STA302 Project

What factors and how influence Ames Iowa Housing Sale Price

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ABSTRACT
First sentence. Second sentence. Third sentence. Fourth sentence.

1 Introduction

The housing issue is a pillar industry of a country, and the healthy development of the housing issue affects the country's economic development level. In order to help the stable development of the housing transaction market, this project plans to better evaluate the value of housing transactions for Ames. So, the main purpose of this project is to explore the factors that influence the sale price of homes in Ames, Iowa, and how they affect the home sales price. The characteristics of the homes we selected include central air condition, car capacity of garage, general shape of property, rate of overall quality, total above ground living area, number of fireplaces and sale year. The remainder of this paper is structured as follows. Section 2....

2 Data

The Raw data collects 82 features of the house, and data quality is not high.

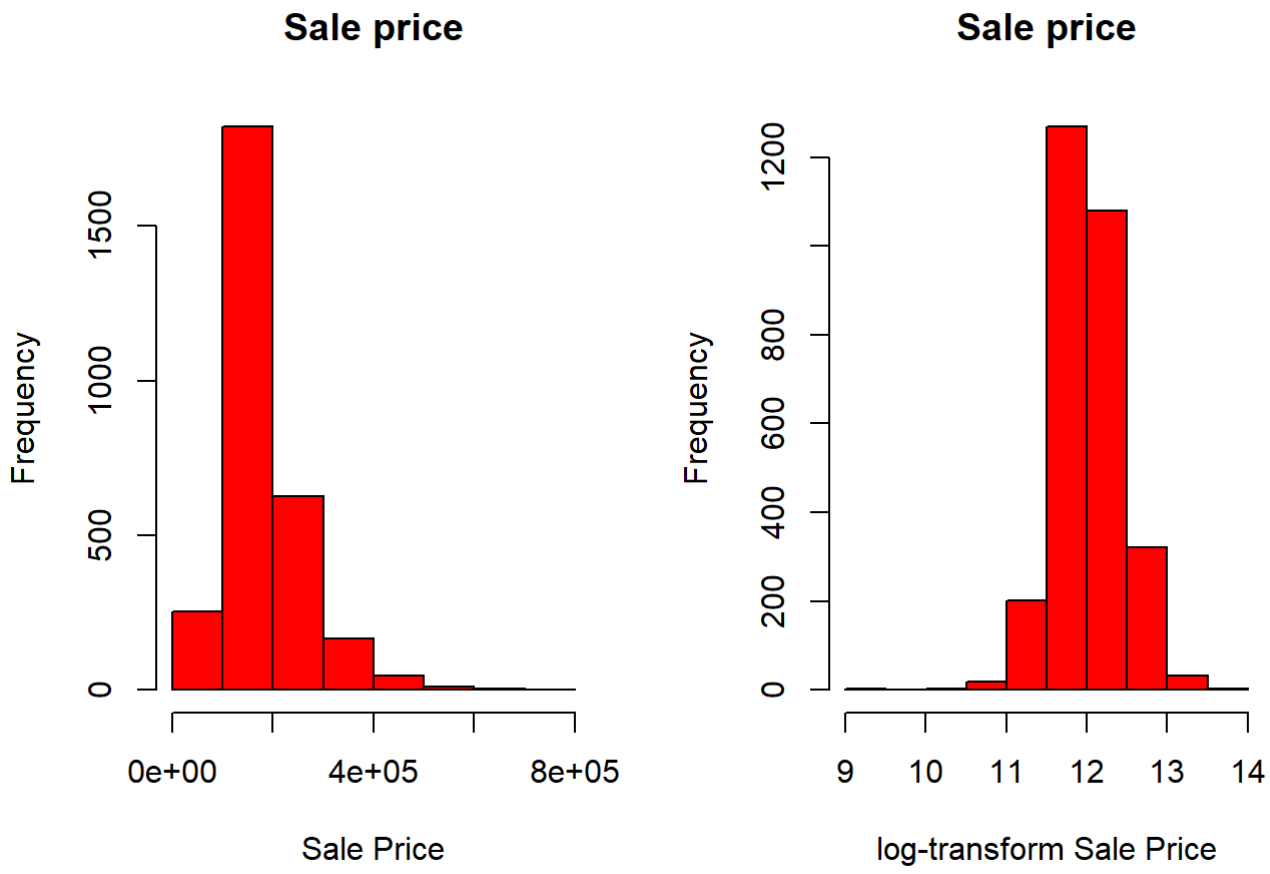
```
  Garage.Cars     Overall.Qual    TotRms.AbvGrd     Gr.Liv.Area
 Min.   :0.000   Min.   : 1.000   Min.   : 2.000   Min.   : 334
 1st Qu.:1.000   1st Qu.: 5.000   1st Qu.: 5.000   1st Qu.:1126
 Median :2.000   Median : 6.000   Median : 6.000   Median :1442
 Mean   :1.767   Mean   : 6.095   Mean   : 6.443   Mean   :1500
 3rd Qu.:2.000   3rd Qu.: 7.000   3rd Qu.: 7.000   3rd Qu.:1742
 Max.   :5.000   Max.   :10.000   Max.   :15.000   Max.   :5642
  Garage.Area       Fireplaces        Yr.Sold       SalePrice
 Min.   :   0.0   Min.   :0.0000   Min.   :2006   Min.   : 12789
 1st Qu.: 320.0   1st Qu.:0.0000   1st Qu.:2007   1st Qu.:129500
 Median : 480.0   Median :1.0000   Median :2008   Median :160000
 Mean   : 472.8   Mean   :0.5995   Mean   :2008   Mean   :180806
 3rd Qu.: 576.0   3rd Qu.:1.0000   3rd Qu.:2009   3rd Qu.:213500
 Max.   :1488.0   Max.   :4.0000   Max.   :2010   Max.   :755000
```

```
   N    Y
 196 2733
```

```
         N         Y
0.06691704 0.93308296
```

