num  -122 -122 -122 -122 -122 ...
##  $ latitude          : num  37.9 37.9 37.9 37.9 37.9 ...
##  $ housing_median_age: num  41 21 52 52 52 52 52 52 42 52 ...
##  $ total_rooms       : num  880 7099 1467 1274 1627 ...
##  $ total_bedrooms    : num  129 1106 190 235 280 ...
##  $ population        : num  322 2401 496 558 565 ...
##  $ households        : num  126 1138 177 219 259 ...
##  $ median_income     : num  8.33 8.3 7.26 5.64 3.85 ...
##  $ median_house_value: num  452600 358500 352100 341300 342200 ...
##  $ ocean_proximity   : Factor w/ 5 levels "<1H OCEAN","INLAND",..: 4 4 4 4 4 4 4 4 4 4 ...
```

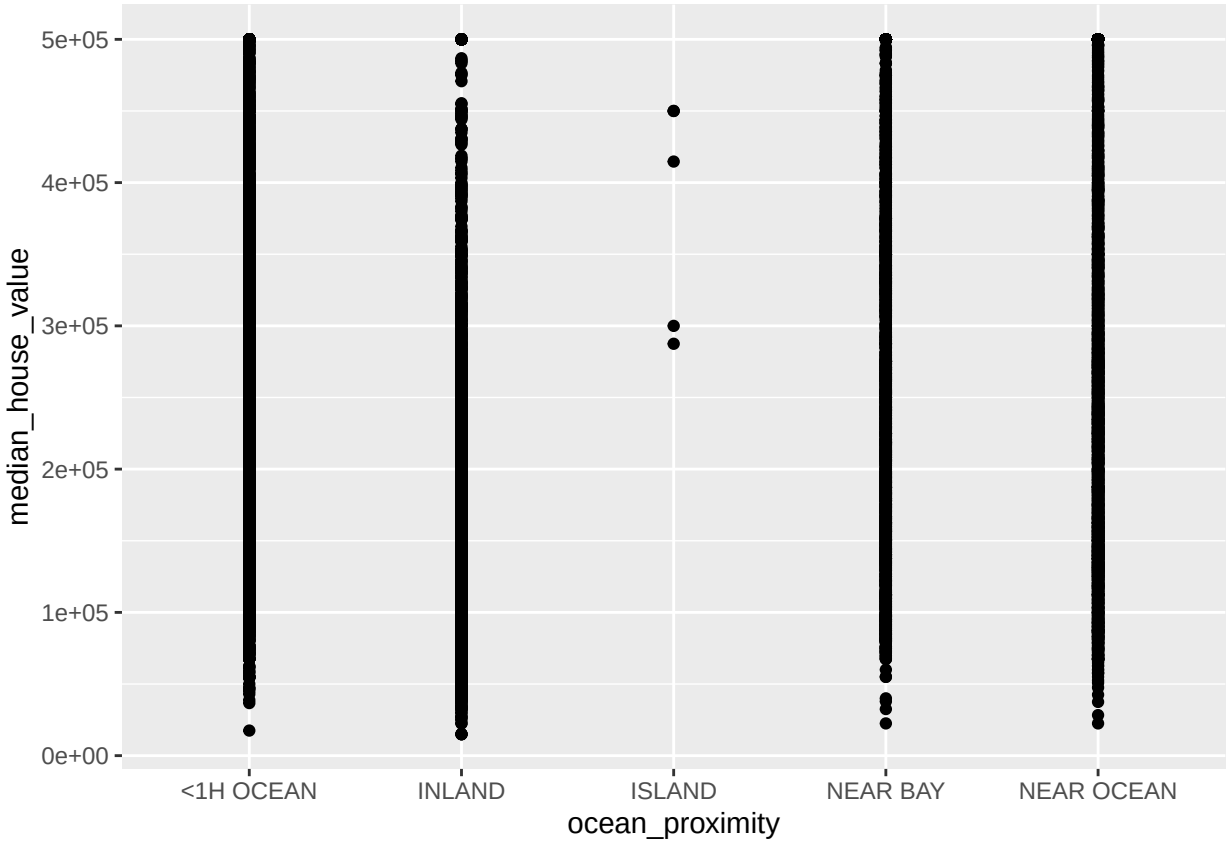
histograms and scatter plots for initial analysis

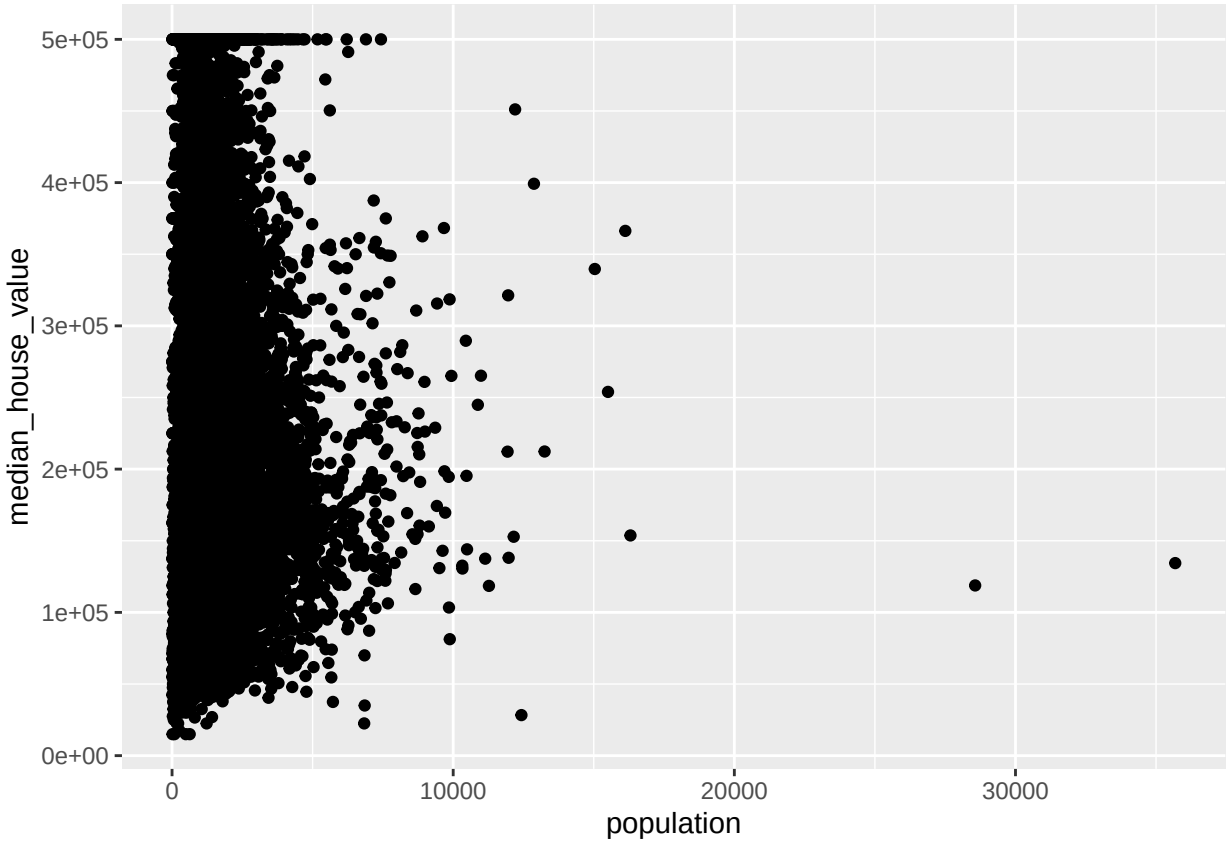

7500
5000
2500
0
count
<1H OCEAN
INLAND
ISLAND
NEAR BAY
NEAR OCEAN
ocean_proximity
ocean_proximity
<1H OCEAN
INLAND
ISLAND
NEAR BAY
NEAR OCEAN

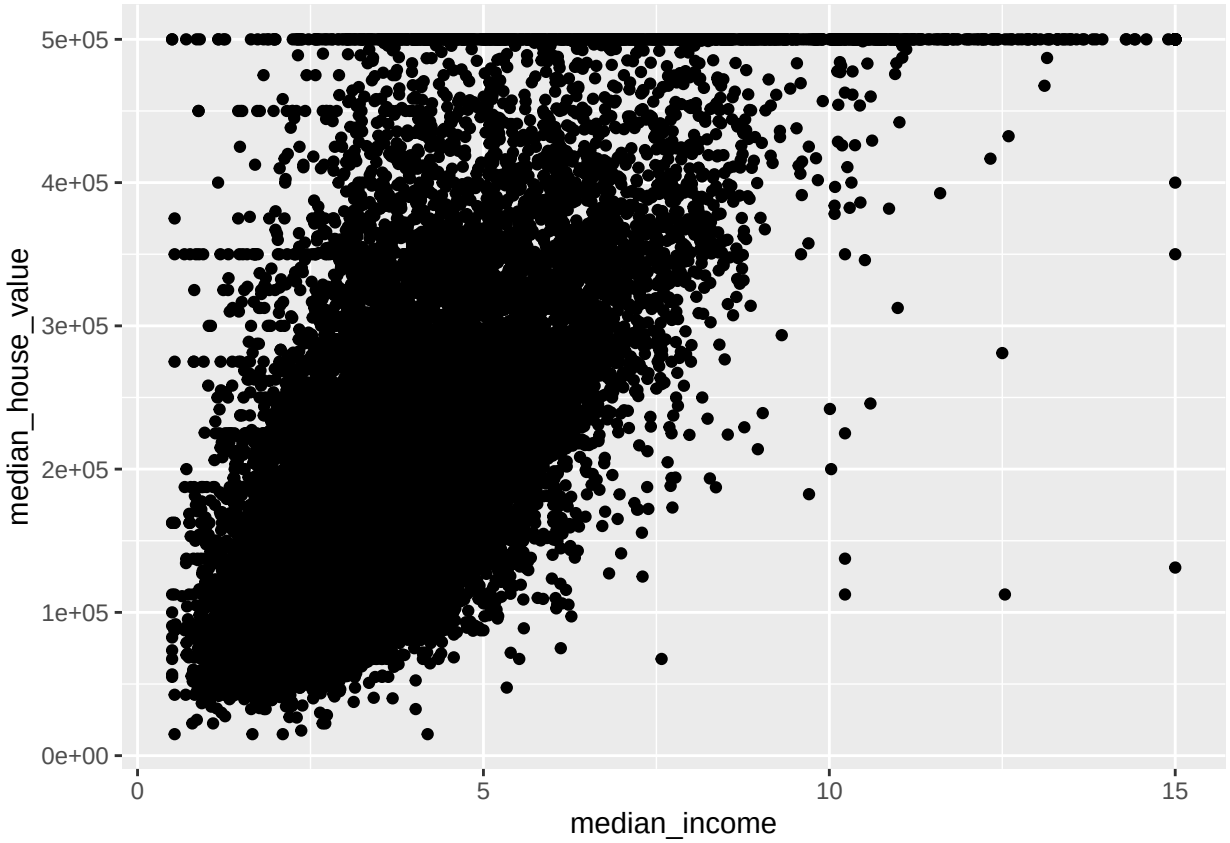

median_house_value
5e+05
4e+05
3e+05
2e+05
1e+05
0e+00
0
10
20
30
40
50
housing_median_age


5e+05
4e+05
3e+05
2e+05
1e+05
0e+00
median_house_value
0
10000
20000
30000
40000
total_rooms


5e+05
4e+05
3e+05
2e+05
1e+05
0e+00
median_house_value
0
2000
4000
6000
total_bedrooms


5e+05
4e+05
3e+05
2e+05
1e+05
0e+00
median_house_value
<1H OCEAN
INLAND
ISLAND
NEAR BAY
NEAR OCEAN
ocean_proximity


5e+05
4e+05
3e+05
2e+05
1e+05
0e+00
median_house_value
0
10000
20000
30000
population



1) There are 5 distinct categories in the ocean proximity variables

2) Housing median age vs. median house value scatter plot

3) scatter plot for total rooms vs. median house value

4) scatter plot for total bedrooms vs. median house value

5) Median House value price ranges are similar in each of the ocean proximity category, looking at the scatter plot

6) scatter plot for population vs median house value

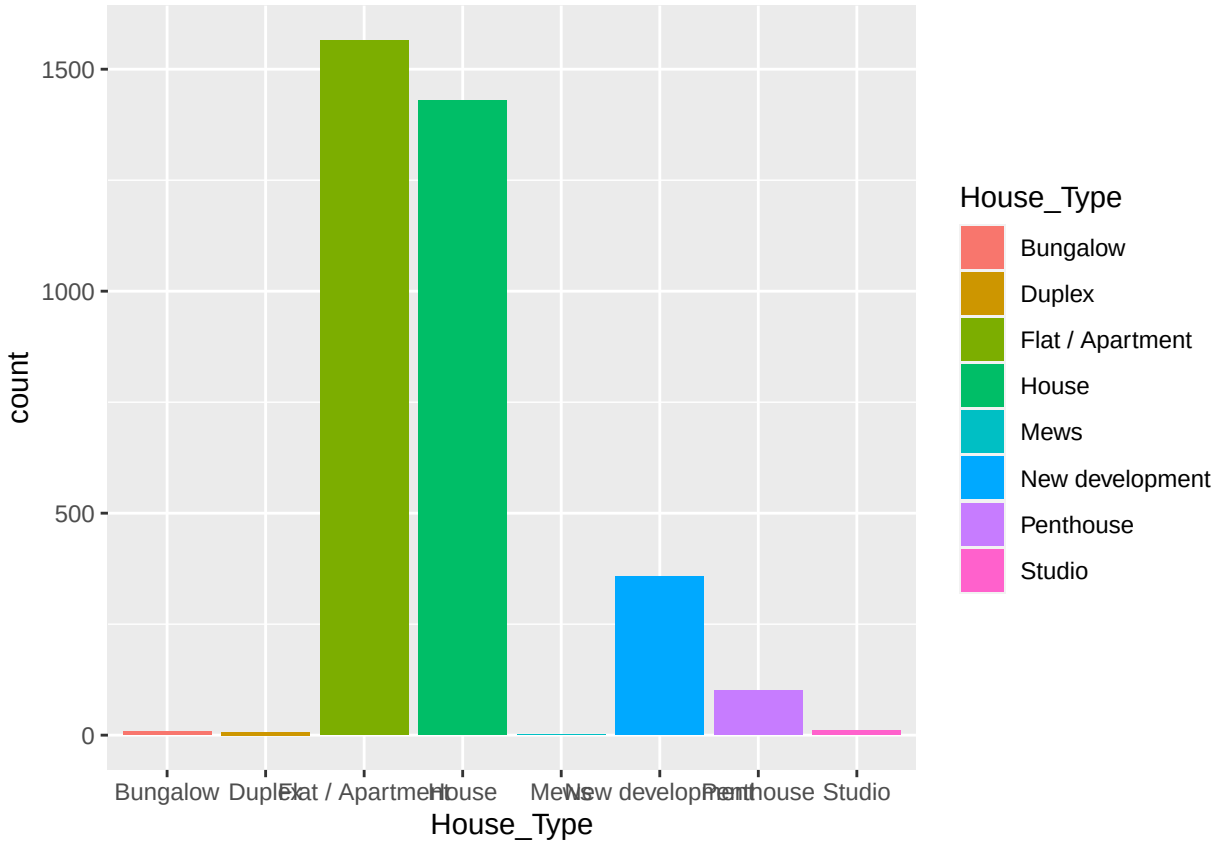
7) median income vs median house value

California Housing prices dataset has 10 columns including median house value and population, ocean proximity etc. there was not much significance and data was almost equally distributed. Thus not enough variables available for analysis. Also, when looked at the plots between. The total number of rooms, bedrooms data is not in standard format and would skew other dataset info, if merged with it. Hence decided not to use this dataset.

initial reading of London Housing prices csv

```
## 'data.frame':    3480 obs. of  6 variables:
##  $ Price         : int  1675000 650000 735000 1765000 675000 420000 1475000 650000 2500000 925000 ..
##  $ House_Type    : Factor w/ 8 levels "Bungalow","Duplex",..: 4 3 3 4 3 3 4 6 4 3 ...
##  $ Area_sqft     : int  2716 814 761 1986 700 403 1548 560 1308 646 ...
##  $ Num_Bedrooms  : int  5 2 2 4 2 1 4 1 3 2 ...
##  $ Num_Bathrooms : int  5 2 2 4 2 1 4 1 3 2 ...
##  $ Num_Receptions: int  5 2 2 4 2 1 4 1 3 2 ...
```

London housing data initial analysis histogram



London Housing prices dataset has just about 11 column variables and some of those variables do not seem to have relation for being picked as predictor (Sequence ID, Property name, Blank / Invalid Location values and in some cases consist of partial street address). Also, the sale prices are in Pounds, which may not be relevant. So decided not to use the dataset.

initial reading of US Housing prices csv file and summary

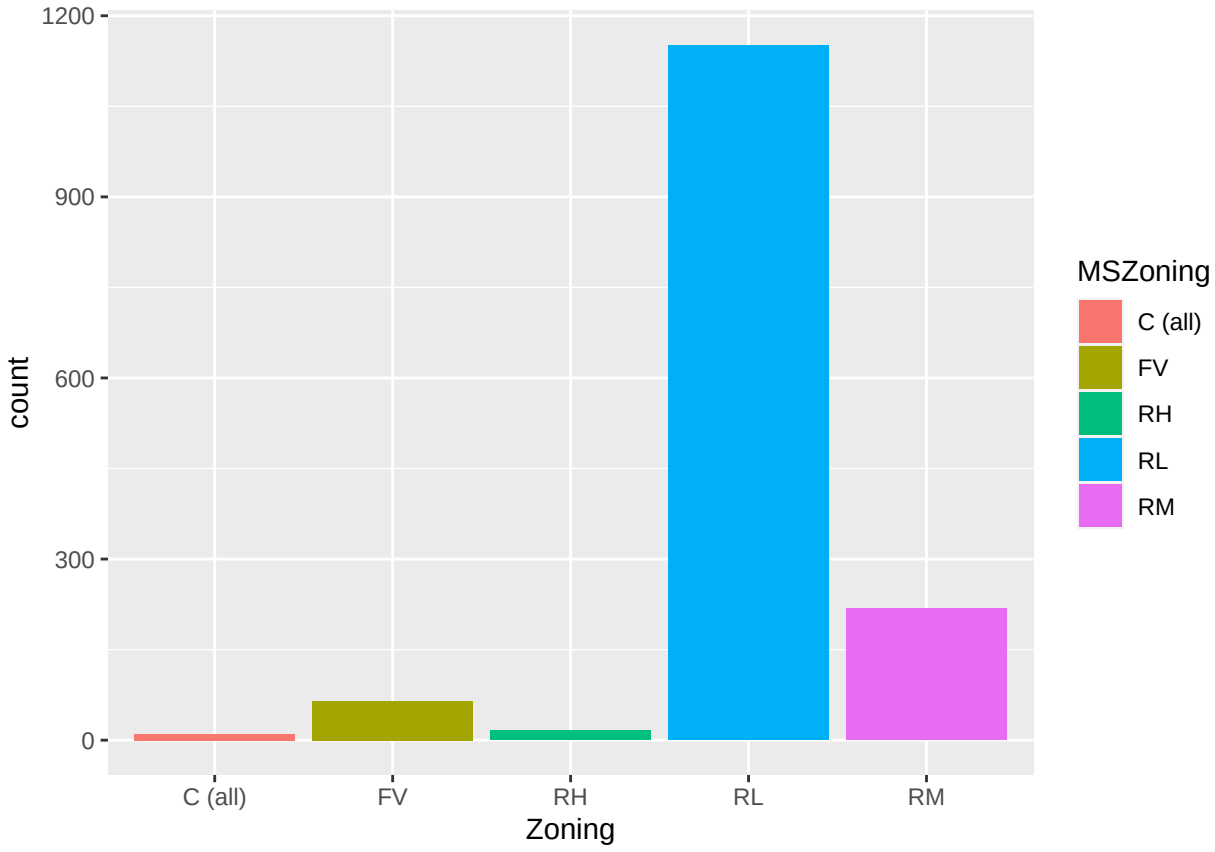
```
##    MSSubClass      MSZoning     LotFrontage        LotArea        BldgType
##  20     :536   C (all):  10   Min.   :  0.00   Min.   :  1300   1Fam  :1220
##  60     :299   FV     :  65   1st Qu.: 42.00   1st Qu.:  7554   2fmCon:  31
##  50     :144   RH     :  16   Median : 63.00   Median :  9478   Duplex:  52
##  120    : 87   RL     :1151   Mean   : 57.62   Mean   : 10517   Twnhs :  43
##  30     : 69   RM     : 218   3rd Qu.: 79.00   3rd Qu.: 11602   TwnhsE: 114
##  160    : 63                  Max.   :313.00   Max.   :215245
##  (Other):262
```

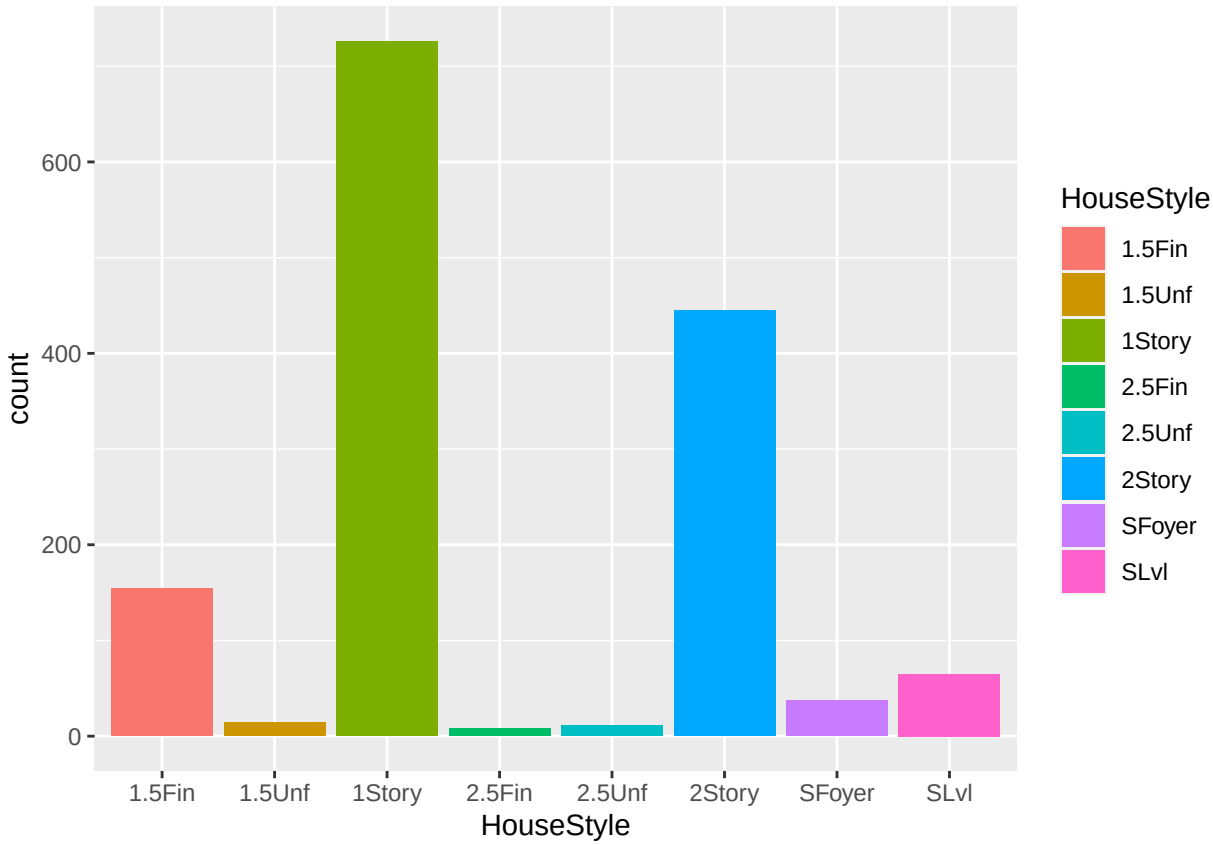
```
##    HouseStyle   LotConfig          Neighborhood        Condition1
##  1Story :726   Length:1460        Length:1460        Length:1460
##  2Story :445   Class :character   Class :character   Class :character
##  1.5Fin :154   Mode  :character   Mode  :character   Mode  :character
##  SLvl   : 65
##  SFoyer : 37
##  1.5Unf : 14
##  (Other): 19
##   Condition2         Foundation         RoofStyle           RoofMatl
##  Length:1460        Length:1460        Length:1460        Length:1460
##  Class :character   Class :character   Class :character   Class :character
##  Mode  :character   Mode  :character   Mode  :character   Mode  :character
##
##
##
##
##  Exterior1st        Exterior2nd         ExterQual          HeatingQC
##  Length:1460        Length:1460        Length:1460        Length:1460
##  Class :character   Class :character   Class :character   Class :character
##  Mode  :character   Mode  :character   Mode  :character   Mode  :character
##
##
##
##
##   Electrical         OverallQual   OverallCond    YearBuilt     YearRemodAdd
##  Length:1460        5      :397   5      :821   Min.   :1872   Min.   :1950
##  Class :character   6      :374   6      :252   1st Qu.:1954   1st Qu.:1967
##  Mode  :character   7      :319   7      :205   Median :1973   Median :1994
##                     8      :168   8      : 72   Mean   :1971   Mean   :1985
##                     4      :116   4      : 57   3rd Qu.:2000   3rd Qu.:2004
##                     9      : 43   3      : 25   Max.   :2010   Max.   :2010
##                     (Other): 43   (Other): 28
##    MasVnrArea       MasVnrType    WoodDeckSF      OpenPorchSF
##  Min.   :   0.0   BrkCmn : 15   Min.   :  0.00   Min.   :  0.00
##  1st Qu.:   0.0   BrkFace:445   1st Qu.:  0.00   1st Qu.:  0.00
##  Median :   0.0   None   :864   Median :  0.00   Median : 25.00
##  Mean   : 103.7   Stone  :128   Mean   : 94.24   Mean   : 46.66
##  3rd Qu.: 166.0   Unk    :  8   3rd Qu.:168.00   3rd Qu.: 68.00
##  Max.   :1600.0                 Max.   :857.00   Max.   :547.00
##  NA's   :8
##  EnclosedPorch      BsmtFinSF1      TotalBsmtSF     BsmtFinType1
##  Min.   :  0.00   Min.   :   0.0   Min.   :   0.0   Length:1460
##  1st Qu.:  0.00   1st Qu.:   0.0   1st Qu.: 795.8   Class :character
##  Median :  0.00   Median : 383.5   Median : 991.5   Mode  :character
##  Mean   : 21.95   Mean   : 443.6   Mean   :1057.4
##  3rd Qu.:  0.00   3rd Qu.: 712.2   3rd Qu.:1298.2
##  Max.   :552.00   Max.   :5644.0   Max.   :6110.0
##
##    BsmtQual           GrLivArea       FullBath        HalfBath
##  Length:1460        Min.   : 334   Min.   :0.000   Min.   :0.0000
##  Class :character   1st Qu.:1130   1st Qu.:1.000   1st Qu.:0.0000
##  Mode  :character   Median :1464   Median :2.000   Median :0.0000
##                     Mean   :1515   Mean   :1.565   Mean   :0.3829
##                     3rd Qu.:1777   3rd Qu.:2.000   3rd Qu.:1.0000
```

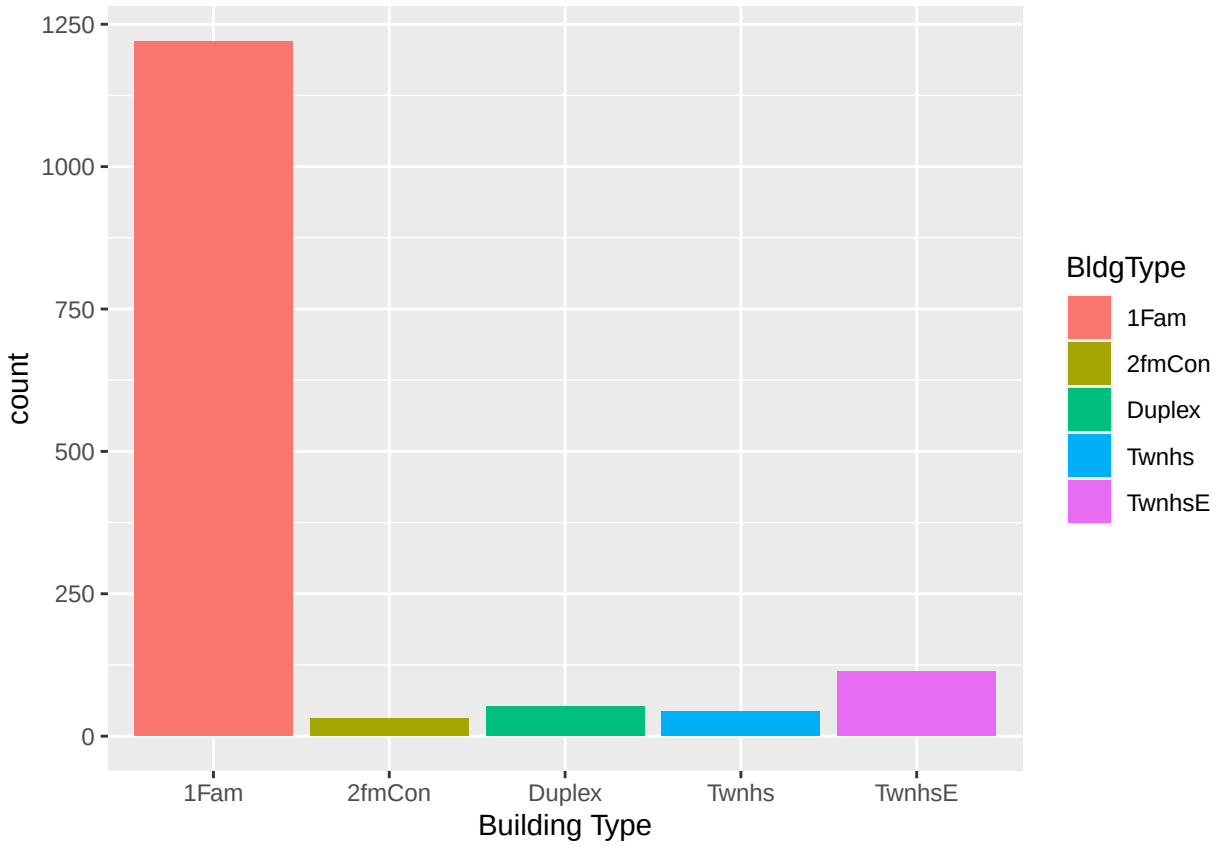
```
##                    Max.   :5642   Max.   :3.000   Max.   :2.0000
##
##   BedroomAbvGr    TotRmsAbvGrd      GarageArea       Fence
##  Min.   :0.000   Min.   : 2.000   Min.   :   0.0   GdPrv:  59
##  1st Qu.:2.000   1st Qu.: 5.000   1st Qu.: 334.5   GdWo :  54
##  Median :3.000   Median : 6.000   Median : 480.0   MnPrv: 157
##  Mean   :2.866   Mean   : 6.518   Mean   : 473.0   MnWw :  11
##  3rd Qu.:3.000   3rd Qu.: 7.000   3rd Qu.: 576.0   NA's :1179
##  Max.   :8.000   Max.   :14.000   Max.   :1418.0
##
##    SalePrice
##  Min.   : 34900
##  1st Qu.:129975
##  Median :163000
##  Mean   :180921
##  3rd Qu.:214000
##  Max.   :755000
##
```

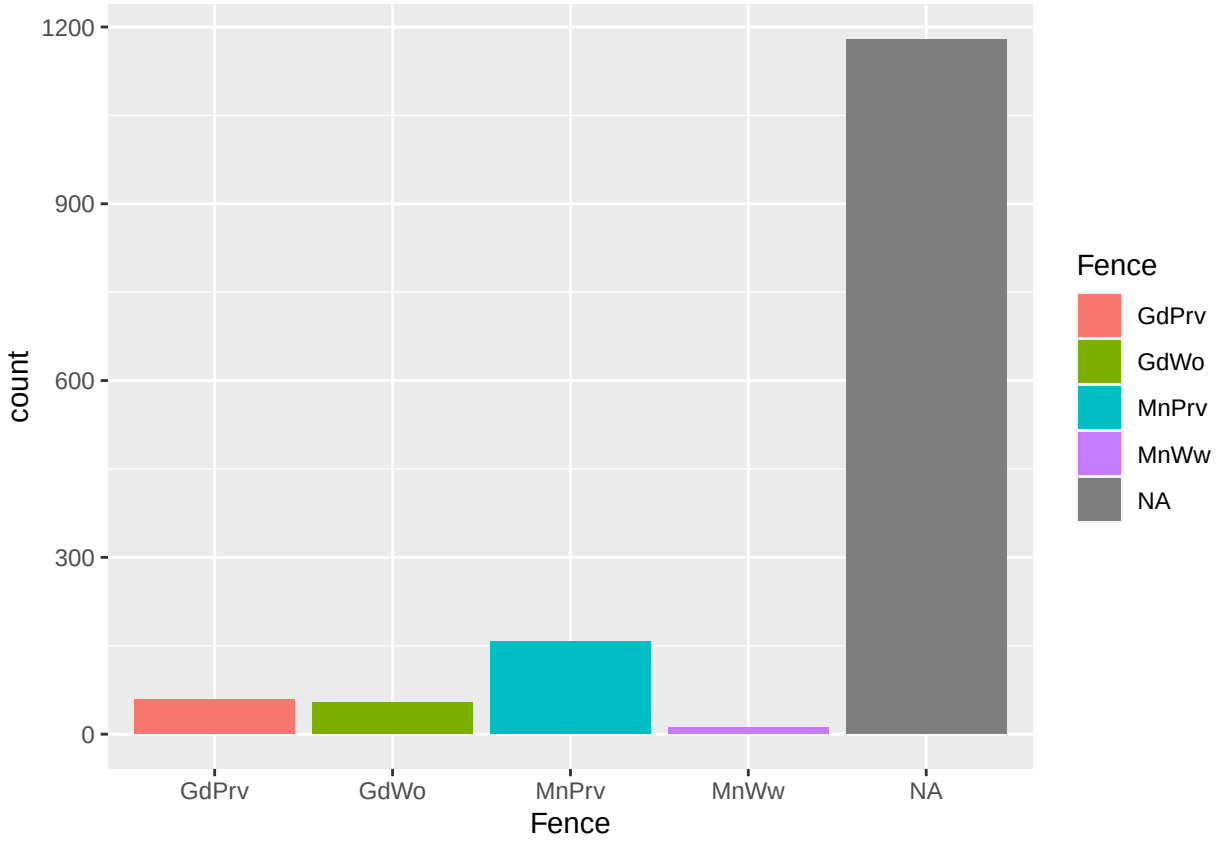
US Housing prices dataset has plenty of variables (81 in all) and hence I will be using this dataset for my analysis purpose. I have manually looked at the data variables and also used some of the plots to understand the data points / variables. I have tried to capture this information below. Noticed that TotalBsmtSF is the addition of BsmtFinSF1, BsmtFinSF2 and BsmtUnfSF. Similarly 1stFlrSF and 2ndFlrSF columns values are combined into and it is present in variable GrLivArea.

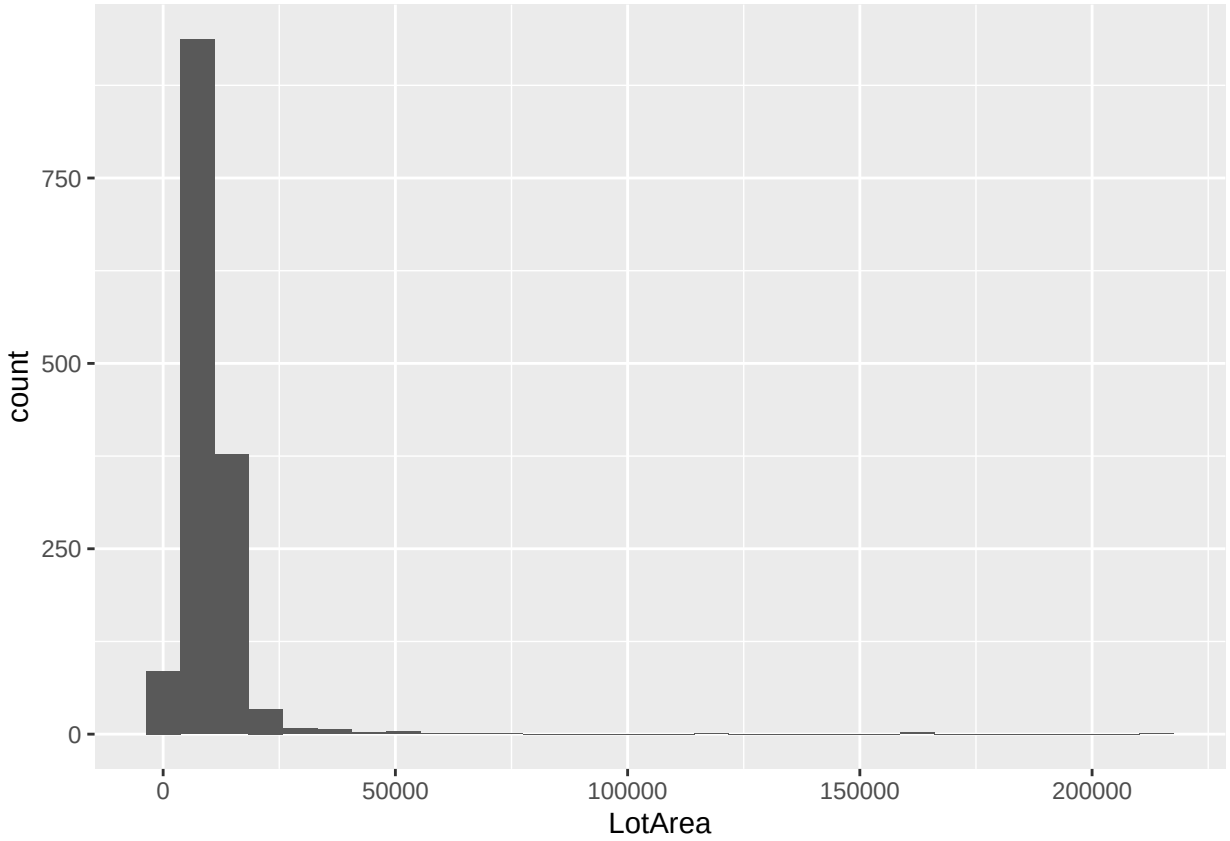
histogram plots for initial analysis of data to also help with data cleanup steps