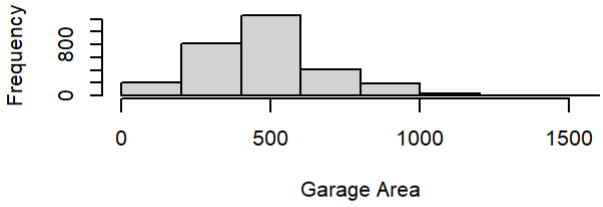
```
 IR1  IR2  IR3  Reg
 979   76   16 1858
```

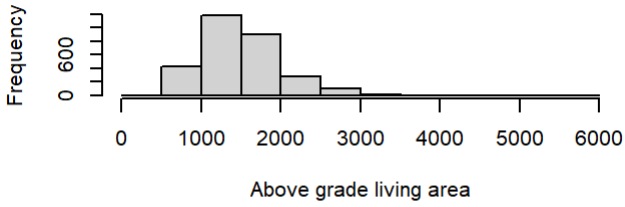
```
        IR1         IR2         IR3         Reg
0.334243769 0.025947422 0.005462615 0.634346193
```

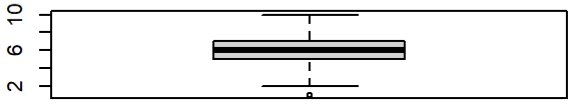


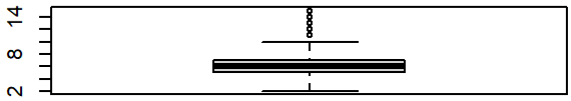
sale price hist

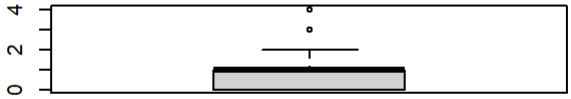
As you can see from the figure, house sales prices are right-skewed data. When building the model, we need to log-transform the house sales prices to make them conform to the normal distribution.