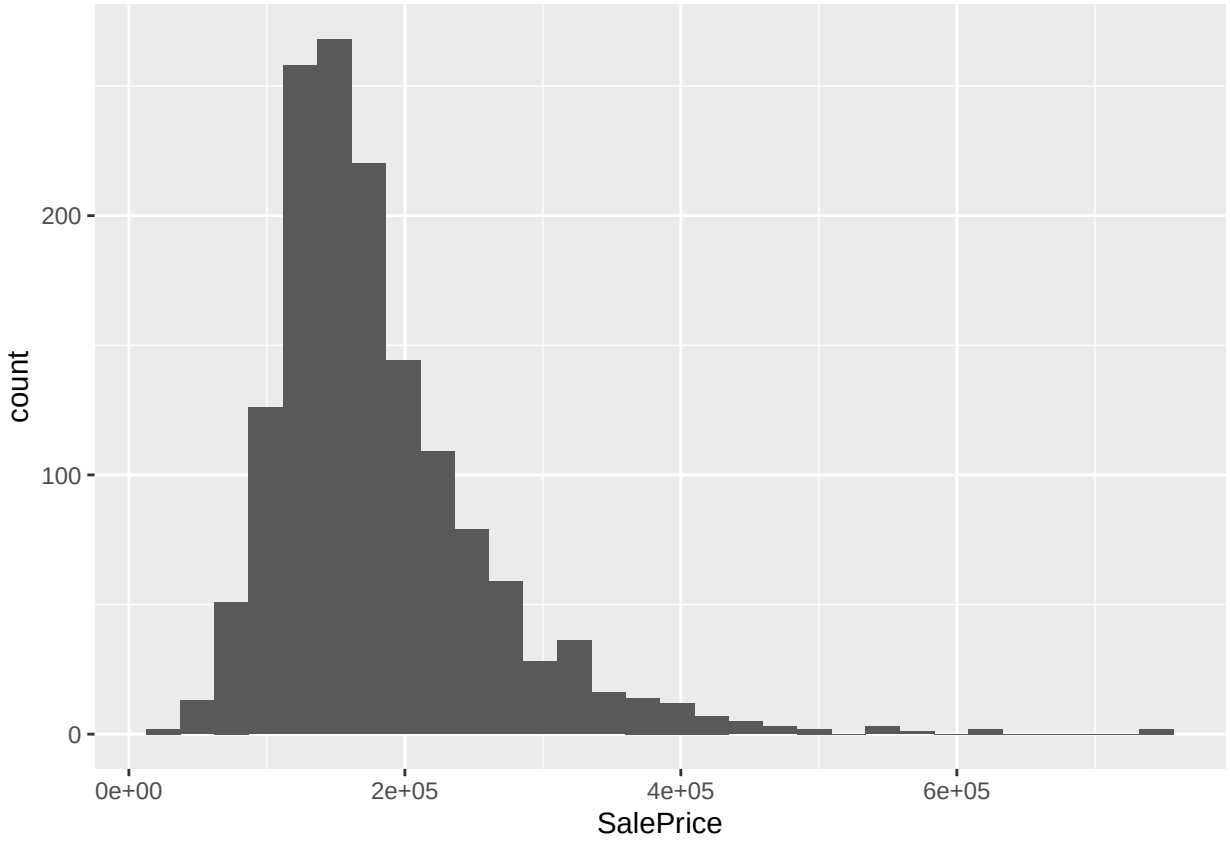

1200
900
600
300
0
count
C (all)
FV
RH
RL
RM
Zoning
MSZoning
C (all)
FV
RH
RL
RM


600
400
200
0
count
1.5Fin
1.5Unf
1Story
2.5Fin
2.5Unf
2Story
SFoyer
SLvl
HouseStyle
HouseStyle
1.5Fin
1.5Unf
1Story
2.5Fin
2.5Unf
2Story
SFoyer
SLvl

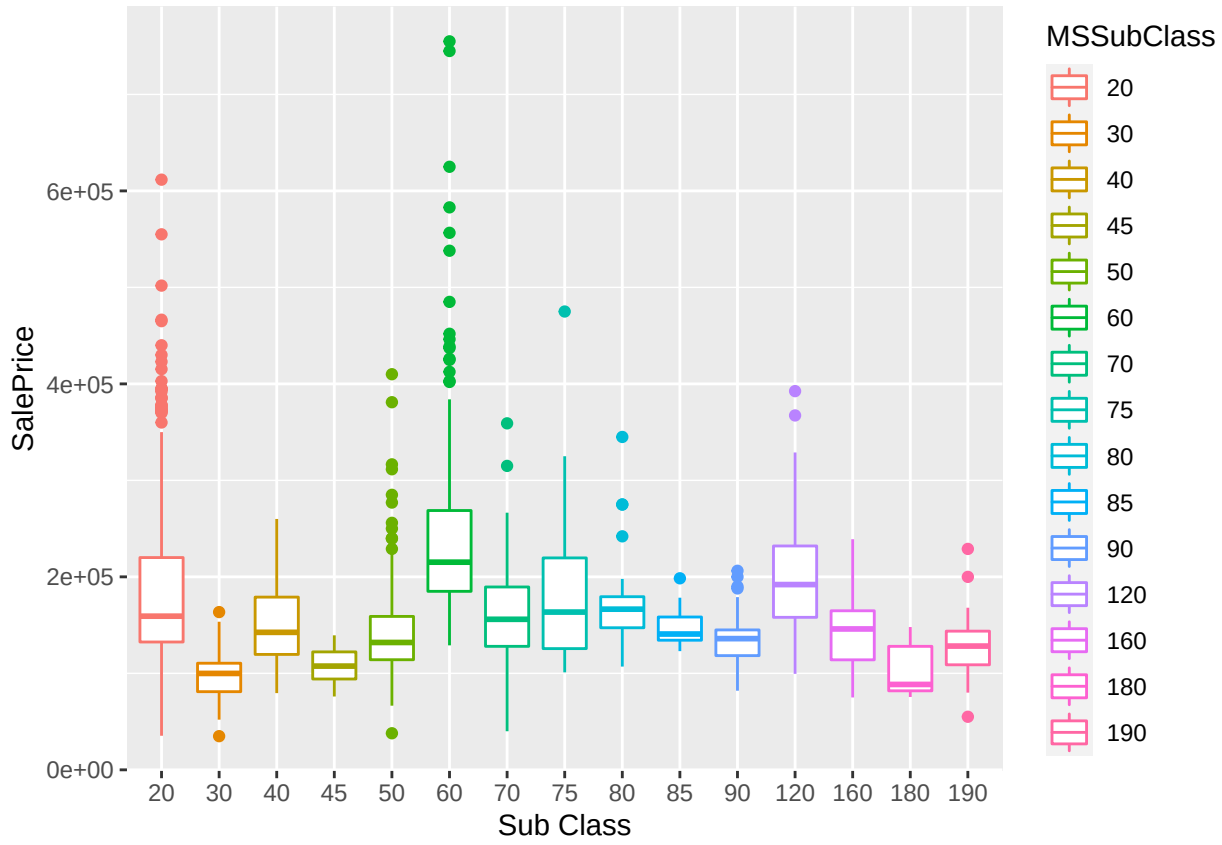

1250
1000
750
500
250
0
count
1Fam
2fmCon
Duplex
Twnhs
TwnhsE
Building Type
BldgType
1Fam
2fmCon
Duplex
Twnhs
TwnhsE

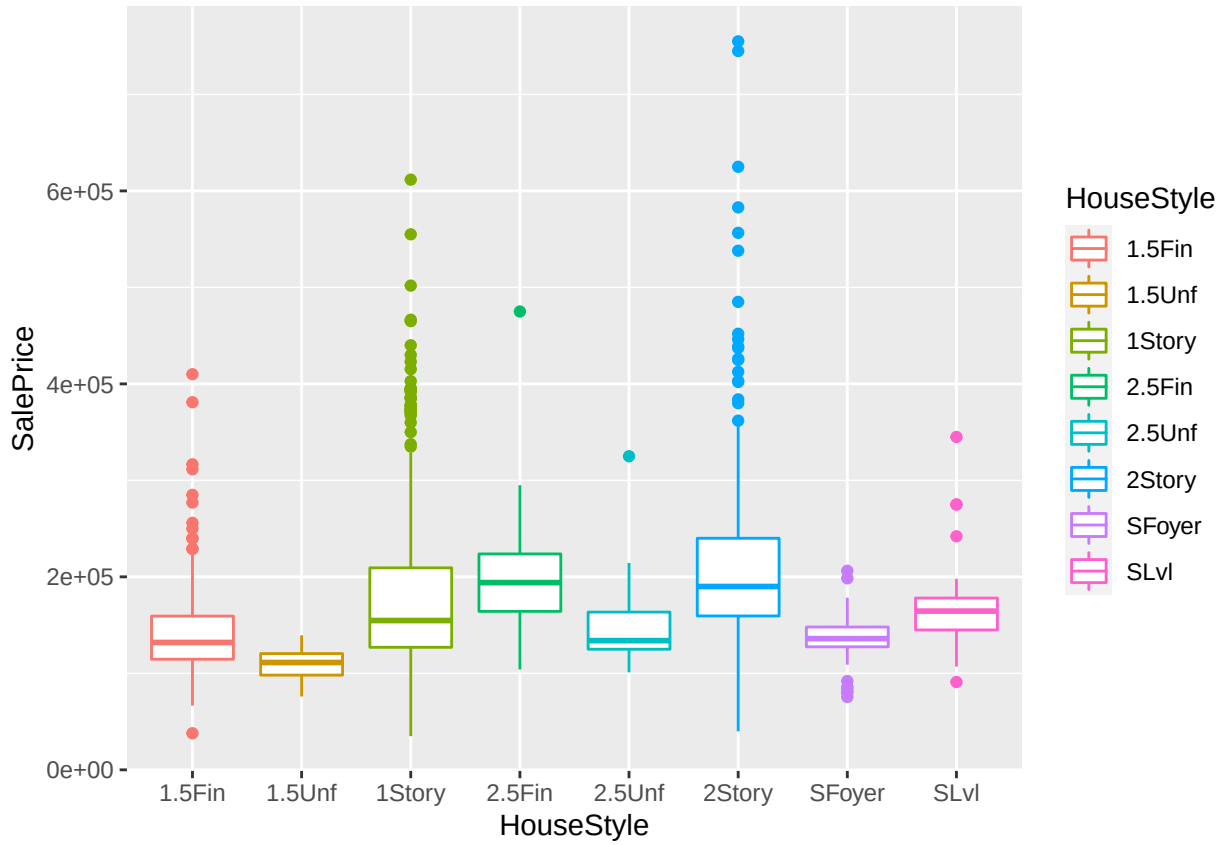

1200
900
600
300
0
count
GdPrv
GdWo
MnPrv
MnWw
NA
Fence
Fence
GdPrv
GdWo
MnPrv
MnWw
NA

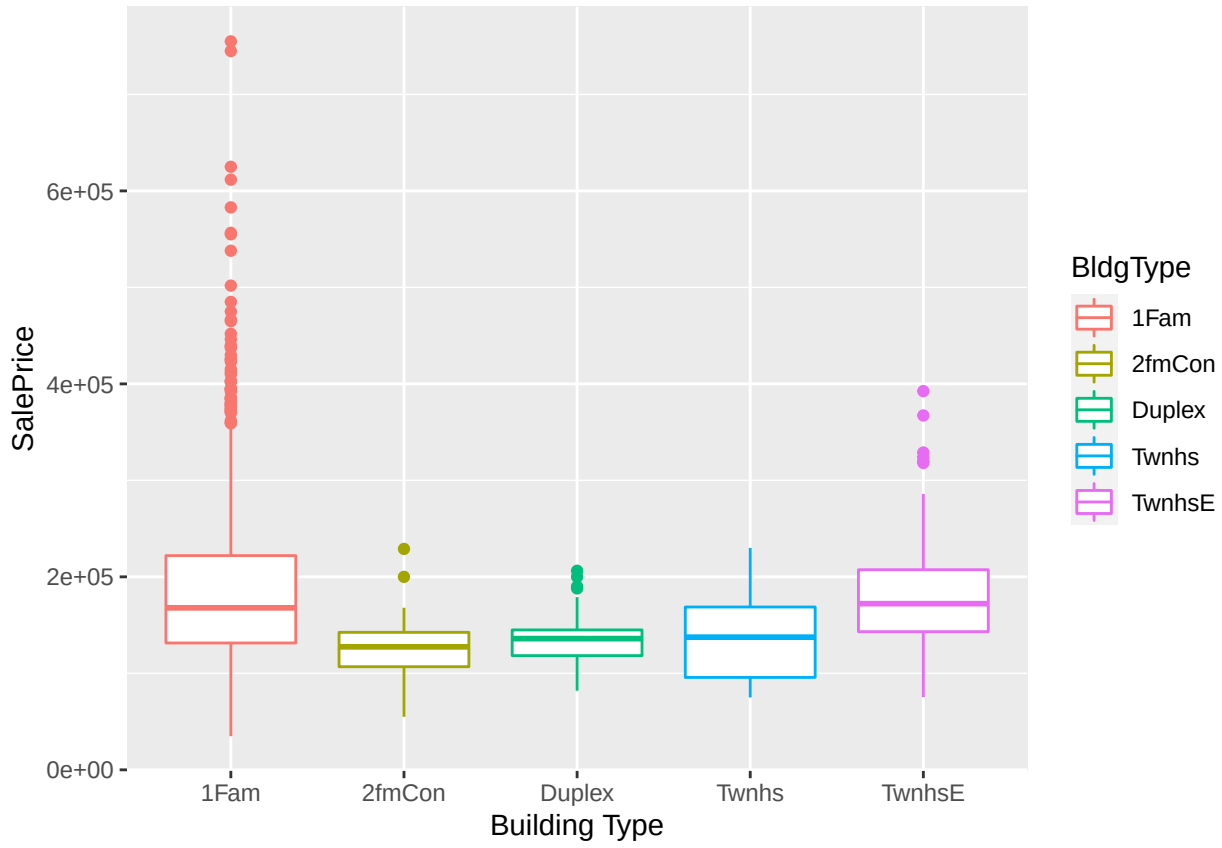

750
500
250
0
count
0
50000
100000
150000
200000
LotArea

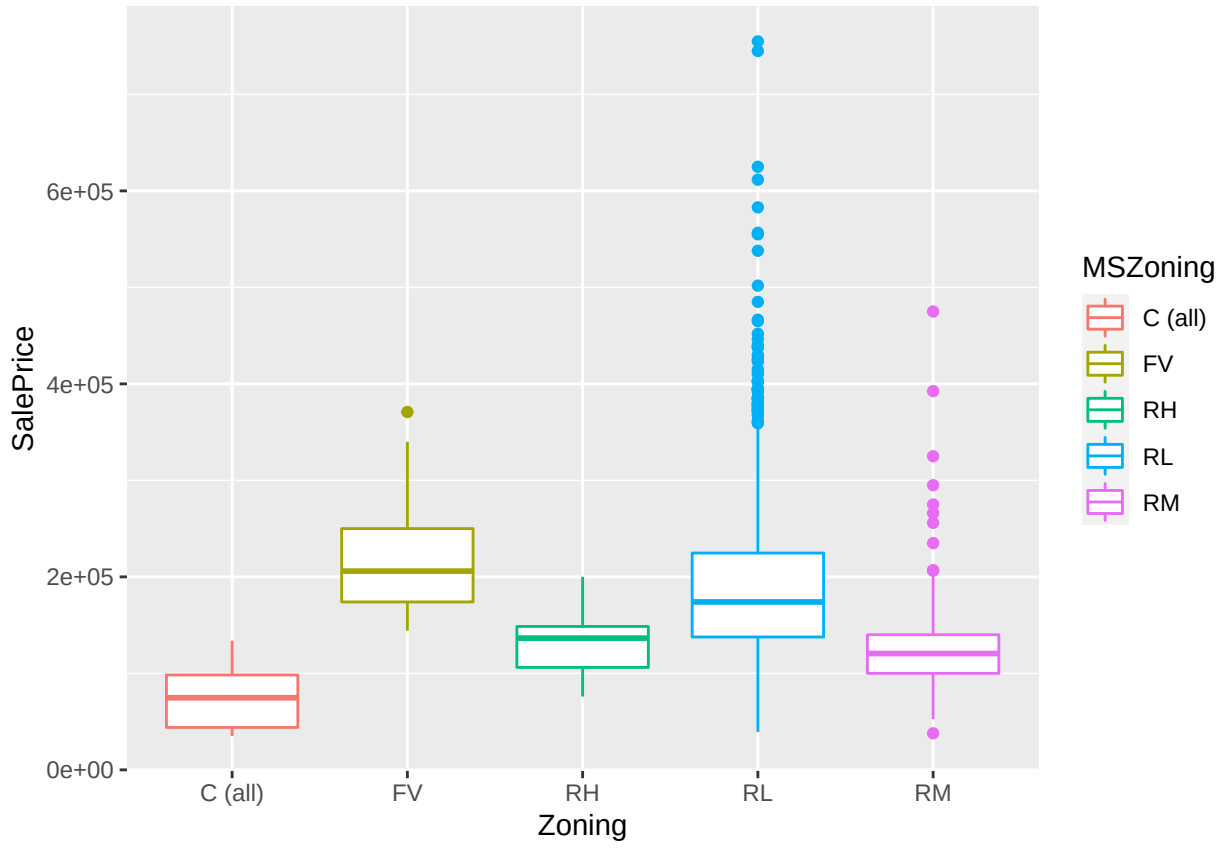


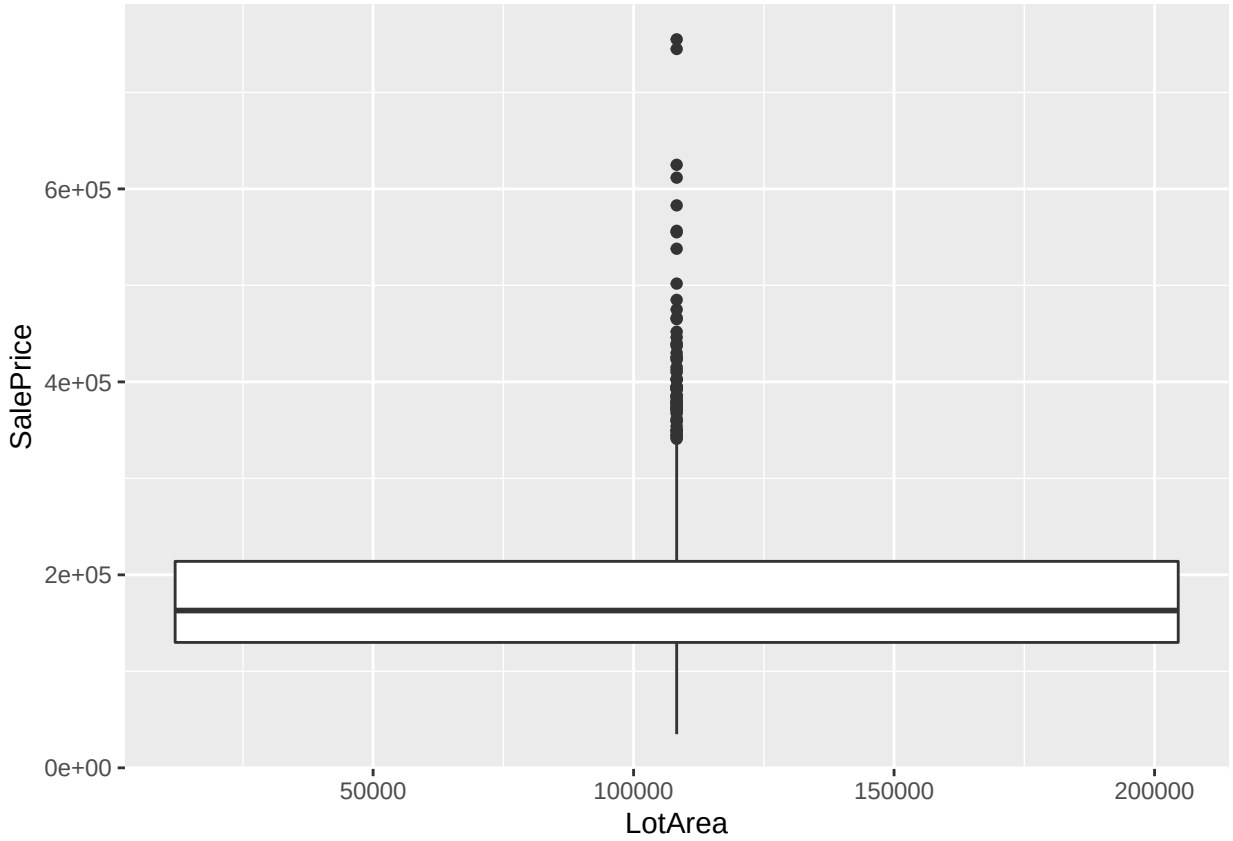
box plots and scatter plots for initial analysis of data to also help with data cleanup steps

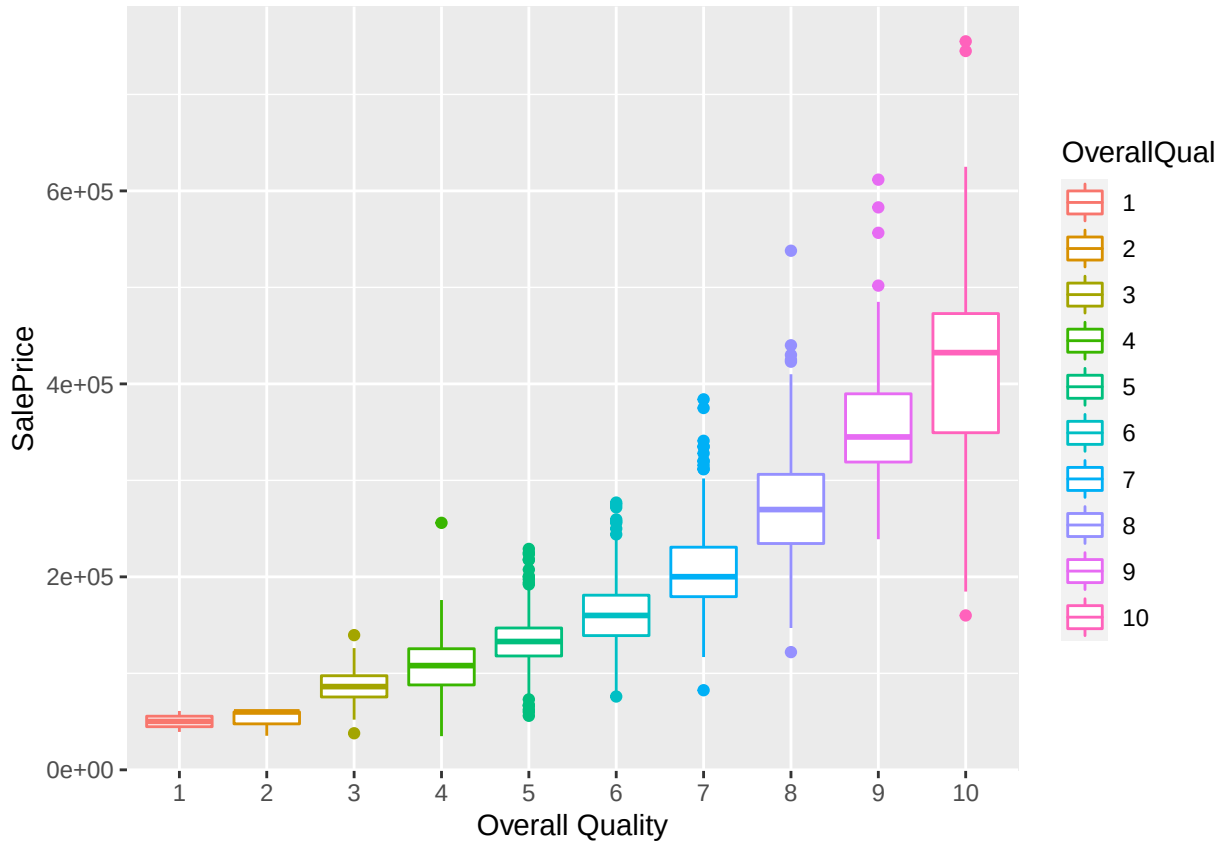

SalePrice
6e+05
4e+05
2e+05
0e+00
20
30
40
45
50
60
70
75
80
85
90
120
160
180
190
Sub Class
MSSubClass
20
30
40
45
50
60
70
75
80
85
90
120
160
180
190

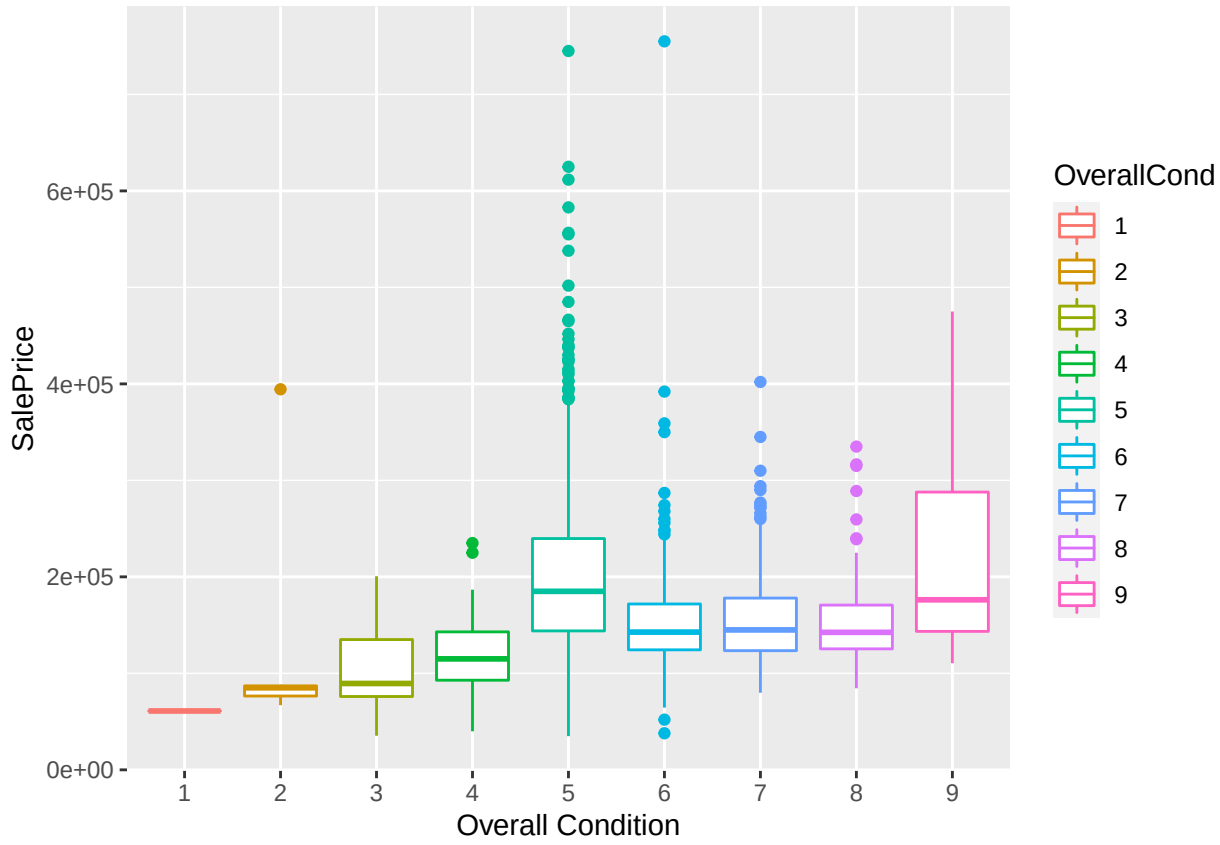

SalePrice
6e+05
4e+05
2e+05
0e+00
1.5Fin
1.5Unf
1Story
2.5Fin
2.5Unf
2Story
SFoyer
SLvl
HouseStyle
HouseStyle
1.5Fin
1.5Unf
1Story
2.5Fin
2.5Unf
2Story
SFoyer
SLvl

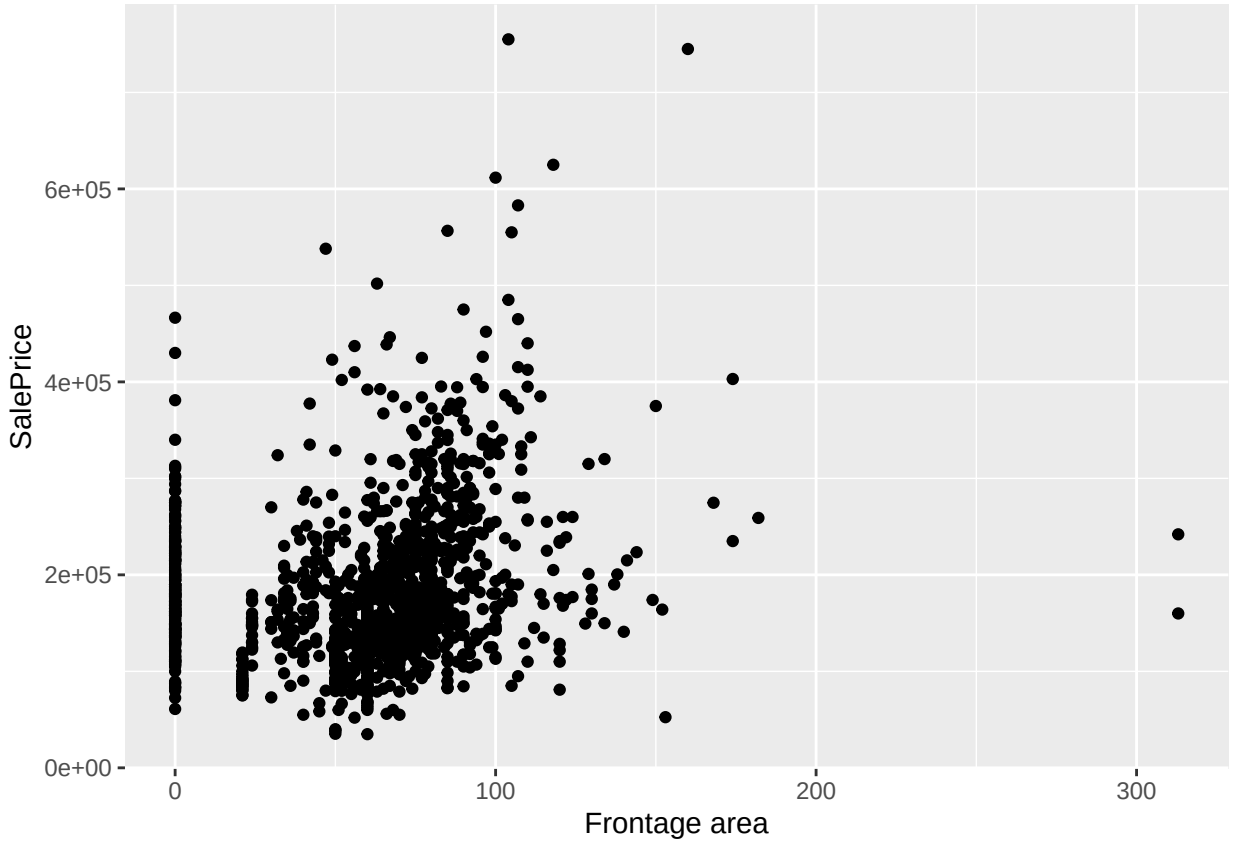

SalePrice
6e+05
4e+05
2e+05
0e+00
1Fam
2fmCon
Duplex
Twnhs
TwnhsE
Building Type
BldgType
1Fam
2fmCon
Duplex
Twnhs
TwnhsE

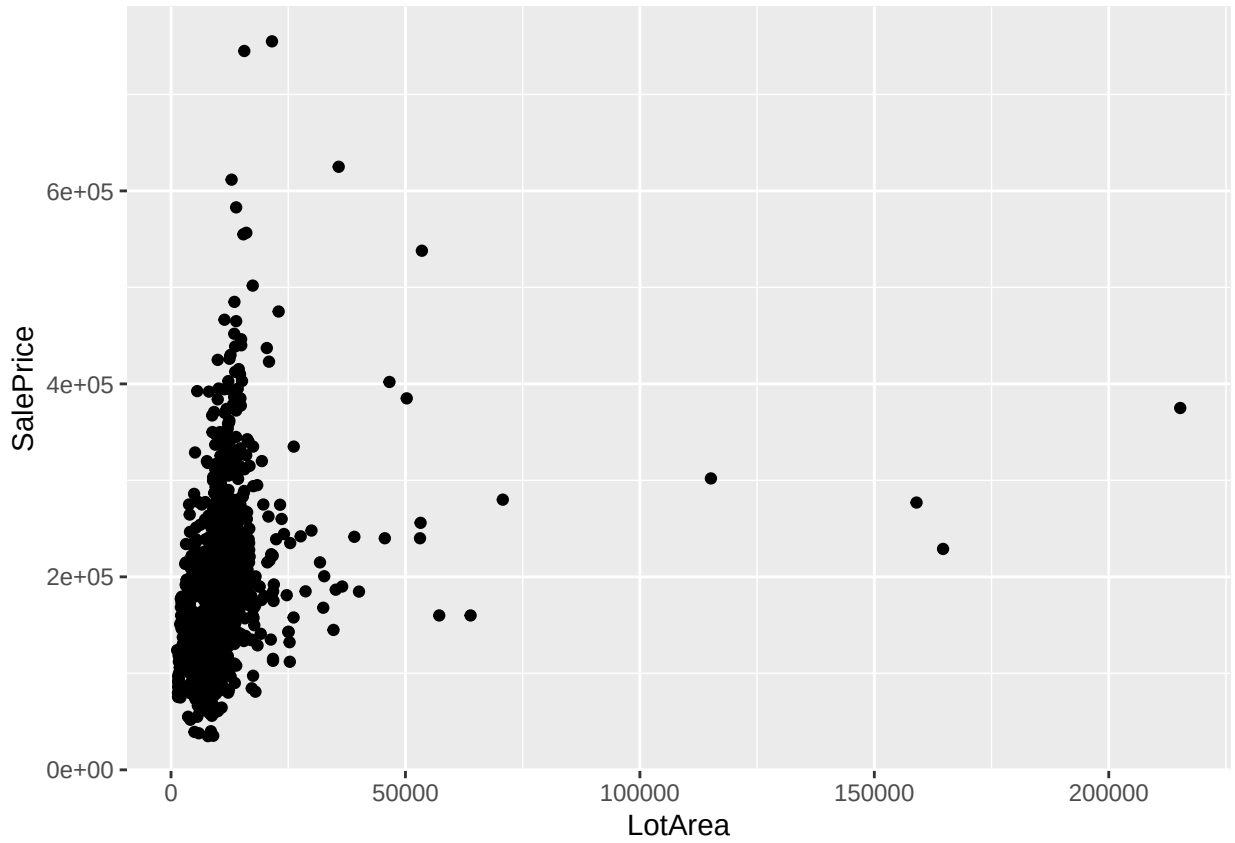

SalePrice
6e+05
4e+05
2e+05
0e+00
C (all)
FV
RH
RL
RM
Zoning
MSZoning
C (all)
FV
RH
RL
RM

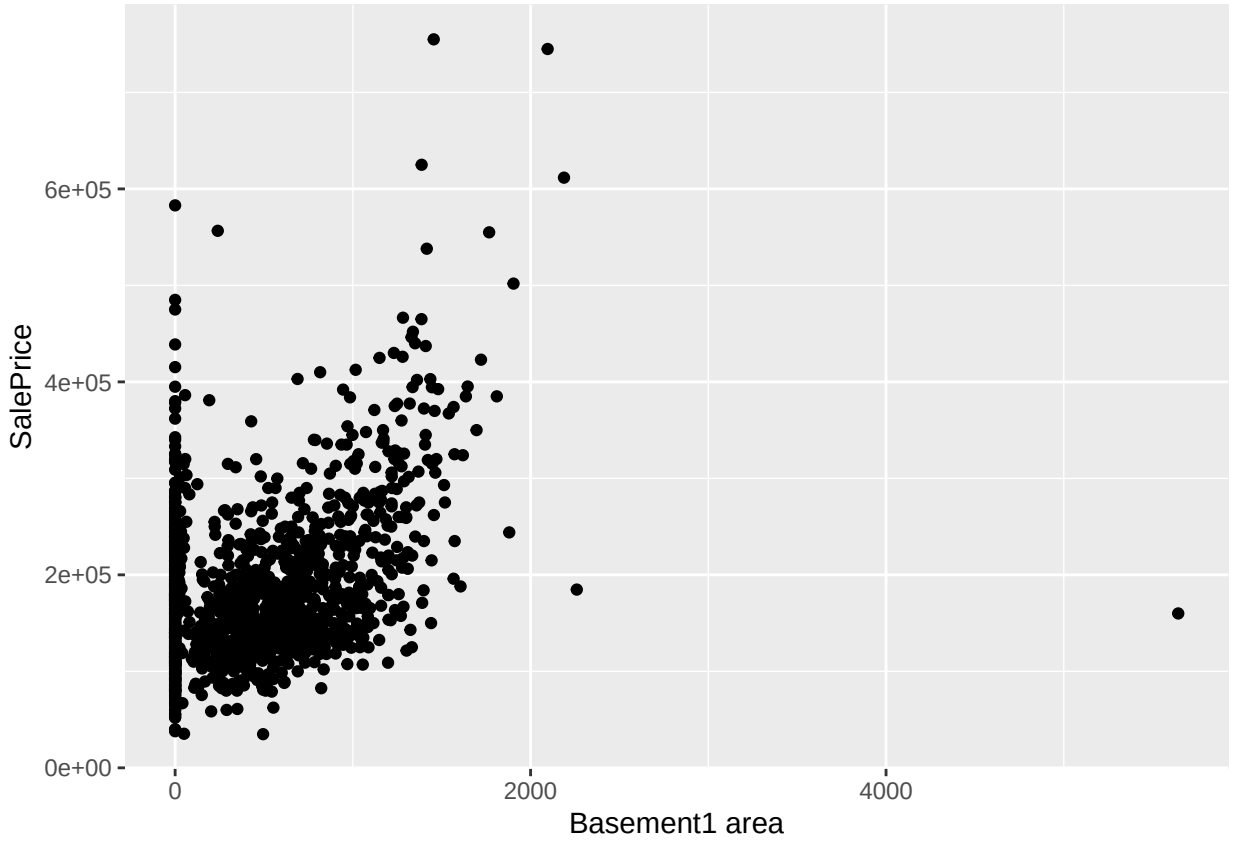

SalePrice
6e+05
4e+05
2e+05
0e+00
50000
100000
150000
200000
LotArea

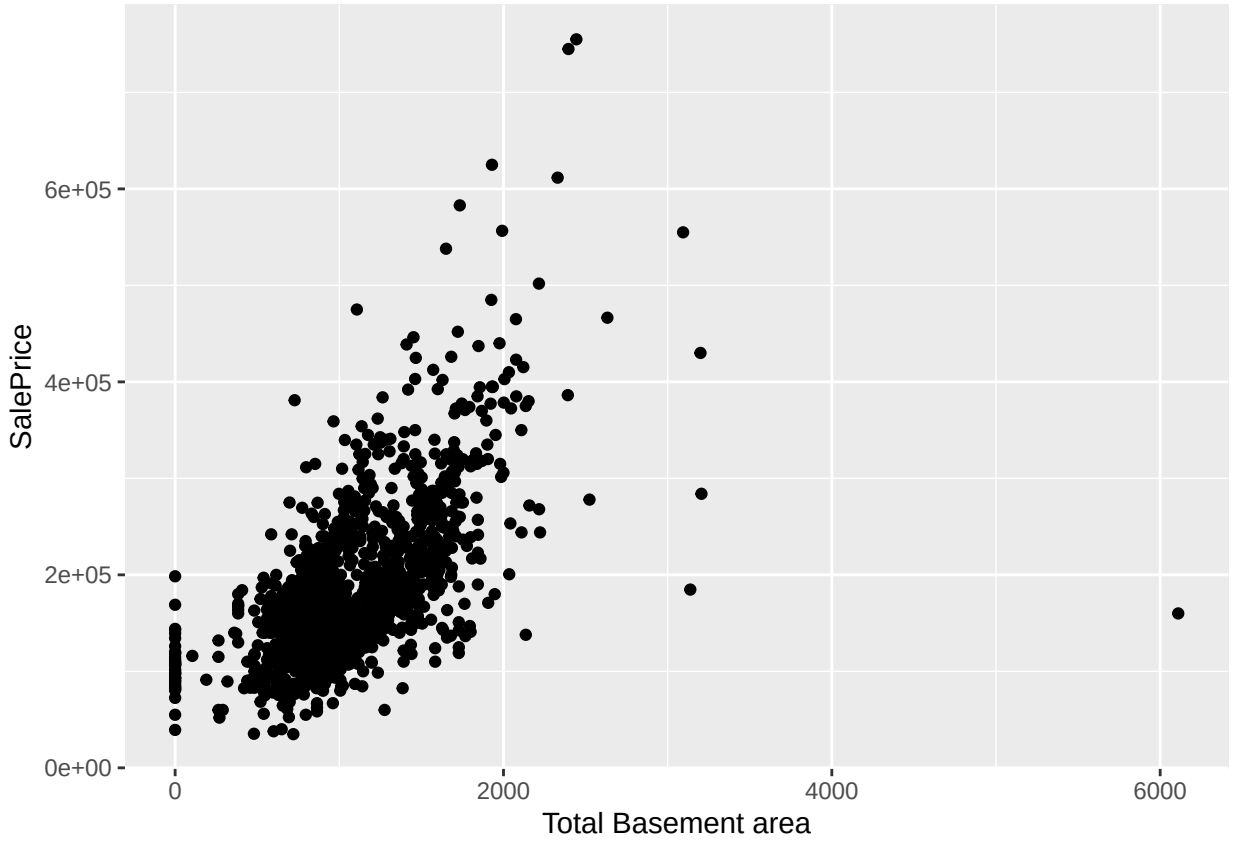

SalePrice
6e+05
4e+05
2e+05
0e+00
1
2
3
4
5
6
7
8
9
10
Overall Quality
OverallQual
1
2
3
4
5
6
7
8
9
10

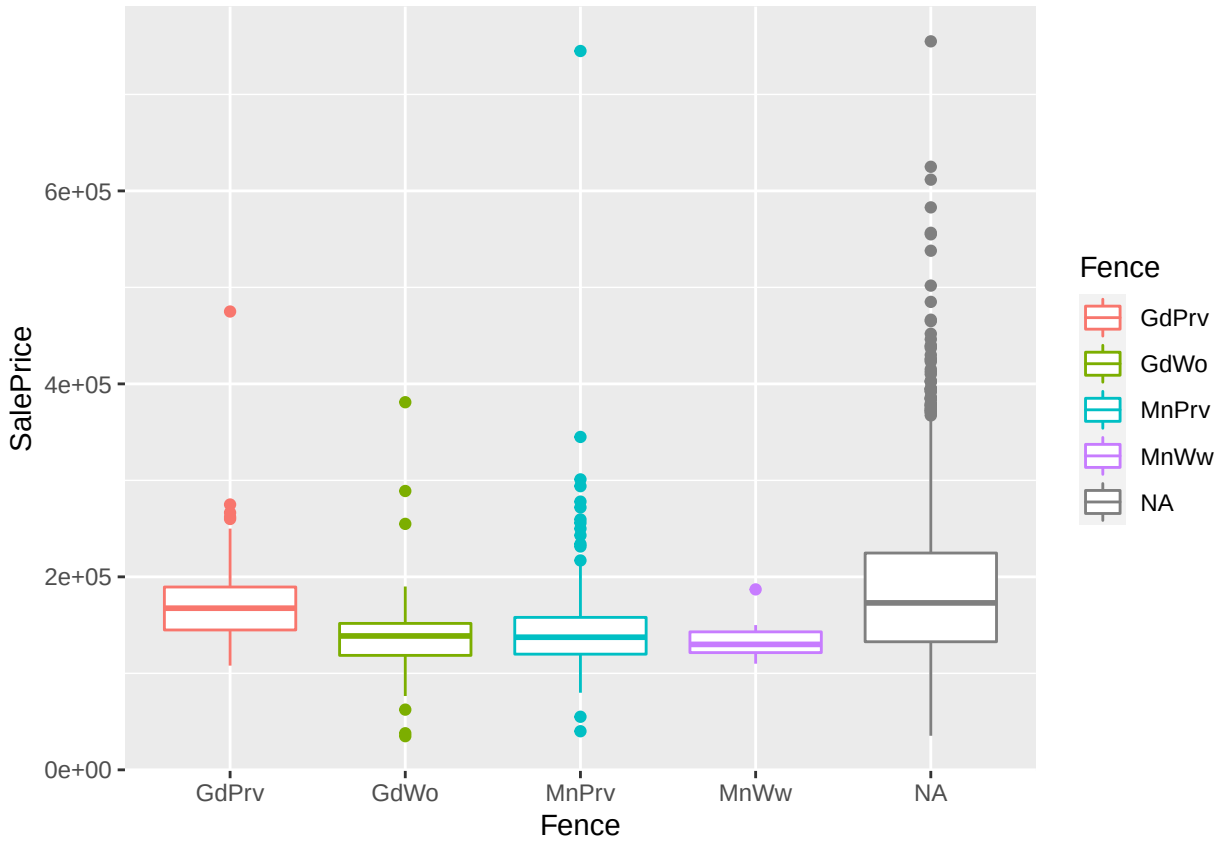

SalePrice
6e+05
4e+05
2e+05
0e+00
1
2
3
4
5
6
7
8
9
Overall Condition
OverallCond
1
2
3
4
5
6
7
8
9

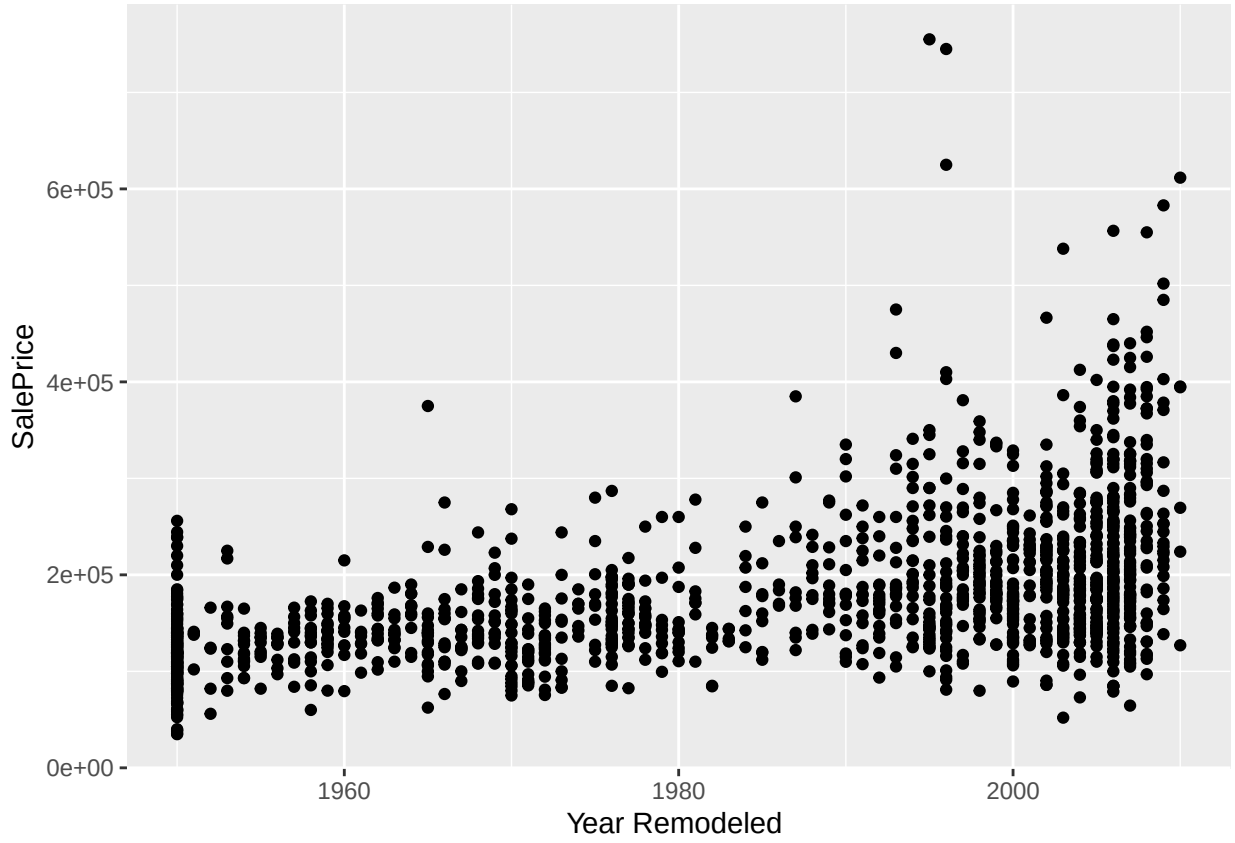

SalePrice
6e+05
4e+05
2e+05
0e+00
0
100
200
300
Frontage area

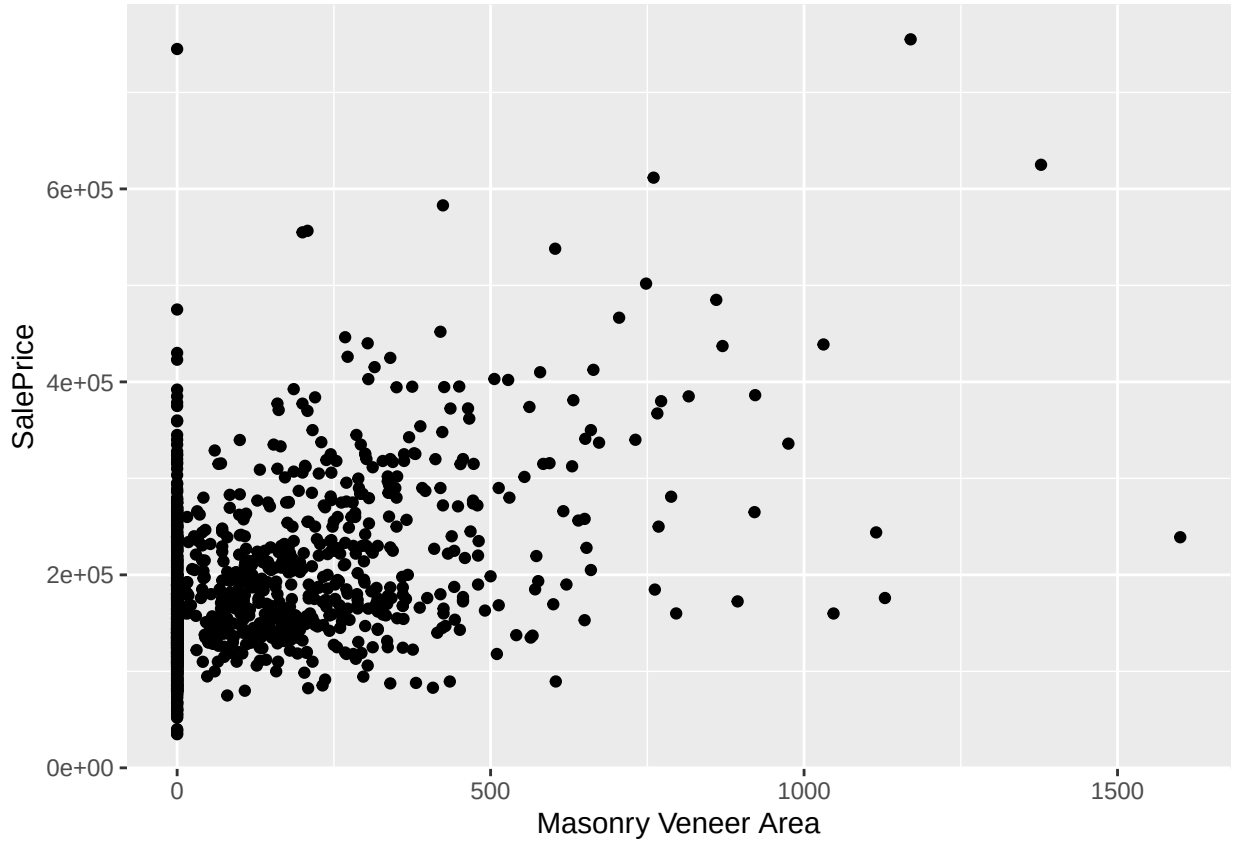

SalePrice
6e+05
4e+05
2e+05
0e+00
0
50000
100000
150000
200000
LotArea

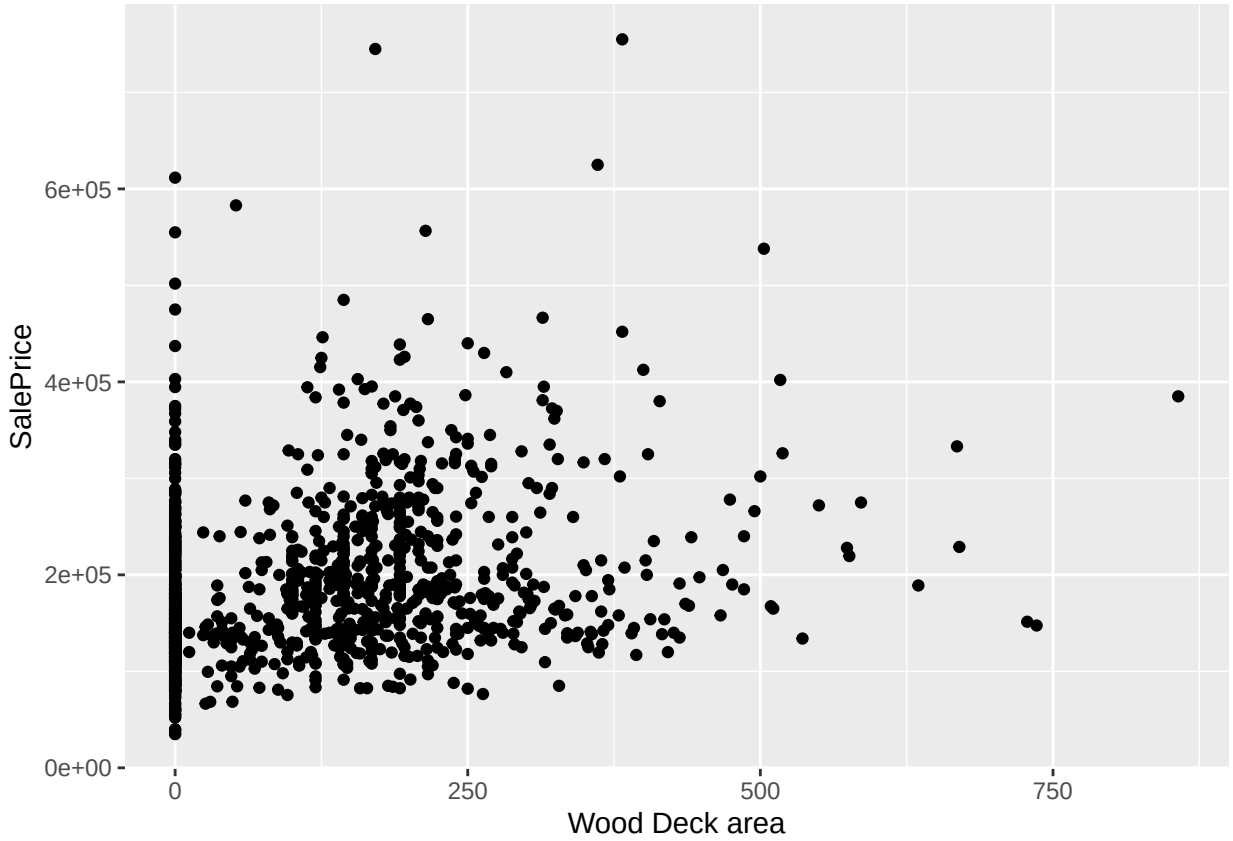

SalePrice
6e+05
4e+05
2e+05
0e+00
0
2000
4000
Basement1 area

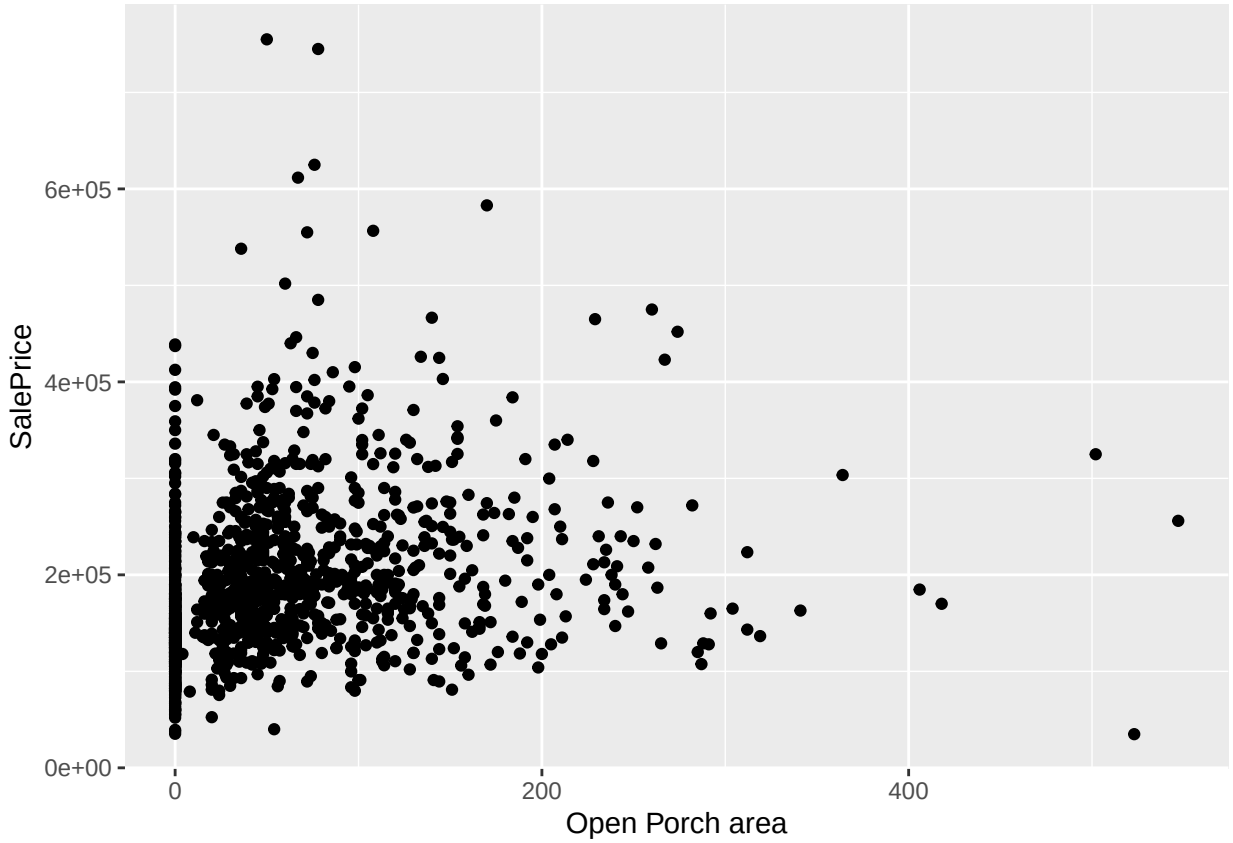

SalePrice
6e+05
4e+05
2e+05
0e+00
0
2000
4000
6000
Total Basement area

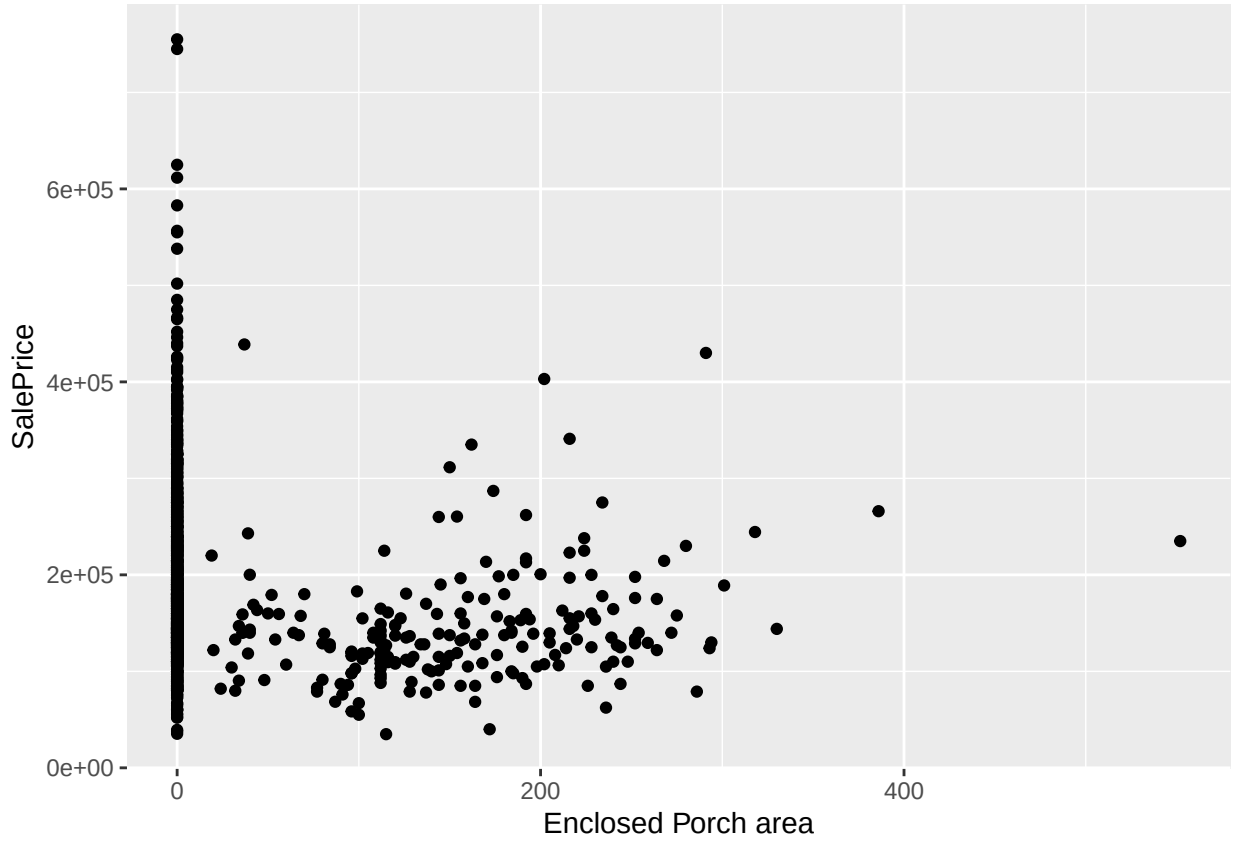

SalePrice
6e+05
4e+05
2e+05
0e+00
GdPrv
GdWo
MnPrv
MnWw
NA
Fence
Fence
GdPrv
GdWo
MnPrv
MnWw
NA


SalePrice
6e+05
4e+05
2e+05
0e+00
1960
1980
2000
Year Remodeled


SalePrice
6e+05
4e+05
2e+05
0e+00
0
500
1000
1500
Masonry Veneer Area


SalePrice
6e+05
4e+05
2e+05
0e+00
0
250
500
750
Wood Deck area


SalePrice
6e+05
4e+05
2e+05
0e+00
0
200
400
Open Porch area



data cleanup / delete outliers and create data subset and summary() of the same subset

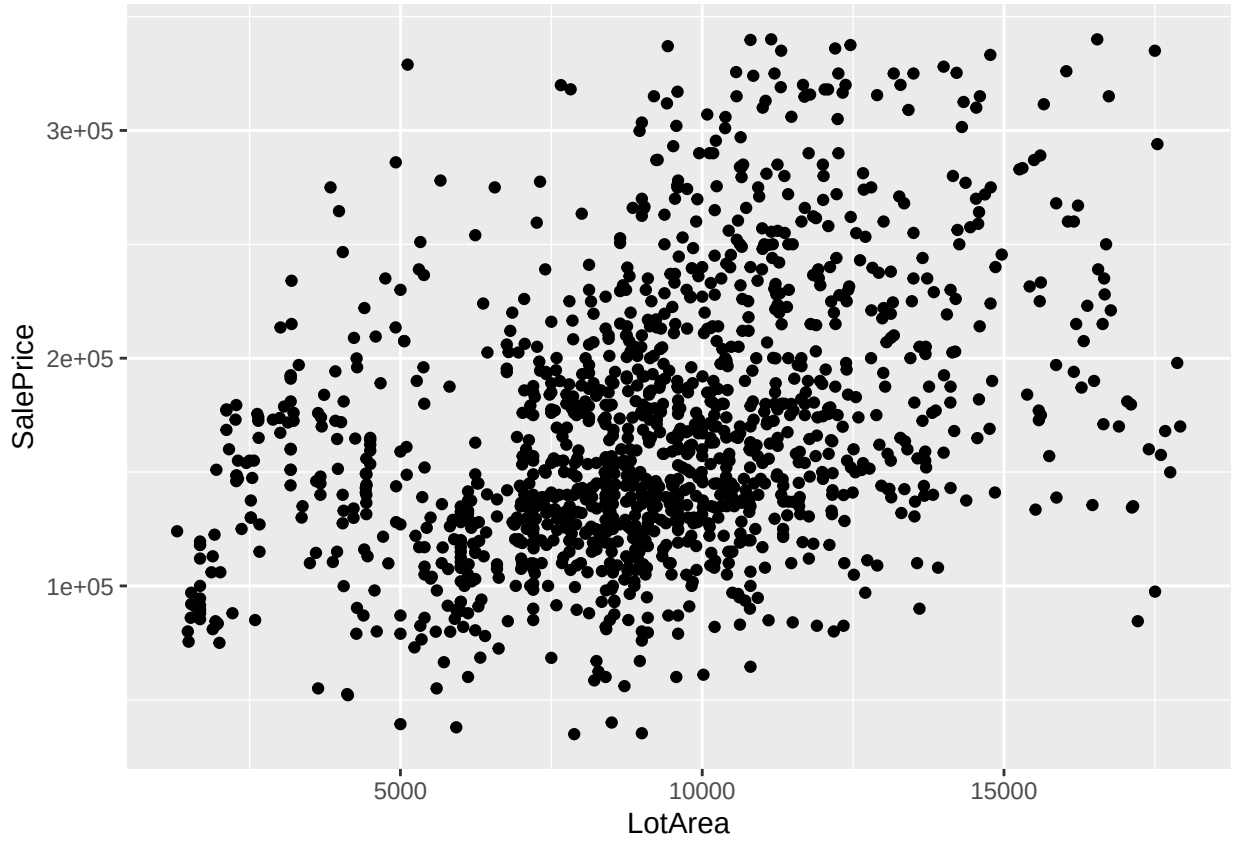
the variables selected in the current subset dataframe have been arrived at after multiple iterations of the model and fine tuning to add / drop variables from the subset to achieve better accuracy.

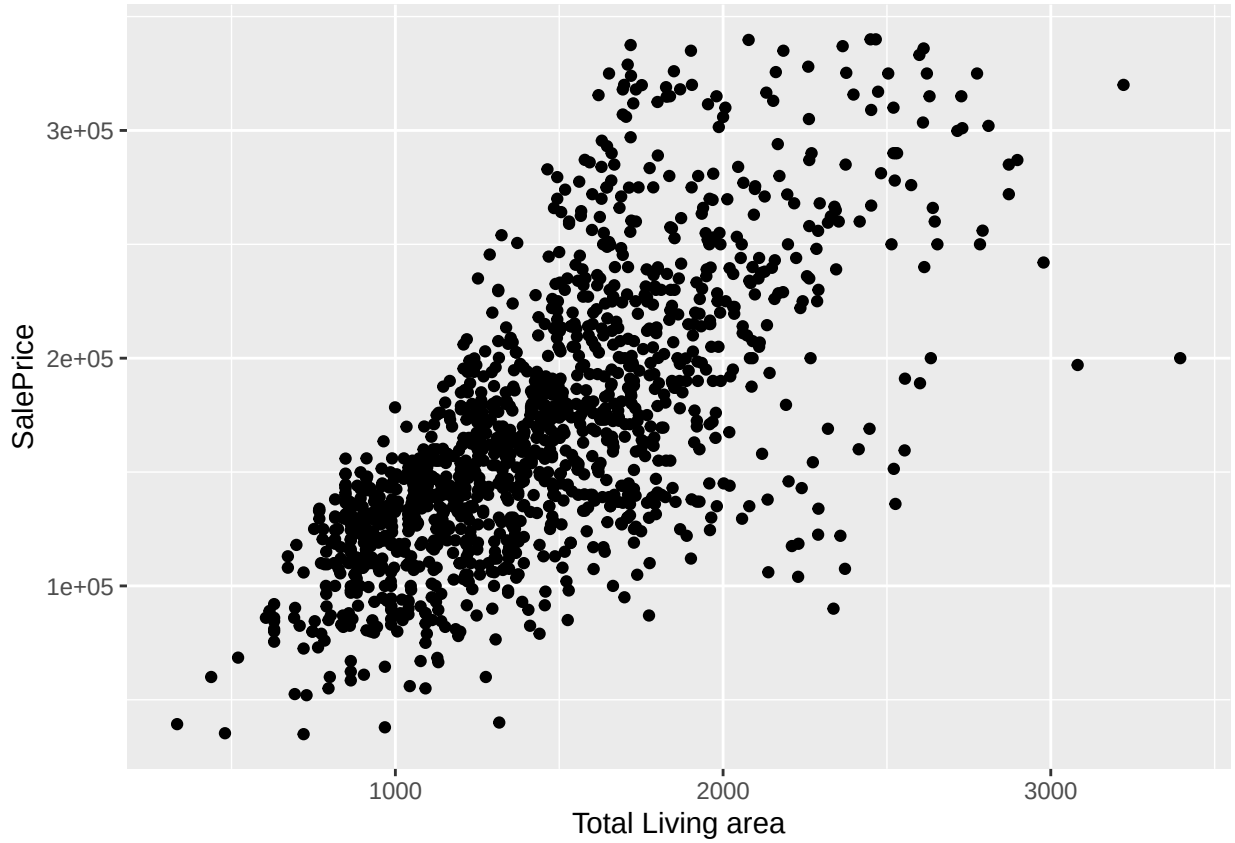
```
## 'data.frame':    1344 obs. of  39 variables:
##  $ MSSubClass   : Factor w/ 15 levels "20","30","40",..: 6 1 6 7 6 5 1 6 5 15 ...
##  $ MSZoning     : Factor w/ 5 levels "C (all)","FV",..: 4 4 4 4 4 4 4 4 5 4 ...
##  $ BldgType     : Factor w/ 5 levels "1Fam","2fmCon",..: 1 1 1 1 1 1 1 1 1 2 ...
##  $ HouseStyle   : Factor w/ 8 levels "1.5Fin","1.5Unf",..: 6 3 6 6 6 1 3 6 1 2 ...
##  $ LotConfig    : chr  "Inside" "FR2" "Inside" "Corner" ...
##  $ Neighborhood : chr  "CollgCr" "Veenker" "CollgCr" "Crawfor" ...
##  $ Condition1   : chr  "Norm" "Feedr" "Norm" "Norm" ...
##  $ Condition2   : chr  "Norm" "Norm" "Norm" "Norm" ...
##  $ Foundation   : chr  "PConc" "CBlock" "PConc" "BrkTil" ...
##  $ RoofStyle    : chr  "Gable" "Gable" "Gable" "Gable" ...
##  $ RoofMatl     : chr  "CompShg" "CompShg" "CompShg" "CompShg" ...
##  $ Exterior1st  : chr  "VinylSd" "MetalSd" "VinylSd" "Wd Sdng" ...
##  $ Exterior2nd  : chr  "VinylSd" "MetalSd" "VinylSd" "Wd Shng" ...
##  $ ExterQual    : chr  "Gd" "TA" "Gd" "TA" ...
##  $ HeatingQC    : chr  "Ex" "Ex" "Ex" "Gd" ...
##  $ Electrical   : chr  "SBrkr" "SBrkr" "SBrkr" "SBrkr" ...
##  $ LotFrontage  : num  65 80 68 60 84 85 75 0 51 50 ...
##  $ LotArea      : int  8450 9600 11250 9550 14260 14115 10084 10382 6120 7420 ...
##  $ OverallQual  : Factor w/ 10 levels "1","2","3","4",..: 7 6 7 7 8 5 8 7 7 5 ...
##  $ OverallCond  : Factor w/ 9 levels "1","2","3","4",..: 5 8 5 5 5 5 5 6 5 6 ...
```

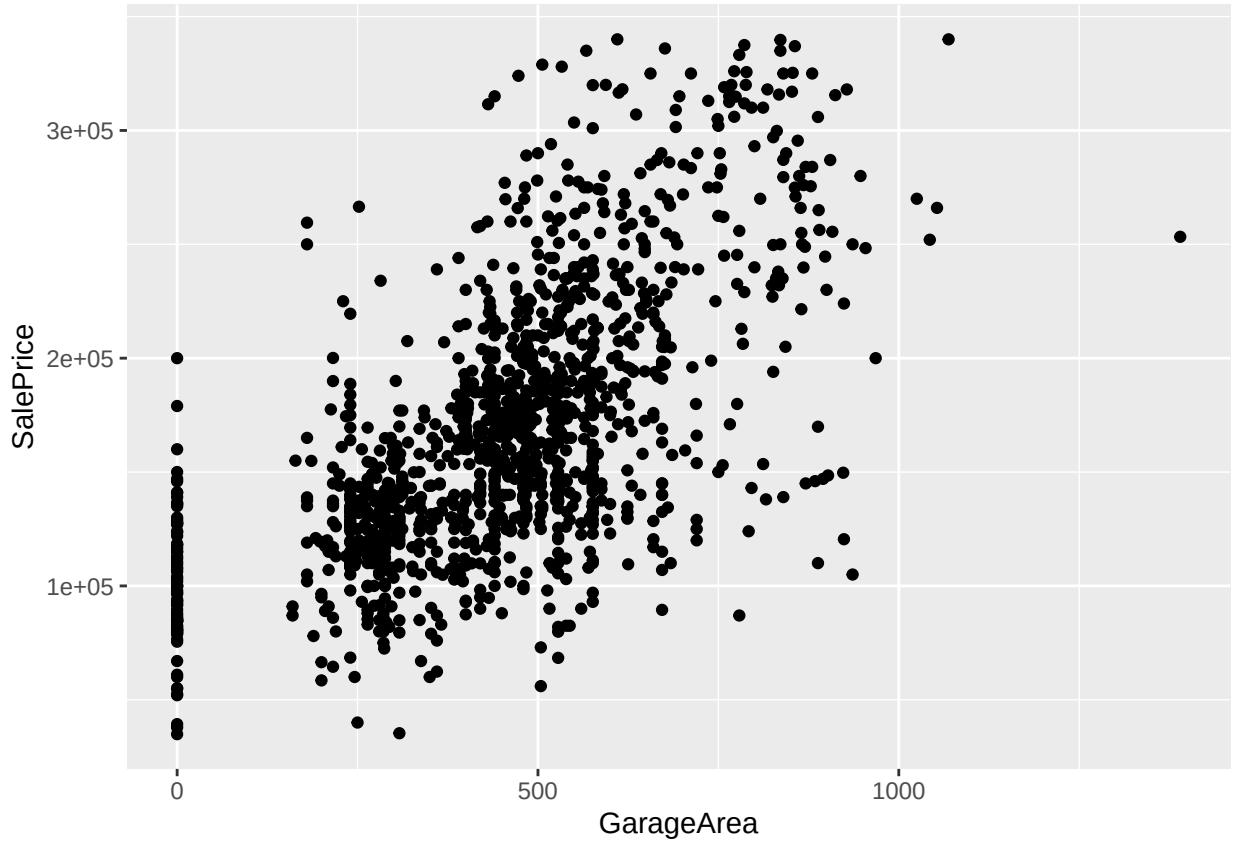
```
##  $ YearBuilt    : int  2003 1976 2001 1915 2000 1993 2004 1973 1931 1939 ...
##  $ YearRemodAdd : int  2003 1976 2002 1970 2000 1995 2005 1973 1950 1950 ...
##  $ MasVnrArea   : int  196 0 162 0 350 0 186 240 0 0 ...
##  $ MasVnrType   : Factor w/ 5 levels "BrkCmn","BrkFace",..: 2 3 2 3 2 3 4 4 3 3 ...
##  $ WoodDeckSF   : int  0 298 0 0 192 40 255 235 90 0 ...
##  $ OpenPorchSF  : int  61 0 42 35 84 30 57 204 0 4 ...
##  $ EnclosedPorch: int  0 0 0 272 0 0 0 228 205 0 ...
##  $ BsmtFinSF1   : int  706 978 486 216 655 732 1369 859 0 851 ...
##  $ TotalBsmtSF  : int  856 1262 920 756 1145 796 1686 1107 952 991 ...
##  $ BsmtFinType1 : chr  "GLQ" "ALQ" "GLQ" "ALQ" ...
##  $ BsmtQual     : chr  "Gd" "Gd" "Gd" "TA" ...
##  $ GrLivArea    : int  1710 1262 1786 1717 2198 1362 1694 2090 1774 1077 ...
##  $ FullBath     : int  2 2 2 1 2 1 2 2 2 1 ...
##  $ HalfBath     : int  1 0 1 0 1 1 0 1 0 0 ...
##  $ TotBaths     : num  2.5 2 2.5 1 2.5 1.5 2 2.5 2 1 ...
##  $ BedroomAbvGr : int  3 3 3 3 4 1 3 3 2 2 ...
##  $ TotRmsAbvGrd : int  8 6 6 7 9 5 7 7 8 5 ...
##  $ GarageArea   : int  548 460 608 642 836 480 636 484 468 205 ...
##  $ SalePrice    : int  208500 181500 223500 140000 250000 143000 307000 200000 129900 118000 ...

##    MSSubClass     MSZoning      BldgType      HouseStyle   LotConfig
##  20     :487   C (all):   9   1Fam  :1111   1Story :669   Length:1344
##  60     :260   FV     :  64   2fmCon:  28   2Story :401   Class :character
##  50     :137   RH     :  16   Duplex:  50   1.5Fin :145   Mode  :character
##  120    : 85   RL     :1040   Twnhs :  43   SLvl   : 61
##  30     : 67   RM     : 215   TwnhsE: 112   SFoyer : 37
##  160    : 63                                1.5Unf : 14
##  (Other):245                                (Other): 17
##  Neighborhood        Condition1         Condition2         Foundation
##  Length:1344        Length:1344        Length:1344        Length:1344
##  Class :character   Class :character   Class :character   Class :character
##  Mode  :character   Mode  :character   Mode  :character   Mode  :character
##
##
##
##
##   RoofStyle           RoofMatl         Exterior1st        Exterior2nd
##  Length:1344        Length:1344        Length:1344        Length:1344
##  Class :character   Class :character   Class :character   Class :character
##  Mode  :character   Mode  :character   Mode  :character   Mode  :character
##
##
##
##
##   ExterQual          HeatingQC          Electrical         LotFrontage
##  Length:1344        Length:1344        Length:1344        Min.   :  0.00
##  Class :character   Class :character   Class :character   1st Qu.: 42.00
##  Mode  :character   Mode  :character   Mode  :character   Median : 61.00
##                                                           Mean   : 56.19
##                                                           3rd Qu.: 77.00
##                                                           Max.   :182.00
##
##     LotArea       OverallQual   OverallCond    YearBuilt     YearRemodAdd
##  Min.   : 1300   5      :380   5      :742   Min.   :1872   Min.   :1950
```

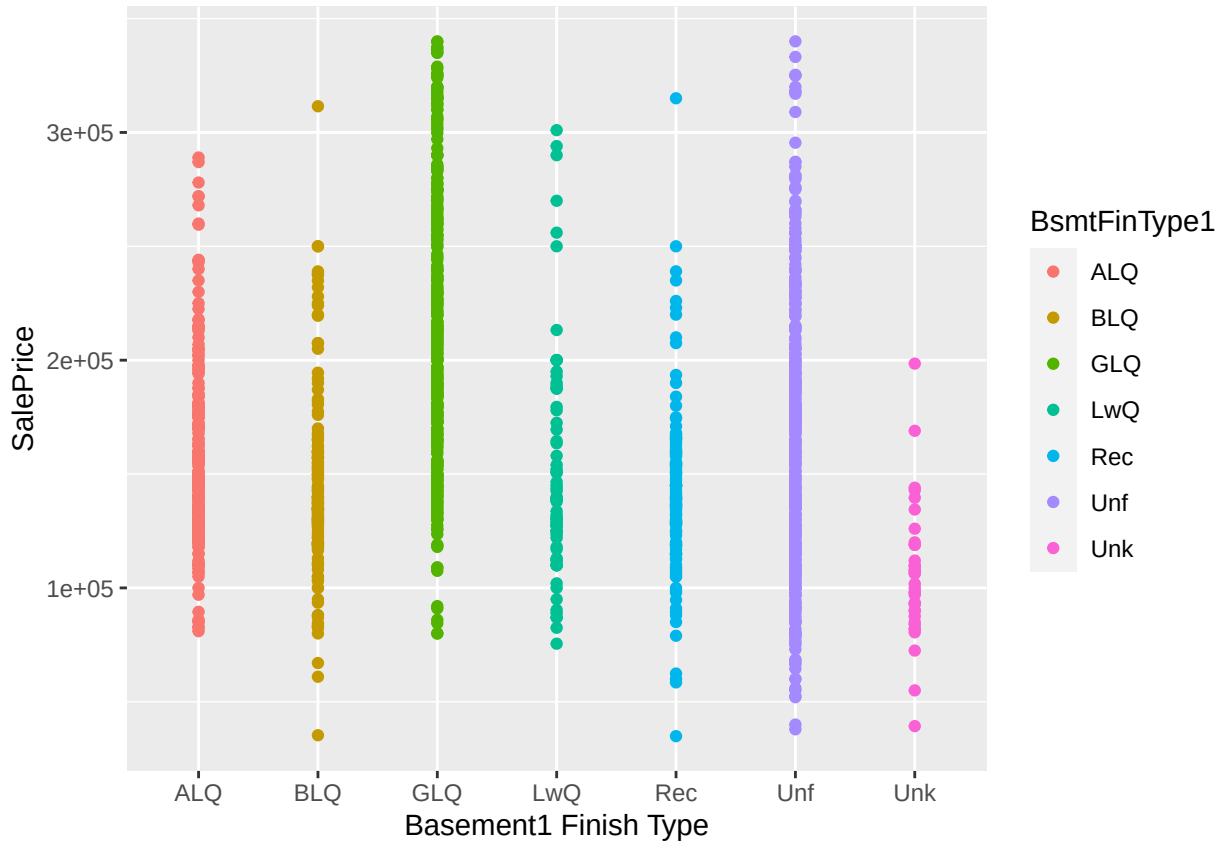
```
##  1st Qu.: 7310   6      :359   6      :240   1st Qu.:1953   1st Qu.:1966
##  Median : 9164   7      :301   7      :194   Median :1972   Median :1992
##  Mean   : 9148   8      :145   8      : 70   Mean   :1970   Mean   :1984
##  3rd Qu.:11042   4      :112   4      : 51   3rd Qu.:2000   3rd Qu.:2003
##  Max.   :17920   9      : 20   3      : 24   Max.   :2009   Max.   :2010
##                  (Other): 27   (Other): 23
##    MasVnrArea        MasVnrType    WoodDeckSF     OpenPorchSF
##  Min.   :   0.00   BrkCmn : 12   Min.   :  0.0   Min.   :  0.00
##  1st Qu.:   0.00   BrkFace:407   1st Qu.:  0.0   1st Qu.:  0.00
##  Median :   0.00   None   :819   Median :  0.0   Median : 22.00
##  Mean   :  89.34   Stone  :100   Mean   : 86.9   Mean   : 43.83
##  3rd Qu.: 143.75   Unk    :  6   3rd Qu.:160.0   3rd Qu.: 64.00
##  Max.   :1600.00                 Max.   :736.0   Max.   :547.00
##  NA's   :6
##  EnclosedPorch      BsmtFinSF1      TotalBsmtSF     BsmtFinType1
##  Min.   :  0.00   Min.   :   0.0   Min.   :   0.0   Length:1344
##  1st Qu.:  0.00   1st Qu.:   0.0   1st Qu.: 783.0   Class :character
##  Median :  0.00   Median : 366.5   Median : 968.5   Mode  :character
##  Mean   : 21.86   Mean   : 407.7   Mean   :1012.8
##  3rd Qu.:  0.00   3rd Qu.: 679.2   3rd Qu.:1237.8
##  Max.   :386.00   Max.   :1880.0   Max.   :3206.0
##
##    BsmtQual           GrLivArea       FullBath        HalfBath
##  Length:1344        Min.   : 334   Min.   :0.000   Min.   :0.0000
##  Class :character   1st Qu.:1113   1st Qu.:1.000   1st Qu.:0.0000
##  Mode  :character   Median :1426   Median :2.000   Median :0.0000
##                     Mean   :1454   Mean   :1.532   Mean   :0.3705
##                     3rd Qu.:1718   3rd Qu.:2.000   3rd Qu.:1.0000
##                     Max.   :3395   Max.   :3.000   Max.   :2.0000
##
##     TotBaths      BedroomAbvGr    TotRmsAbvGrd      GarageArea
##  Min.   :0.000   Min.   :0.000   Min.   : 2.000   Min.   :   0.0
##  1st Qu.:1.000   1st Qu.:2.000   1st Qu.: 5.000   1st Qu.: 308.0
##  Median :2.000   Median :3.000   Median : 6.000   Median : 464.5
##  Mean   :1.717   Mean   :2.854   Mean   : 6.381   Mean   : 454.0
##  3rd Qu.:2.000   3rd Qu.:3.000   3rd Qu.: 7.000   3rd Qu.: 572.0
##  Max.   :3.500   Max.   :8.000   Max.   :14.000   Max.   :1390.0
##
##    SalePrice
##  Min.   : 34900
##  1st Qu.:128000
##  Median :157700
##  Mean   :168855
##  3rd Qu.:200625
##  Max.   :340000
##
```

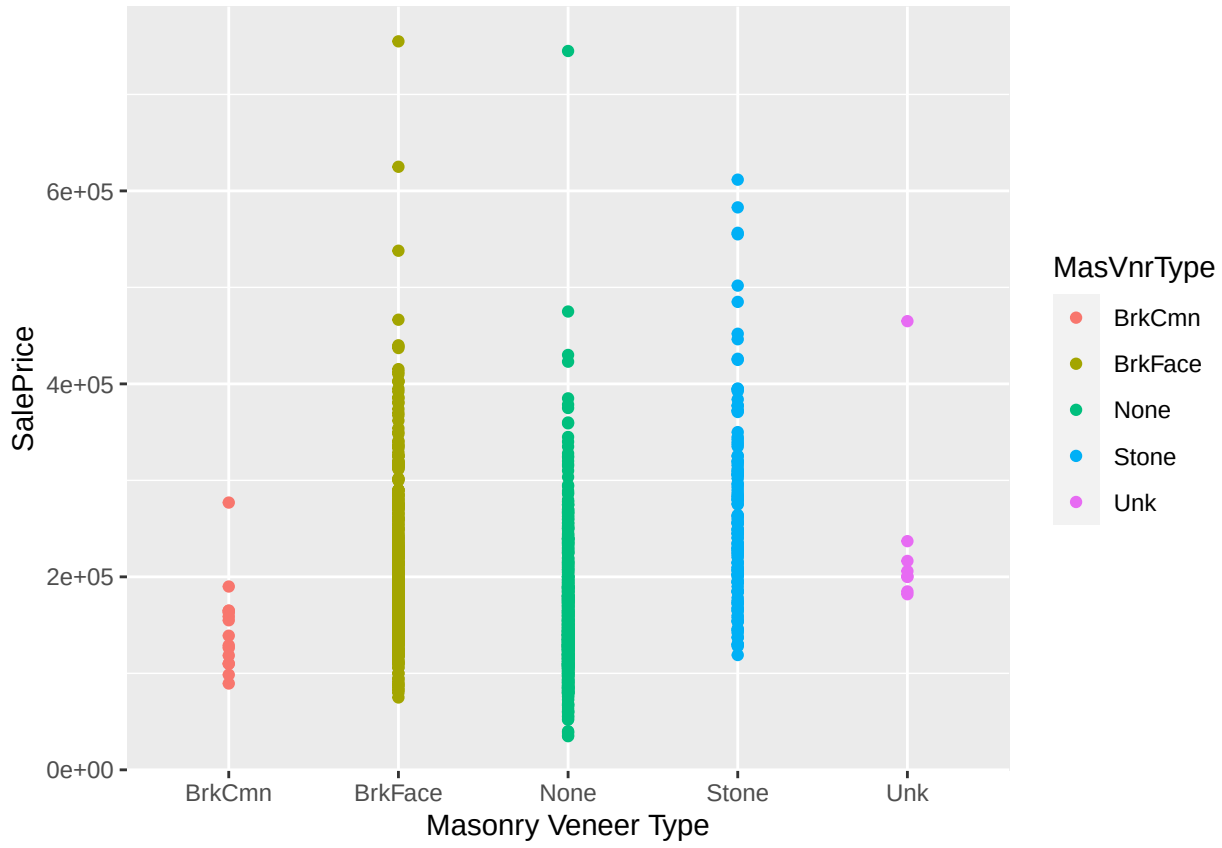
Scatter Plots for relationship between Sale Price and some of the predictor variables

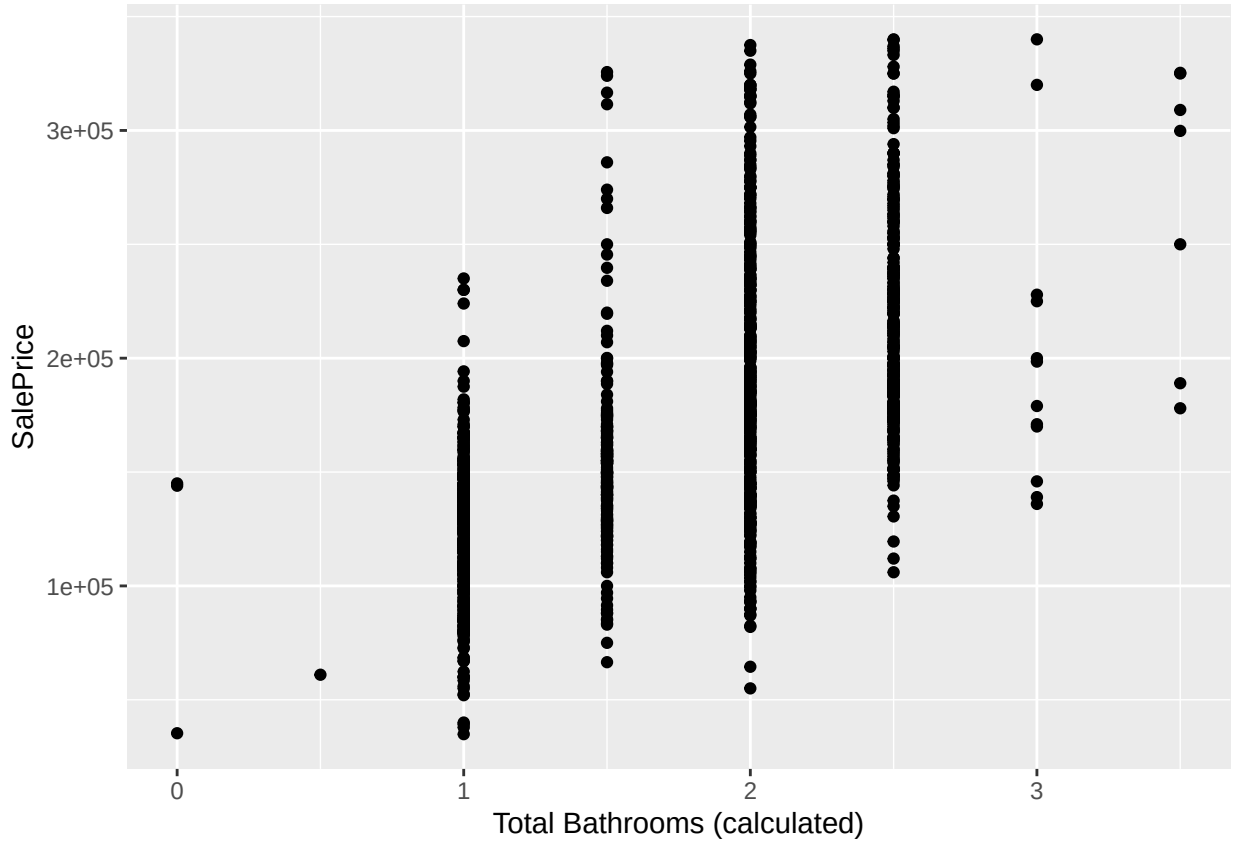

3e+05
2e+05
1e+05
SalePrice
5000
10000
15000
LotArea

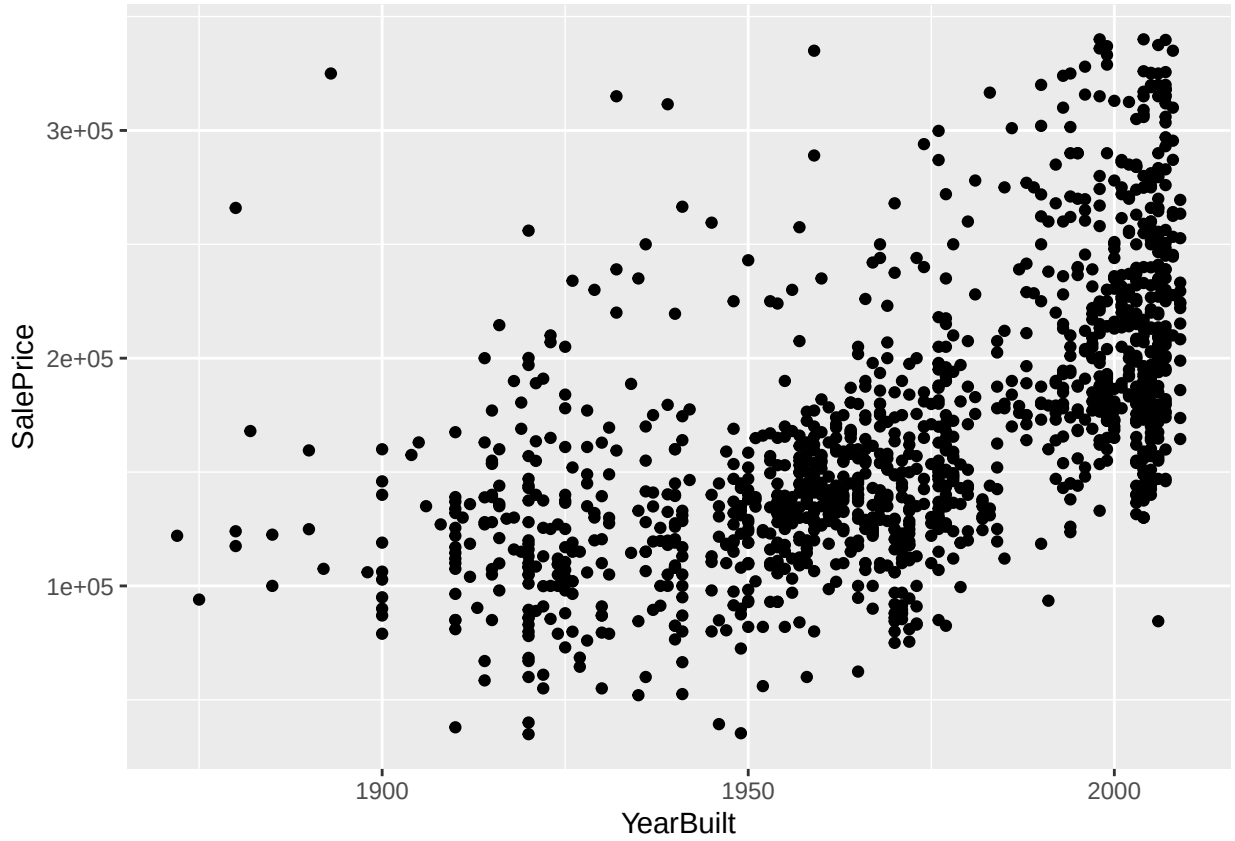

3e+05
2e+05
1e+05
SalePrice
1000
2000
3000
Total Living area

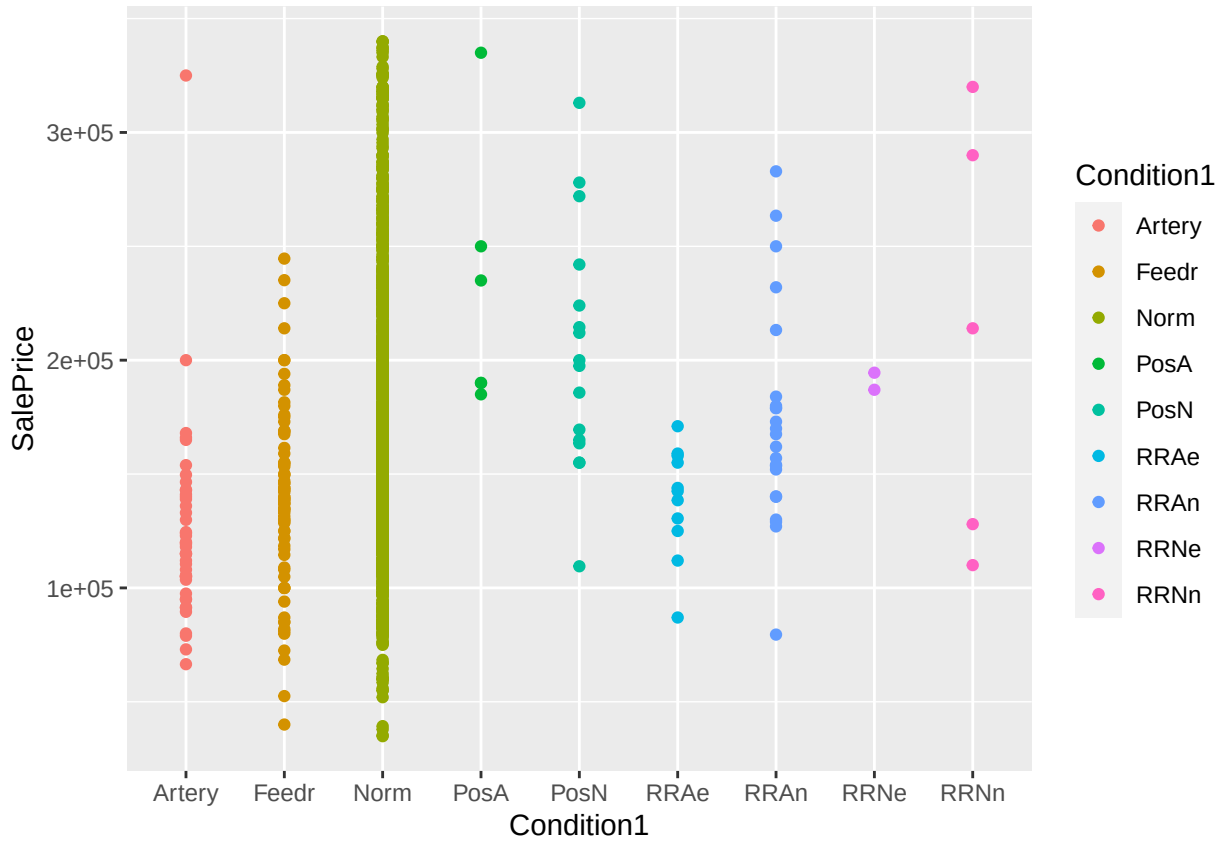

3e+05
2e+05
1e+05
SalePrice
0
500
1000
GarageArea

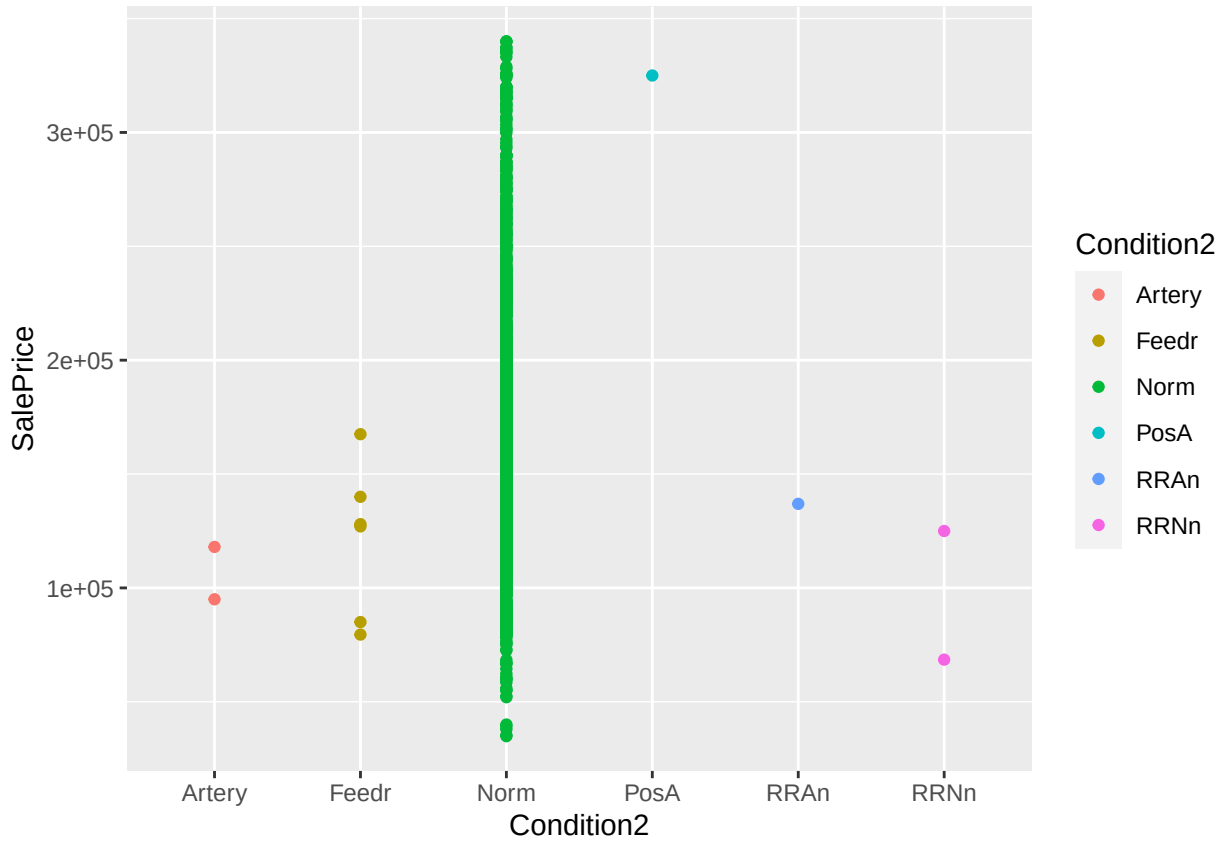

SalePrice
3e+05
2e+05
1e+05
ALQ
BLQ
GLQ
LwQ
Rec
Unf
Unk
Basement1 Finish Type
BsmtFinType1
ALQ
BLQ
GLQ
LwQ
Rec
Unf
Unk

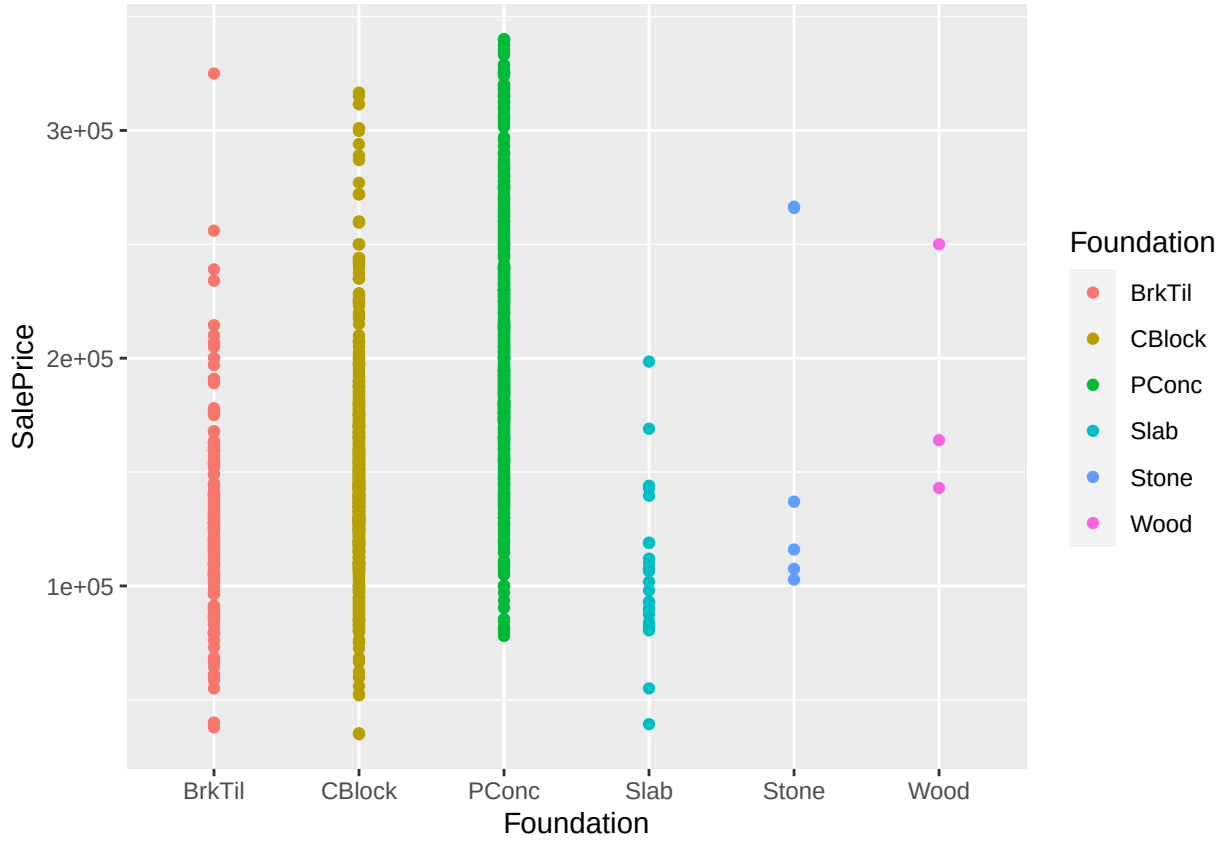

SalePrice
6e+05
4e+05
2e+05
0e+00
BrkCmn
BrkFace
None
Stone
Unk
Masonry Veneer Type
MasVnrType
BrkCmn
BrkFace
None
Stone
Unk


SalePrice
3e+05
2e+05
1e+05
0
1
2
3
Total Bathrooms (calculated)


3e+05
2e+05
1e+05
SalePrice
1900
1950
2000
YearBuilt


SalePrice
3e+05
2e+05
1e+05
Artery
Feedr
Norm
PosA
PosN
RRAe
RRAn
RRNe
RRNn
Condition1
Condition1
Artery
Feedr
Norm
PosA
PosN
RRAe
RRAn
RRNe
RRNn


SalePrice
3e+05
2e+05
1e+05
Artery
Feedr
Norm
PosA
RRAn
RRNn
Condition2
Condition2
Artery
Feedr
Norm
PosA
RRAn
RRNn



head() from the modified subset data frame

```
##   MSSubClass MSZoning BldgType HouseStyle LotConfig Neighborhood Condition1
## 1         60       RL     1Fam     2Story    Inside      CollgCr       Norm
## 2         20       RL     1Fam     1Story       FR2      Veenker      Feedr
## 3         60       RL     1Fam     2Story    Inside      CollgCr       Norm
## 4         70       RL     1Fam     2Story    Corner      Crawfor       Norm
## 5         60       RL     1Fam     2Story       FR2      NoRidge       Norm
## 6         50       RL     1Fam     1.5Fin    Inside      Mitchel       Norm
##   Condition2 Foundation RoofStyle RoofMatl Exterior1st Exterior2nd ExterQual
## 1       Norm      PConc     Gable  CompShg     VinylSd     VinylSd        Gd
## 2       Norm     CBlock     Gable  CompShg     MetalSd     MetalSd        TA
## 3       Norm      PConc     Gable  CompShg     VinylSd     VinylSd        Gd
## 4       Norm     BrkTil     Gable  CompShg     Wd Sdng     Wd Shng        TA
## 5       Norm      PConc     Gable  CompShg     VinylSd     VinylSd        Gd
## 6       Norm       Wood     Gable  CompShg     VinylSd     VinylSd        TA
##   HeatingQC Electrical LotFrontage LotArea OverallQual OverallCond YearBuilt
## 1        Ex      SBrkr          65    8450           7           5      2003
## 2        Ex      SBrkr          80    9600           6           8      1976
## 3        Ex      SBrkr          68   11250           7           5      2001
## 4        Gd      SBrkr          60    9550           7           5      1915
## 5        Ex      SBrkr          84   14260           8           5      2000
## 6        Ex      SBrkr          85   14115           5           5      1993
##   YearRemodAdd MasVnrArea MasVnrType WoodDeckSF OpenPorchSF EnclosedPorch
## 1         2003        196    BrkFace          0          61             0
## 2         1976          0       None        298           0             0
```

```
## 3         2002        162    BrkFace          0          42             0
## 4         1970          0       None          0          35           272
## 5         2000        350    BrkFace        192          84             0
## 6         1995          0       None         40          30             0
##   BsmtFinSF1 TotalBsmtSF BsmtFinType1 BsmtQual GrLivArea FullBath HalfBath
## 1        706         856          GLQ       Gd      1710        2        1
## 2        978        1262          ALQ       Gd      1262        2        0
## 3        486         920          GLQ       Gd      1786        2        1
## 4        216         756          ALQ       TA      1717        1        0
## 5        655        1145          GLQ       Gd      2198        2        1
## 6        732         796          GLQ       Gd      1362        1        1
##   TotBaths BedroomAbvGr TotRmsAbvGrd GarageArea SalePrice
## 1      2.5            3            8        548    208500
## 2      2.0            3            6        460    181500
## 3      2.5            3            6        608    223500
## 4      1.0            3            7        642    140000
## 5      2.5            4            9        836    250000
## 6      1.5            1            5        480    143000
```

correlation - R2 for various numeric variables with Sale Price

```
cor(housing_df$SalePrice, housing_df$LotArea)^2
```

```
## [1] 0.1528357
```

```
cor(housing_df$SalePrice, housing_df$YearBuilt)^2
```

```
## [1] 0.3497324
```

```
cor(housing_df$SalePrice, housing_df$YearRemodAdd)^2
```

```
## [1] 0.3085205
```

```
cor(housing_df$SalePrice, housing_df$GrLivArea)^2
```

```
## [1] 0.4813659
```

```
cor(housing_df$SalePrice, (housing_df$FullBath + (housing_df$HalfBath * 0.5)))^2
```

```
## [1] 0.390098
```

```
cor(housing_df$SalePrice, housing_df$BedroomAbvGr)^2
```

```
## [1] 0.0397595
```

```
cor(housing_df$SalePrice, housing_df$TotRmsAbvGrd)^2
```

```
## [1] 0.2298562
```

```
cor(housing_df$SalePrice, housing_df$GarageArea)^2
```

```
## [1] 0.4066953
```

```
cor(housing_df$SalePrice, housing_df$BsmtFinSF1)^2
```

```
## [1] 0.09712678
```

```
cor(housing_df$SalePrice, housing_df$TotalBsmtSF)^2
```

```
## [1] 0.3482836
```

```
cor(housing_df$SalePrice, housing_df$WoodDeckSF)^2
```

```
## [1] 0.08447678
```

```
cor(housing_df$SalePrice, housing_df$OpenPorchSF)^2
```

```
## [1] 0.1118559
```

```
cor(housing_df$SalePrice, housing_df$EnclosedPorch)^2
```

```
## [1] 0.02645305
```

housing price prediction - multiple regression model creation and summary() of the models

```
##
## Call:
## lm(formula = SalePrice ~ Neighborhood + RoofStyle + LotArea +
##     LotFrontage + OverallQual + OverallCond + YearBuilt + OpenPorchSF +
##     GrLivArea + TotRmsAbvGrd + GarageArea + TotalBsmtSF, data = housing_df)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -123224   -9749     443   10078   73042
##
## Coefficients:
##                       Estimate Std. Error t value Pr(>|t|)
## (Intercept)         -1.072e+06  8.912e+04 -12.032  < 2e-16 ***
## NeighborhoodBlueste -1.235e+04  1.449e+04  -0.852 0.394427
## NeighborhoodBrDale  -1.582e+04  6.970e+03  -2.270 0.023365 *
## NeighborhoodBrkSide  1.272e+03  6.172e+03   0.206 0.836806
## NeighborhoodClearCr  5.621e+03  7.312e+03   0.769 0.442220
## NeighborhoodCollgCr -4.745e+03  5.156e+03  -0.920 0.357529
## NeighborhoodCrawfor  2.259e+04  6.254e+03   3.611 0.000316 ***
## NeighborhoodEdwards -1.115e+04  5.704e+03  -1.955 0.050794 .
## NeighborhoodGilbert -5.734e+03  5.536e+03  -1.036 0.300517
## NeighborhoodIDOTRR  -1.140e+04  6.572e+03  -1.734 0.083185 .
```

```
## NeighborhoodMeadowV -1.856e+04  6.980e+03  -2.659 0.007940 **
## NeighborhoodMitchel -1.229e+04  5.861e+03  -2.097 0.036167 *
## NeighborhoodNAmes   -9.416e+03  5.443e+03  -1.730 0.083889 .
## NeighborhoodNoRidge  1.595e+04  6.289e+03   2.537 0.011311 *
## NeighborhoodNPkVill -4.605e+03  8.139e+03  -0.566 0.571647
## NeighborhoodNridgHt  1.215e+04  5.628e+03   2.158 0.031096 *
## NeighborhoodNWAmes  -1.484e+04  5.669e+03  -2.618 0.008951 **
## NeighborhoodOldTown -1.371e+04  6.042e+03  -2.270 0.023372 *
## NeighborhoodSawyer  -1.154e+04  5.771e+03  -1.999 0.045841 *
## NeighborhoodSawyerW -4.365e+03  5.599e+03  -0.780 0.435785
## NeighborhoodSomerst  4.243e+03  5.291e+03   0.802 0.422704
## NeighborhoodStoneBr  1.046e+04  6.893e+03   1.518 0.129364
## NeighborhoodSWISU   -5.618e+03  6.946e+03  -0.809 0.418826
## NeighborhoodTimber  -4.514e+02  6.132e+03  -0.074 0.941340
## NeighborhoodVeenker  1.334e+04  7.994e+03   1.668 0.095475 .
## RoofStyleGable      -5.562e+03  8.816e+03  -0.631 0.528203
## RoofStyleGambrel     4.837e+02  1.058e+04   0.046 0.963526
## RoofStyleHip        -3.948e+03  8.855e+03  -0.446 0.655816
## RoofStyleMansard     4.372e+03  1.153e+04   0.379 0.704539
## LotArea              2.128e+00  2.308e-01   9.221  < 2e-16 ***
## LotFrontage         -2.275e+01  1.799e+01  -1.264 0.206324
## OverallQual2        -8.049e+03  2.225e+04  -0.362 0.717556
## OverallQual3        -6.559e+03  2.022e+04  -0.324 0.745743
## OverallQual4        -8.637e+03  1.991e+04  -0.434 0.664549
## OverallQual5        -5.874e+03  1.992e+04  -0.295 0.768082
## OverallQual6        -4.223e+02  1.994e+04  -0.021 0.983105
## OverallQual7         1.377e+04  2.001e+04   0.688 0.491516
## OverallQual8         3.650e+04  2.016e+04   1.811 0.070439 .
## OverallQual9         7.290e+04  2.064e+04   3.532 0.000427 ***
## OverallQual10        9.259e+04  2.310e+04   4.008 6.47e-05 ***
## OverallCond2        -3.949e+03  2.947e+04  -0.134 0.893437
## OverallCond3         4.236e+03  2.732e+04   0.155 0.876825
## OverallCond4         1.496e+04  2.785e+04   0.537 0.591206
## OverallCond5         2.392e+04  2.779e+04   0.861 0.389429
## OverallCond6         3.202e+04  2.779e+04   1.152 0.249393
## OverallCond7         4.267e+04  2.779e+04   1.535 0.124999
## OverallCond8         4.803e+04  2.786e+04   1.724 0.084957 .
## OverallCond9         5.513e+04  2.815e+04   1.958 0.050394 .
## YearBuilt            5.602e+02  4.410e+01  12.701  < 2e-16 ***
## OpenPorchSF          2.742e+01  9.050e+00   3.030 0.002497 **
## GrLivArea            5.162e+01  2.577e+00  20.031  < 2e-16 ***
## TotRmsAbvGrd        -2.592e+03  6.528e+02  -3.970 7.57e-05 ***
## GarageArea           2.563e+01  3.548e+00   7.223 8.66e-13 ***
## TotalBsmtSF          2.305e+01  1.813e+00  12.712  < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 19080 on 1290 degrees of freedom
## Multiple R-squared:  0.8993, Adjusted R-squared:  0.8952
## F-statistic: 217.4 on 53 and 1290 DF,  p-value: < 2.2e-16
```

looking at model statistics iteratively, I refined the model a little bit from the beginning to include more relevant variables with higher impact on the prices and omit the ones having higher p values. Logistic regression is mainly useful for classification rather than predicting numeric

values which can take any number of values, like house prices based on various factors. So, using only multiple linear regression model.

Finalized model with little better predictive power

```
##
## Call:
## lm(formula = SalePrice ~ Neighborhood + RoofStyle + LotArea +
##     LotFrontage + OverallQual + OverallCond + YearBuilt + OpenPorchSF +
##     GrLivArea + TotRmsAbvGrd + GarageArea + TotalBsmtSF + Exterior1st +
##     ExterQual + YearRemodAdd + MasVnrArea + MasVnrType + WoodDeckSF +
##     BsmtFinType1 + MSSubClass + MSZoning + HouseStyle + LotConfig +
##     Foundation + Condition1 + Condition2, data = housing_df)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -108352   -8740     470    8553   68971
##
## Coefficients:
##                       Estimate Std. Error t value Pr(>|t|)
## (Intercept)         -1.167e+06  1.202e+05  -9.709  < 2e-16 ***
## NeighborhoodBlueste  1.106e+04  1.381e+04   0.800 0.423615
## NeighborhoodBrDale   7.856e+03  8.074e+03   0.973 0.330751
## NeighborhoodBrkSide  1.068e+03  6.743e+03   0.158 0.874225
## NeighborhoodClearCr -4.503e+03  6.950e+03  -0.648 0.517173
## NeighborhoodCollgCr -1.226e+04  5.206e+03  -2.355 0.018699 *
## NeighborhoodCrawfor  1.781e+04  6.234e+03   2.858 0.004341 **
## NeighborhoodEdwards -1.502e+04  5.784e+03  -2.598 0.009497 **
## NeighborhoodGilbert -1.190e+04  5.631e+03  -2.112 0.034849 *
## NeighborhoodIDOTRR  -5.261e+03  7.628e+03  -0.690 0.490469
## NeighborhoodMeadowV -1.740e+04  8.783e+03  -1.981 0.047775 *
## NeighborhoodMitchel -1.360e+04  5.916e+03  -2.299 0.021682 *
## NeighborhoodNAmes   -1.359e+04  5.591e+03  -2.431 0.015213 *
## NeighborhoodNoRidge  4.181e+03  6.289e+03   0.665 0.506282
## NeighborhoodNPkVill  1.108e+04  8.017e+03   1.382 0.167082
## NeighborhoodNridgHt  6.412e+03  5.472e+03   1.172 0.241542
## NeighborhoodNWAmes  -1.715e+04  5.787e+03  -2.964 0.003098 **
## NeighborhoodOldTown -1.173e+04  6.864e+03  -1.709 0.087626 .
## NeighborhoodSawyer  -1.125e+04  5.845e+03  -1.924 0.054588 .
## NeighborhoodSawyerW -6.873e+03  5.615e+03  -1.224 0.221181
## NeighborhoodSomerst -3.555e+03  6.703e+03  -0.530 0.596023
## NeighborhoodStoneBr  1.291e+04  6.460e+03   1.998 0.045978 *
## NeighborhoodSWISU   -7.453e+03  6.941e+03  -1.074 0.283126
## NeighborhoodTimber  -5.062e+03  6.013e+03  -0.842 0.400020
## NeighborhoodVeenker  1.364e+04  7.645e+03   1.784 0.074669 .
## RoofStyleGable      -1.192e+04  8.258e+03  -1.443 0.149287
## RoofStyleGambrel    -3.474e+03  9.911e+03  -0.350 0.726034
## RoofStyleHip        -1.085e+04  8.302e+03  -1.307 0.191299
## RoofStyleMansard    -4.423e+03  1.073e+04  -0.412 0.680311
## LotArea              1.676e+00  2.395e-01   6.997 4.31e-12 ***
## LotFrontage         -6.596e+00  1.747e+01  -0.378 0.705813
## OverallQual2         1.270e+04  2.103e+04   0.604 0.546011
## OverallQual3         5.332e+03  1.928e+04   0.277 0.782200
## OverallQual4         6.855e+03  1.902e+04   0.360 0.718633
```

```
## OverallQual5         8.354e+03  1.912e+04   0.437 0.662219
## OverallQual6         1.201e+04  1.916e+04   0.627 0.530830
## OverallQual7         2.240e+04  1.922e+04   1.166 0.243958
## OverallQual8         4.016e+04  1.935e+04   2.076 0.038122 *
## OverallQual9         7.250e+04  1.983e+04   3.657 0.000267 ***
## OverallQual10        7.578e+04  2.331e+04   3.251 0.001181 **
## OverallCond2        -1.044e+04  2.669e+04  -0.391 0.695834
## OverallCond3        -5.511e+03  2.486e+04  -0.222 0.824573
## OverallCond4         3.609e+03  2.527e+04   0.143 0.886451
## OverallCond5         1.203e+04  2.527e+04   0.476 0.634153
## OverallCond6         1.818e+04  2.528e+04   0.719 0.472299
## OverallCond7         2.496e+04  2.530e+04   0.986 0.324121
## OverallCond8         2.807e+04  2.538e+04   1.106 0.269006
## OverallCond9         3.380e+04  2.572e+04   1.314 0.189152
## YearBuilt            4.180e+02  5.452e+01   7.667 3.59e-14 ***
## OpenPorchSF          1.760e+01  8.559e+00   2.057 0.039919 *
## GrLivArea            4.937e+01  2.964e+00  16.657  < 2e-16 ***
## TotRmsAbvGrd        -1.695e+03  6.414e+02  -2.643 0.008330 **
## GarageArea           2.333e+01  3.242e+00   7.198 1.07e-12 ***
## TotalBsmtSF          2.163e+01  2.870e+00   7.535 9.53e-14 ***
## Exterior1stAsphShn  -3.045e+03  1.830e+04  -0.166 0.867853
## Exterior1stBrkComm  -3.039e+04  1.397e+04  -2.176 0.029743 *
## Exterior1stBrkFace   1.646e+04  5.017e+03   3.282 0.001060 **
## Exterior1stCBlock   -8.865e+03  1.909e+04  -0.464 0.642470
## Exterior1stCemntBd   8.534e+03  5.512e+03   1.548 0.121801
## Exterior1stHdBoard  -5.218e+03  4.520e+03  -1.154 0.248612
## Exterior1stImStucc   1.025e+02  1.779e+04   0.006 0.995404
## Exterior1stMetalSd   9.382e+02  4.349e+03   0.216 0.829242
## Exterior1stPlywood  -3.588e+03  4.765e+03  -0.753 0.451574
## Exterior1stStone    -2.251e+03  1.315e+04  -0.171 0.864102
## Exterior1stStucco    9.208e+03  5.786e+03   1.591 0.111781
## Exterior1stVinylSd  -1.716e+03  4.459e+03  -0.385 0.700470
## Exterior1stWd Sdng  -5.484e+02  4.377e+03  -0.125 0.900318
## Exterior1stWdShing  -1.475e+02  5.503e+03  -0.027 0.978619
## ExterQualFa         -2.291e+03  8.149e+03  -0.281 0.778630
## ExterQualGd         -3.336e+03  4.805e+03  -0.694 0.487673
## ExterQualTA         -4.133e+03  5.028e+03  -0.822 0.411314
## YearRemodAdd         1.639e+02  3.758e+01   4.360 1.41e-05 ***
## MasVnrArea           1.073e+01  4.587e+00   2.339 0.019515 *
## MasVnrTypeBrkFace    1.065e+04  5.118e+03   2.081 0.037621 *
## MasVnrTypeNone       9.505e+03  5.152e+03   1.845 0.065271 .
## MasVnrTypeStone      1.745e+04  5.480e+03   3.184 0.001491 **
## WoodDeckSF           1.348e+01  4.350e+00   3.099 0.001989 **
## BsmtFinType1BLQ     -1.134e+03  1.947e+03  -0.582 0.560377
## BsmtFinType1GLQ      6.516e+03  1.800e+03   3.619 0.000308 ***
## BsmtFinType1LwQ     -3.599e+03  2.499e+03  -1.441 0.149970
## BsmtFinType1Rec     -2.125e+03  2.099e+03  -1.012 0.311620
## BsmtFinType1Unf     -8.328e+03  1.701e+03  -4.895 1.11e-06 ***
## BsmtFinType1Unk      3.677e+01  6.050e+03   0.006 0.995151
## MSSubClass30        -7.712e+02  3.415e+03  -0.226 0.821342
## MSSubClass40        -1.867e+03  1.044e+04  -0.179 0.858038
## MSSubClass45        -4.801e+03  1.514e+04  -0.317 0.751145
## MSSubClass50        -2.990e+02  6.263e+03  -0.048 0.961934
## MSSubClass60         8.268e+03  5.284e+03   1.565 0.117901
```

```
## MSSubClass70         4.366e+03  5.870e+03   0.744 0.457188
## MSSubClass75         7.205e+03  1.196e+04   0.602 0.547089
## MSSubClass80        -5.569e+03  8.027e+03  -0.694 0.487961
## MSSubClass85        -5.682e+03  7.168e+03  -0.793 0.428139
## MSSubClass90        -1.694e+04  3.657e+03  -4.633 3.99e-06 ***
## MSSubClass120       -7.718e+03  3.111e+03  -2.481 0.013249 *
## MSSubClass160       -2.080e+04  6.399e+03  -3.251 0.001181 **
## MSSubClass180       -1.270e+04  8.770e+03  -1.448 0.147782
## MSSubClass190       -2.333e+03  5.471e+03  -0.426 0.669850
## MSZoningFV           4.349e+04  8.743e+03   4.974 7.51e-07 ***
## MSZoningRH           3.068e+04  8.593e+03   3.571 0.000370 ***
## MSZoningRL           3.483e+04  7.351e+03   4.738 2.41e-06 ***
## MSZoningRM           2.891e+04  6.890e+03   4.196 2.92e-05 ***
## HouseStyle1.5Unf     1.109e+04  1.520e+04   0.730 0.465690
## HouseStyle1Story    -1.245e+03  6.153e+03  -0.202 0.839742
## HouseStyle2.5Fin    -3.052e+04  1.184e+04  -2.578 0.010061 *
## HouseStyle2.5Unf    -4.657e+03  1.169e+04  -0.399 0.690324
## HouseStyle2Story    -3.664e+03  5.582e+03  -0.656 0.511715
## HouseStyleSFoyer     5.860e+03  7.903e+03   0.742 0.458497
## HouseStyleSLvl       4.904e+03  8.947e+03   0.548 0.583666
## LotConfigCulDSac     2.001e+03  2.467e+03   0.811 0.417565
## LotConfigFR2        -6.985e+03  2.959e+03  -2.360 0.018415 *
## LotConfigFR3        -8.706e+03  9.152e+03  -0.951 0.341677
## LotConfigInside     -1.742e+03  1.287e+03  -1.353 0.176208
## FoundationCBlock     1.323e+03  2.261e+03   0.585 0.558571
## FoundationPConc      4.988e+03  2.470e+03   2.020 0.043624 *
## FoundationSlab       5.175e+03  6.607e+03   0.783 0.433616
## FoundationStone      8.711e+03  7.501e+03   1.161 0.245728
## FoundationWood      -2.825e+04  1.027e+04  -2.751 0.006027 **
## Condition1Feedr      3.353e+03  3.603e+03   0.930 0.352313
## Condition1Norm       7.510e+03  3.020e+03   2.487 0.013020 *
## Condition1PosA       1.237e+04  7.868e+03   1.572 0.116122
## Condition1PosN       9.669e+03  5.417e+03   1.785 0.074547 .
## Condition1RRAe      -1.679e+04  6.210e+03  -2.704 0.006941 **
## Condition1RRAn       1.971e+03  5.090e+03   0.387 0.698700
## Condition1RRNe      -1.295e+04  1.266e+04  -1.023 0.306586
## Condition1RRNn       1.849e+04  8.855e+03   2.088 0.037044 *
## Condition2Feedr      1.577e+04  1.725e+04   0.914 0.360901
## Condition2Norm       1.822e+04  1.507e+04   1.209 0.226885
## Condition2PosA       5.505e+04  2.695e+04   2.043 0.041312 *
## Condition2RRAn      -4.469e+02  2.315e+04  -0.019 0.984604
## Condition2RRNn       2.138e+04  1.959e+04   1.092 0.275233
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 16710 on 1208 degrees of freedom
##   (6 observations deleted due to missingness)
## Multiple R-squared:  0.9275, Adjusted R-squared:  0.9198
## F-statistic: 119.9 on 129 and 1208 DF,  p-value: < 2.2e-16
```

Finally, this derived model consists of about 27 predictor variables and produces little around 92.75% accuracy (Multiple R2 value). Adjusted R-squared value is around 92%. So, this differences is around 0.0075 a small value - less than 0.8%. Thus this model has slight variation in accuracy but can be a good representation of the large population of real world data with p-value

of 15 zeroes prior to 22 i.e. very very small value and gives us good confidence that this model is a fairly accurate.

95 % confidence interval

```
##                              2.5 %        97.5 %
## (Intercept)         -1.402535e+06 -9.309811e+05
## NeighborhoodBlueste -1.604578e+04  3.816150e+04
## NeighborhoodBrDale  -7.984968e+03  2.369748e+04
## NeighborhoodBrkSide -1.216193e+04  1.429717e+04
## NeighborhoodClearCr -1.813716e+04  9.131933e+03
## NeighborhoodCollgCr -2.247117e+04 -2.044505e+03
## NeighborhoodCrawfor  5.583352e+03  3.004279e+04
## NeighborhoodEdwards -2.637222e+04 -3.677551e+03
## NeighborhoodGilbert -2.294365e+04 -8.478095e+02
## NeighborhoodIDOTRR  -2.022641e+04  9.703633e+03
## NeighborhoodMeadowV -3.463597e+04 -1.708544e+02
## NeighborhoodMitchel -2.520629e+04 -1.993373e+03
## NeighborhoodNAmes   -2.456143e+04 -2.621355e+03
## NeighborhoodNoRidge -8.157641e+03  1.652019e+04
## NeighborhoodNPkVill -4.645344e+03  2.681115e+04
## NeighborhoodNridgHt -4.324095e+03  1.714753e+04
## NeighborhoodNWAmes  -2.850400e+04 -5.797728e+03
## NeighborhoodOldTown -2.520137e+04  1.733163e+03
## NeighborhoodSawyer  -2.271507e+04  2.216383e+02
## NeighborhoodSawyerW -1.788886e+04  4.143267e+03
## NeighborhoodSomerst -1.670596e+04  9.596852e+03
## NeighborhoodStoneBr  2.307892e+02  2.557988e+04
## NeighborhoodSWISU   -2.107106e+04  6.164502e+03
## NeighborhoodTimber  -1.685829e+04  6.734431e+03
## NeighborhoodVeenker -1.360060e+03  2.863919e+04
## RoofStyleGable      -2.811654e+04  4.285366e+03
## RoofStyleGambrel    -2.291826e+04  1.597092e+04
## RoofStyleHip        -2.714253e+04  5.433244e+03
## RoofStyleMansard    -2.547990e+04  1.663326e+04
## LotArea              1.205986e+00  2.145739e+00
## LotFrontage         -4.086941e+01  2.767751e+01
## OverallQual2        -2.856396e+04  5.396923e+04
## OverallQual3        -3.250164e+04  4.316632e+04
## OverallQual4        -3.046610e+04  4.417662e+04
## OverallQual5        -2.915484e+04  4.586266e+04
## OverallQual6        -2.557269e+04  4.959055e+04
## OverallQual7        -1.530258e+04  6.011114e+04
## OverallQual8         2.203433e+03  7.812247e+04
## OverallQual9         3.359846e+04  1.113953e+05
## OverallQual10        3.005308e+04  1.215148e+05
## OverallCond2        -6.279347e+04  4.192204e+04
## OverallCond3        -5.427586e+04  4.325410e+04
## OverallCond4        -4.597130e+04  5.319013e+04
## OverallCond5        -3.754328e+04  6.159707e+04
## OverallCond6        -3.142518e+04  6.777996e+04
## OverallCond7        -2.468316e+04  7.460244e+04
## OverallCond8        -2.172877e+04  7.786697e+04
## OverallCond9        -1.667127e+04  8.426394e+04
```

```
## YearBuilt            3.110587e+02  5.249870e+02
## OpenPorchSF          8.120258e-01  3.439635e+01
## GrLivArea            4.355148e+01  5.518074e+01
## TotRmsAbvGrd        -2.953587e+03 -4.367040e+02
## GarageArea           1.697331e+01  2.969310e+01
## TotalBsmtSF          1.599781e+01  2.726110e+01
## Exterior1stAsphShn  -3.894715e+04  3.285639e+04
## Exterior1stBrkComm  -5.779688e+04 -2.991076e+03
## Exterior1stBrkFace   6.622232e+03  2.630756e+04
## Exterior1stCBlock   -4.631784e+04  2.858842e+04
## Exterior1stCemntBd  -2.279632e+03  1.934817e+04
## Exterior1stHdBoard  -1.408622e+04  3.650797e+03
## Exterior1stImStucc  -3.480350e+04  3.500852e+04
## Exterior1stMetalSd  -7.594495e+03  9.470889e+03
## Exterior1stPlywood  -1.293634e+04  5.760153e+03
## Exterior1stStone    -2.805038e+04  2.354809e+04
## Exterior1stStucco   -2.143913e+03  2.055989e+04
## Exterior1stVinylSd  -1.046496e+04  7.033191e+03
## Exterior1stWd Sdng  -9.135300e+03  8.038597e+03
## Exterior1stWdShing  -1.094355e+04  1.064853e+04
## ExterQualFa         -1.827897e+04  1.369651e+04
## ExterQualGd         -1.276387e+04  6.091804e+03
## ExterQualTA         -1.399814e+04  5.732722e+03
## YearRemodAdd         9.012503e+01  2.375817e+02
## MasVnrArea           1.727942e+00  1.972469e+01
## MasVnrTypeBrkFace    6.107305e+02  2.069442e+04
## MasVnrTypeNone      -6.019663e+02  1.961224e+04
## MasVnrTypeStone      6.695029e+03  2.819773e+04
## WoodDeckSF           4.944807e+00  2.201348e+01
## BsmtFinType1BLQ     -4.954894e+03  2.686404e+03
## BsmtFinType1GLQ      2.983494e+03  1.004759e+04
## BsmtFinType1LwQ     -8.501300e+03  1.302689e+03
## BsmtFinType1Rec     -6.244133e+03  1.993798e+03
## BsmtFinType1Unf     -1.166538e+04 -4.990189e+03
## BsmtFinType1Unk     -1.183267e+04  1.190622e+04
## MSSubClass30        -7.470418e+03  5.927926e+03
## MSSubClass40        -2.233968e+04  1.860582e+04
## MSSubClass45        -3.449882e+04  2.489597e+04
## MSSubClass50        -1.258696e+04  1.198899e+04
## MSSubClass60        -2.098597e+03  1.863469e+04
## MSSubClass70        -7.150722e+03  1.588186e+04
## MSSubClass75        -1.626493e+04  3.067521e+04
## MSSubClass80        -2.131714e+04  1.017947e+04
## MSSubClass85        -1.974508e+04  8.381524e+03
## MSSubClass90        -2.411921e+04 -9.769781e+03
## MSSubClass120       -1.382161e+04 -1.613869e+03
## MSSubClass160       -3.335851e+04 -8.250124e+03
## MSSubClass180       -2.990743e+04  4.504092e+03
## MSSubClass190       -1.306578e+04  8.399860e+03
## MSZoningFV           2.633466e+04  6.064246e+04
## MSZoningRH           1.382493e+04  4.754114e+04
## MSZoningRL           2.040941e+04  4.925495e+04
## MSZoningRM           1.539175e+04  4.242732e+04
## HouseStyle1.5Unf    -1.872981e+04  4.091457e+04
```

```
## HouseStyle1Story    -1.331614e+04  1.082707e+04
## HouseStyle2.5Fin    -5.373973e+04 -7.290386e+03
## HouseStyle2.5Unf    -2.758564e+04  1.827112e+04
## HouseStyle2Story    -1.461458e+04  7.287303e+03
## HouseStyleSFoyer    -9.644062e+03  2.136459e+04
## HouseStyleSLvl      -1.264825e+04  2.245707e+04
## LotConfigCulDSac    -2.839421e+03  6.840428e+03
## LotConfigFR2        -1.279004e+04 -1.178991e+03
## LotConfigFR3        -2.666193e+04  9.250135e+03
## LotConfigInside     -4.267233e+03  7.833785e+02
## FoundationCBlock    -3.112896e+03  5.758799e+03
## FoundationPConc      1.429359e+02  9.833685e+03
## FoundationSlab      -7.787189e+03  1.813725e+04
## FoundationStone     -6.005010e+03  2.342731e+04
## FoundationWood      -4.838734e+04 -8.103013e+03
## Condition1Feedr     -3.716615e+03  1.042208e+04
## Condition1Norm       1.585439e+03  1.343538e+04
## Condition1PosA      -3.064736e+03  2.780651e+04
## Condition1PosN      -9.596227e+02  2.029698e+04
## Condition1RRAe      -2.897784e+04 -4.610146e+03
## Condition1RRAn      -8.014816e+03  1.195584e+04
## Condition1RRNe      -3.778628e+04  1.188850e+04
## Condition1RRNn       1.112733e+03  3.585899e+04
## Condition2Feedr     -1.807634e+04  4.960833e+04
## Condition2Norm      -1.134419e+04  4.777844e+04
## Condition2PosA       2.173432e+03  1.079338e+05
## Condition2RRAn      -4.587019e+04  4.497647e+04
## Condition2RRNn      -1.705024e+04  5.981909e+04
```

analysis of variance

```
anova(housing_mod_lm)
```

```
## Analysis of Variance Table
##
## Response: SalePrice
##                Df     Sum Sq    Mean Sq   F value    Pr(>F)
## Neighborhood   24 2.5828e+12 1.0762e+11  385.4439 < 2.2e-16 ***
## RoofStyle       4 5.4117e+10 1.3529e+10   48.4569 < 2.2e-16 ***
## LotArea         1 3.2302e+11 3.2302e+11 1156.9286 < 2.2e-16 ***
## LotFrontage     1 3.5851e+09 3.5851e+09   12.8406 0.0003527 ***
## OverallQual     9 7.0095e+11 7.7883e+10  278.9506 < 2.2e-16 ***
## OverallCond     8 3.3621e+10 4.2027e+09   15.0524 < 2.2e-16 ***
## YearBuilt       1 7.1141e+10 7.1141e+10  254.8011 < 2.2e-16 ***
## OpenPorchSF     1 2.8734e+10 2.8734e+10  102.9146 < 2.2e-16 ***
## GrLivArea       1 2.9544e+11 2.9544e+11 1058.1680 < 2.2e-16 ***
## TotRmsAbvGrd    1 1.0907e+10 1.0907e+10   39.0656 5.671e-10 ***
## GarageArea      1 2.4246e+10 2.4246e+10   86.8398 < 2.2e-16 ***
## TotalBsmtSF     1 5.8762e+10 5.8762e+10  210.4637 < 2.2e-16 ***
## Exterior1st    14 1.9818e+10 1.4156e+09    5.0701 2.567e-09 ***
## ExterQual       3 1.6559e+09 5.5196e+08    1.9769 0.1156329
## YearRemodAdd    1 5.0122e+09 5.0122e+09   17.9519 2.438e-05 ***
## MasVnrArea      1 3.4172e+09 3.4172e+09   12.2393 0.0004849 ***
```

```
## MasVnrType      3 2.1021e+09 7.0069e+08    2.5096 0.0573383 .
## WoodDeckSF      1 5.1416e+09 5.1416e+09   18.4152 1.918e-05 ***
## BsmtFinType1    6 3.0695e+10 5.1159e+09   18.3233 < 2.2e-16 ***
## MSSubClass     14 3.1769e+10 2.2692e+09    8.1275 < 2.2e-16 ***
## MSZoning        4 8.4356e+09 2.1089e+09    7.5534 5.211e-06 ***
## HouseStyle      7 3.8457e+09 5.4939e+08    1.9677 0.0563050 .
## LotConfig       4 2.1583e+09 5.3957e+08    1.9326 0.1027184
## Foundation      5 4.4389e+09 8.8777e+08    3.1797 0.0073949 **
## Condition1      8 1.0052e+10 1.2565e+09    4.5002 2.110e-05 ***
## Condition2      5 1.5241e+09 3.0483e+08    1.0918 0.3630854
## Residuals    1208 3.3728e+11 2.7920e+08
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Analysis of Variance statistics for the given model help to confirm the significance of selected variables.

assumptions of independence durbin watson test

```
##  lag Autocorrelation D-W Statistic p-value
##    1      0.03595457      1.928091    0.21
##  Alternative hypothesis: rho != 0
```

From the Durbin-Watson test, we can see that Autocorrelation coefficient is around 0.03 - a small value and D-W statistic value is around 1.92, which is very close to 2. This indicates that the predictor variables we have selected may not be correlations amongst themselves. So, we should be good with these. Only slight concern is p-value is around 0.15 (above 0.05).

assumptions of no multicolinearity

```
v <- vif(housing_mod_lm)

v
```

```
##                      GVIF Df GVIF^(1/(2*Df))
## Neighborhood 6.260709e+04 24        1.258722
## RoofStyle    2.251882e+00  4        1.106798
## LotArea      2.795870e+00  1        1.672085
## LotFrontage  1.462912e+00  1        1.209509
## OverallQual  1.062198e+02  9        1.295887
## OverallCond  1.891167e+01  8        1.201699
## YearBuilt    1.288356e+01  1        3.589367
## OpenPorchSF  1.429299e+00  1        1.195533
## GrLivArea    8.476724e+00  1        2.911481
## TotRmsAbvGrd 4.491318e+00  1        2.119273
## GarageArea   2.037311e+00  1        1.427344
## TotalBsmtSF  5.659159e+00  1        2.378899
## Exterior1st  5.802099e+01 14        1.156073
## ExterQual    1.102684e+01  3        1.491907
## YearRemodAdd 2.884558e+00  1        1.698399
## MasVnrArea   2.506809e+00  1        1.583291
## MasVnrType   4.698417e+00  3        1.294172
```

```
## WoodDeckSF   1.273914e+00  1        1.128678
## BsmtFinType1 1.821869e+01  6        1.273629
## MSSubClass   7.312065e+07 14        1.909231
## MSZoning     4.599684e+01  4        1.613768
## HouseStyle   1.112154e+06  7        2.703142
## LotConfig    1.998494e+00  4        1.090405
## Foundation   2.881236e+01  5        1.399452
## Condition1   4.620963e+00  8        1.100388
## Condition2   5.605796e+00  5        1.188129
```

```
1/v
```

```
##                       GVIF         Df GVIF^(1/(2*Df))
## Neighborhood 1.597263e-05 0.04166667       0.7944569
## RoofStyle    4.440730e-01 0.25000000       0.9035076
## LotArea      3.576705e-01 1.00000000       0.5980556
## LotFrontage  6.835682e-01 1.00000000       0.8267818
## OverallQual  9.414441e-03 0.11111111       0.7716725
## OverallCond  5.287741e-02 0.12500000       0.8321553
## YearBuilt    7.761832e-02 1.00000000       0.2786006
## OpenPorchSF  6.996435e-01 1.00000000       0.8364470
## GrLivArea    1.179701e-01 1.00000000       0.3434678
## TotRmsAbvGrd 2.226518e-01 1.00000000       0.4718599
## GarageArea   4.908430e-01 1.00000000       0.7006019
## TotalBsmtSF  1.767047e-01 1.00000000       0.4203626
## Exterior1st  1.723514e-02 0.07142857       0.8649974
## ExterQual    9.068780e-02 0.33333333       0.6702829
## YearRemodAdd 3.466736e-01 1.00000000       0.5887899
## MasVnrArea   3.989135e-01 1.00000000       0.6315960
## MasVnrType   2.128376e-01 0.33333333       0.7726950
## WoodDeckSF   7.849822e-01 1.00000000       0.8859922
## BsmtFinType1 5.488869e-02 0.16666667       0.7851577
## MSSubClass   1.367603e-08 0.07142857       0.5237710
## MSZoning     2.174063e-02 0.25000000       0.6196679
## HouseStyle   8.991560e-07 0.14285714       0.3699398
## LotConfig    5.003769e-01 0.25000000       0.9170904
## Foundation   3.470732e-02 0.20000000       0.7145656
## Condition1   2.164051e-01 0.12500000       0.9087705
## Condition2   1.783868e-01 0.20000000       0.8416592
```

```
t <- 0

for(i in 1:24)
{
    t = t + v[i, 3]
}

t/24
```

```
## [1] 1.654531
```

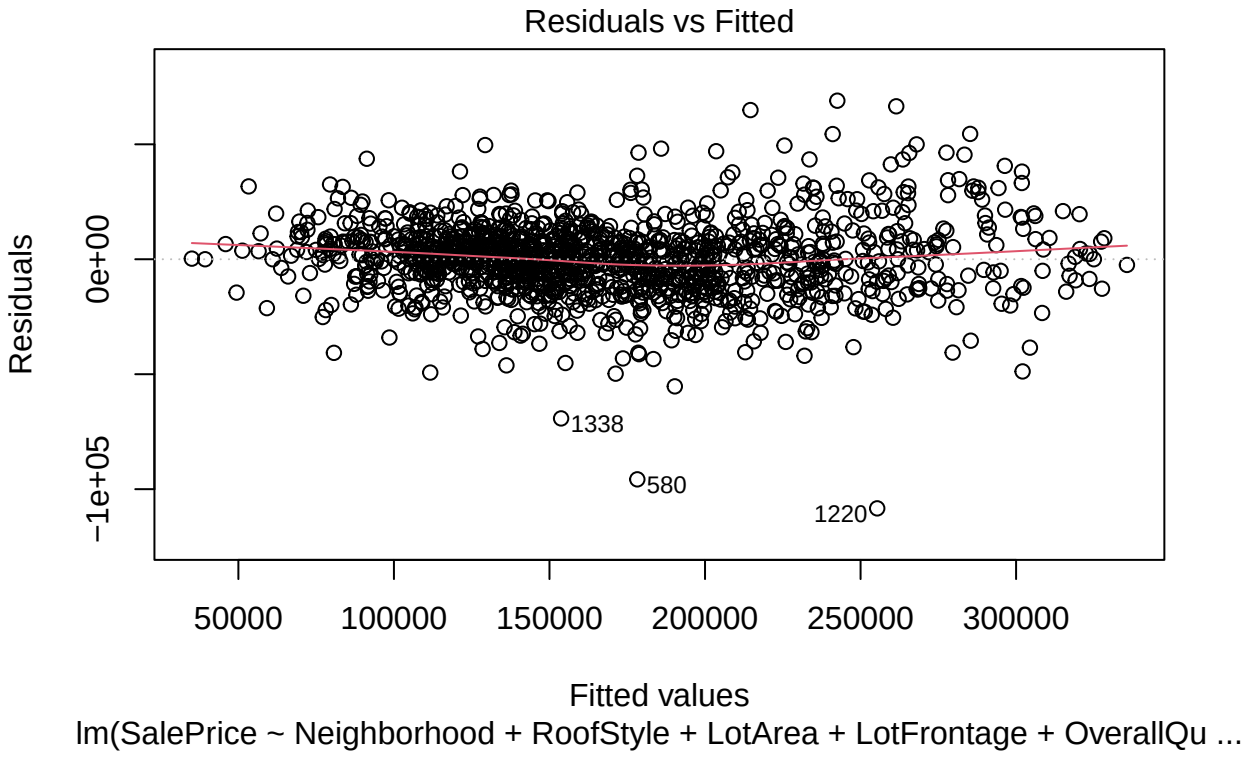
Based on (Field, Miles, and Field 2012) book

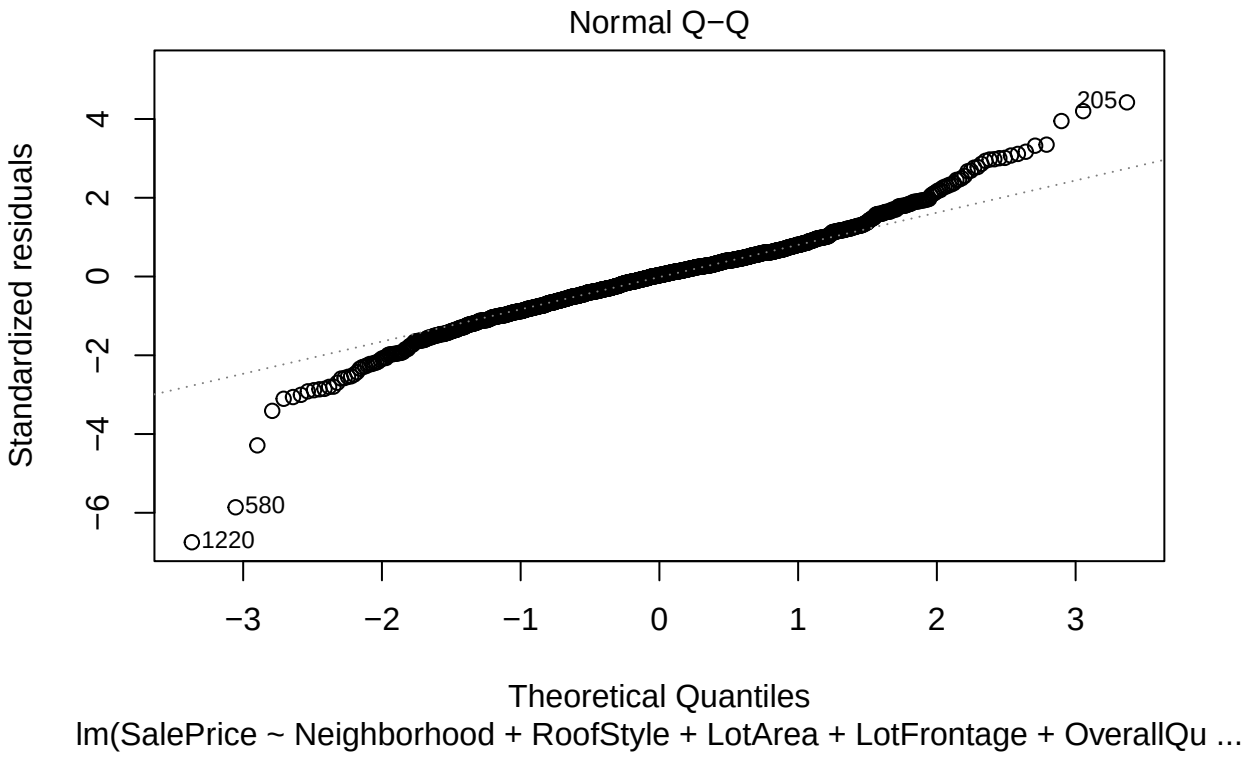
All of the VIF values are well below 10. SO, there is no cause of concerns.

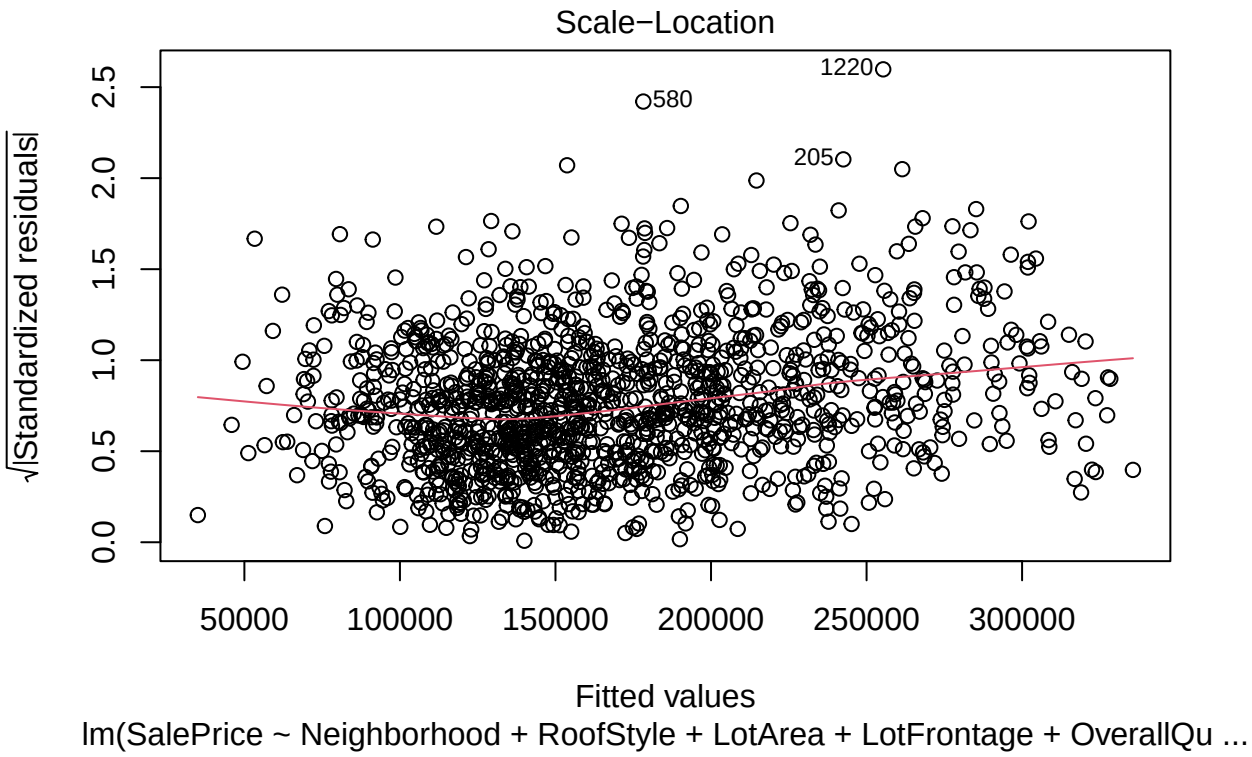
All of the tolerance values are well above 0.1, so there is no cause of concerns.

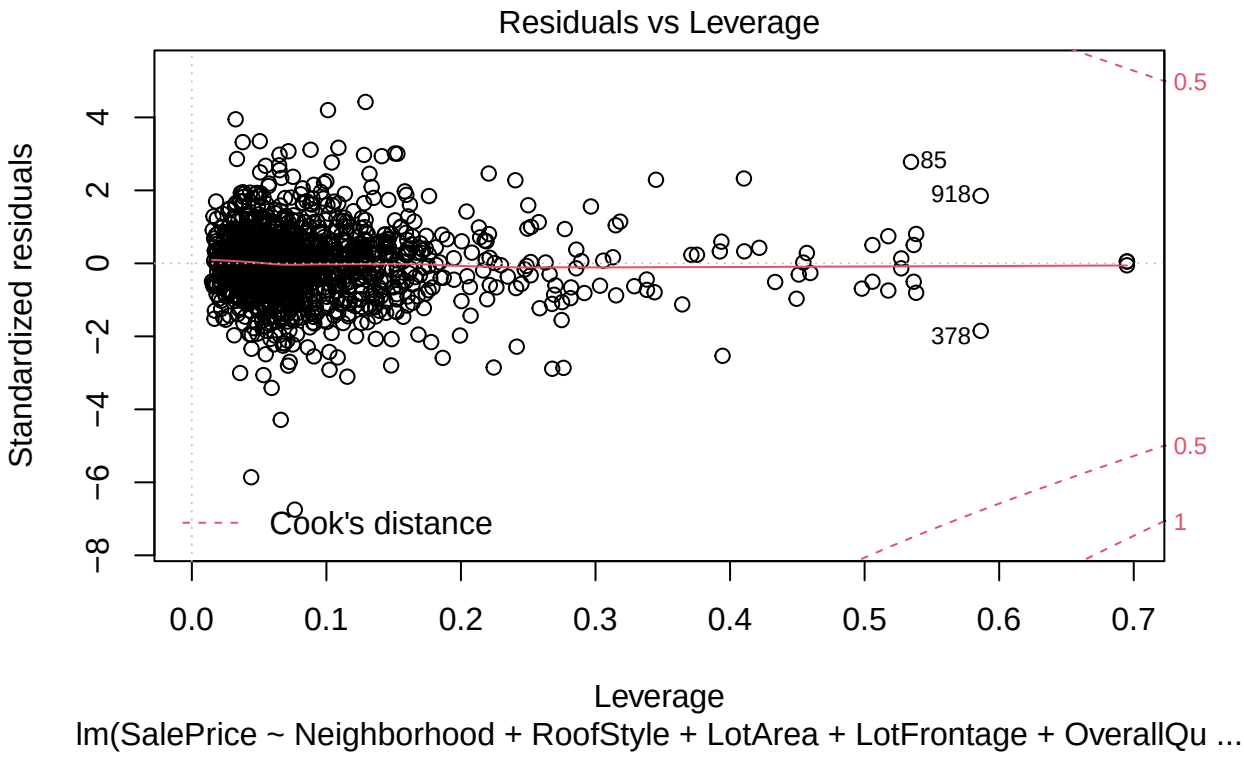
Mean of VIF values is little bit above 1, indicates our model might be slightly biased and may be needs to consider additional predictor variables or more cleaning of data needed or additional / larger size of data is needed. Current data size after filtering became 1344 records.

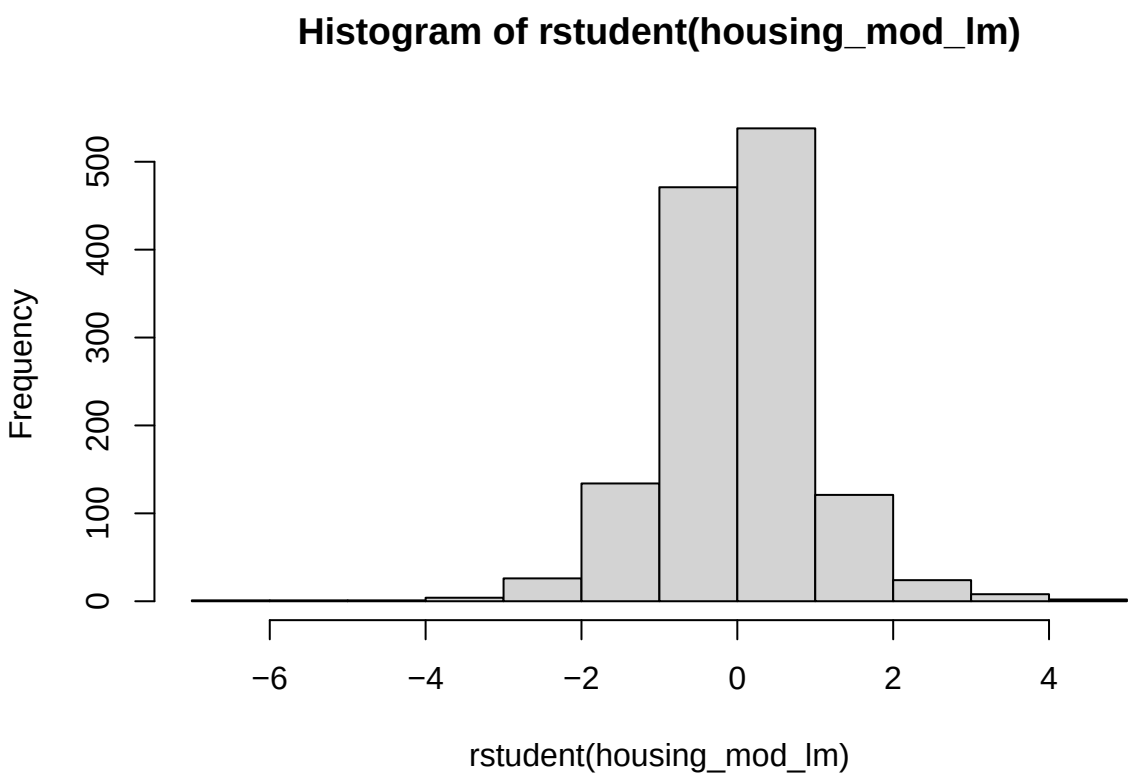
plot() and hist() function

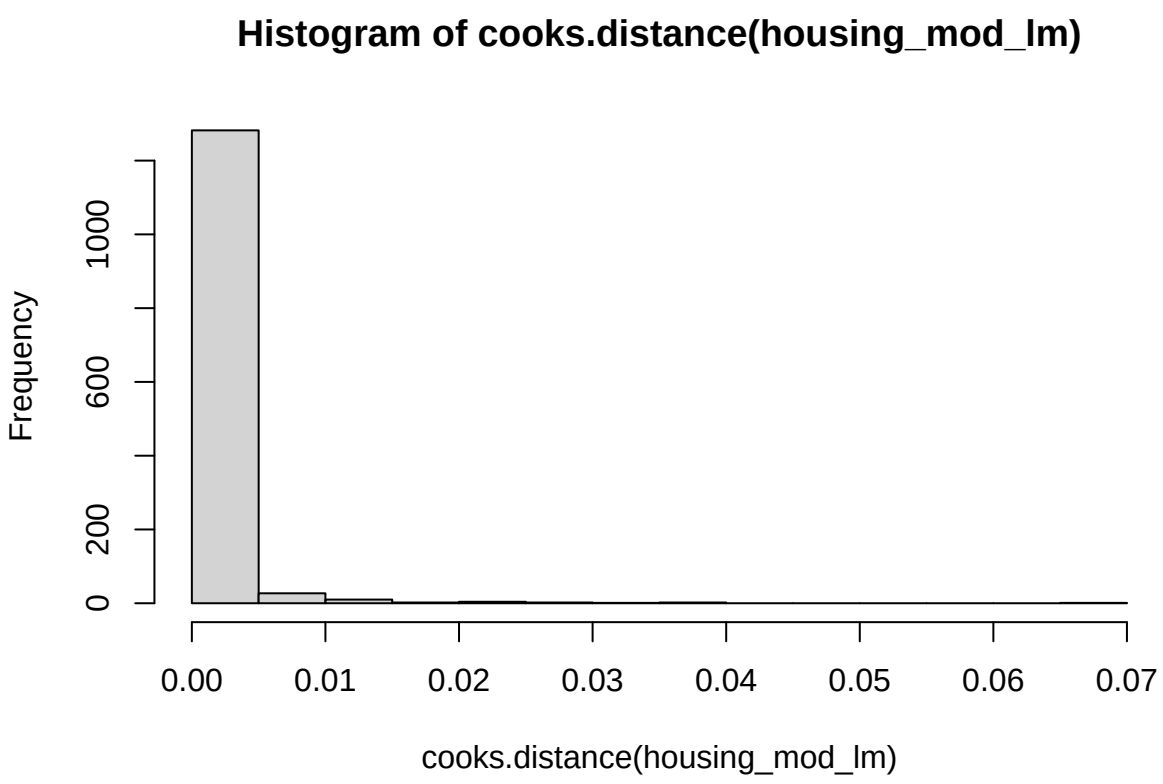



Normal Q−Q
Standardized residuals
Theoretical Quantiles
lm(SalePrice ~ Neighborhood + RoofStyle + LotArea + LotFrontage + OverallQu ...
205
580
1220
−6
−4
−2
0
2
4
−3
−2
−1
0
1
2
3


Scale−Location
√|Standardized residuals|
0.0
0.5
1.0
1.5
2.0
2.5
1220
580
205
50000
100000
150000
200000
250000
300000
Fitted values
lm(SalePrice ~ Neighborhood + RoofStyle + LotArea + LotFrontage + OverallQu ...


Residuals vs Leverage
Standardized residuals
Leverage
lm(SalePrice ~ Neighborhood + RoofStyle + LotArea + LotFrontage + OverallQu ...
Cook's distance
0.5
0.5
1
85
918
378
−8
−6
−4
−2
0
2
4
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7


Histogram of rstudent(housing_mod_lm)
Frequency
0
100
200
300
400
500
−6
−4
−2
0
2
4
rstudent(housing_mod_lm)



As we can see, fitted line on Residuals vs Fitted values, is close to 0 residuals line and as we go towards the lower and upper extremes, the line seems to deviate from ideal fitted line. It can be improved with possibly more number of records for model creation and possibly reducing some of outliers on the lower and upper ends. Also in this plot, residuals in our model shows a fairly random pattern, which is indicative of situation in which the assumptions of linearity, randomness and homoscedasticity have been met.

Normal Q-Q plot shows most of the records fall between 2 standard deviations of the mean, mostly along the straight line fit and thus the model is a good representation of the data, for predictions.

Histogram of Studentized residuals also shows a close to normal distribution up to 2 standard deviations around mean, although we can confirm the same cases earlier that we might be having some level of outliers / skewness in the distribution which might be causing slight deviation of the residuals from the straight line.

All of the records have Cook's distance less than 1, hence we should be good about the model.

Looking at the model, it is fairly close representation of the sample and a generalizable model to the larger population. It can be improved further by deleting outliers for model building purpose. We may need to consider additional predictor variables or more cleaning of data is needed. Another way, perhaps could be finding additional / larger size of data, which can smoothen out the normal distribution even further and help improve accuracy of the model. Current data size after filtering became 1344 records. So, possibly a little larger data size could help.

Conclusion

Overall, people interested in buying a house need to consider not only the basic factors like area / size, number of rooms / bathrooms, neighborhood, garage area, year of initial built but also the overall quality of the construction, Foundations well Roof types, when the house is remodeled, if applicable and Exteriors, open areas and masonry work along with Basement finishing. Based on different geographic locations, the proximity to key essentials and amenities like hospitals, schools, shopping malls, commercial buildings etc. are also important.

References

Field, A., J. Miles, and Z. Field. 2012. *Discovering Statistics Using r*. SAGE Publications. https://books.google.com/books?id=wd2K2zC3swIC.