hists

```
`geom_smooth()` using formula = 'y ~ x'
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```
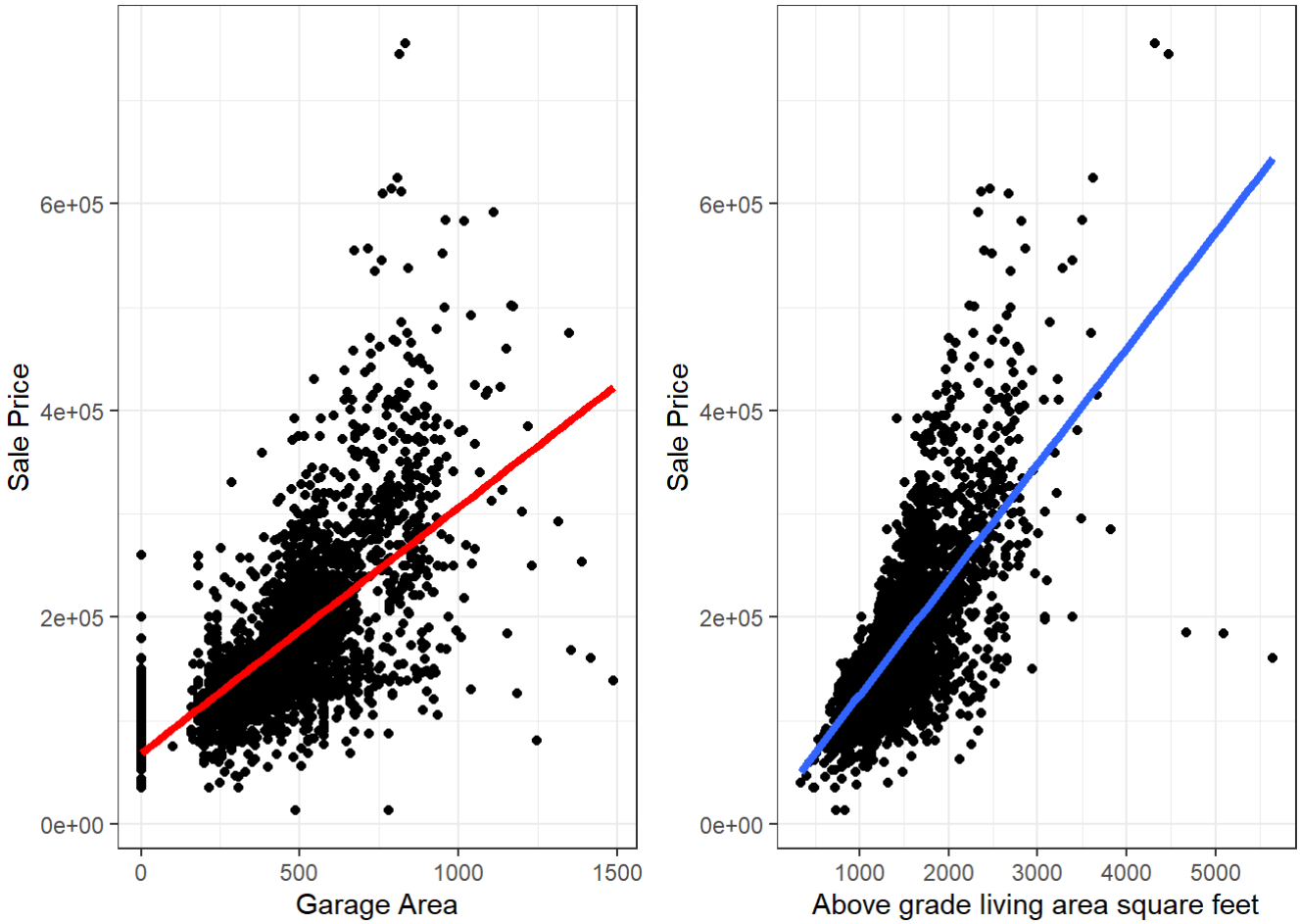



points

The above scatter plot shows that both Garage Area and Above grade living area have a certain positive impact on sale price, especially the positive correlation between Above grade living area and sale price is very strong.

3 Model

3.1 Model set-up

After data processing, the data set is a clean data set with 2929 observations and 10 house characteristic variables. In order to evaluate the performance of the model, we randomly split the analysis data set into a test set and a training set in a ratio of 75%:25%.

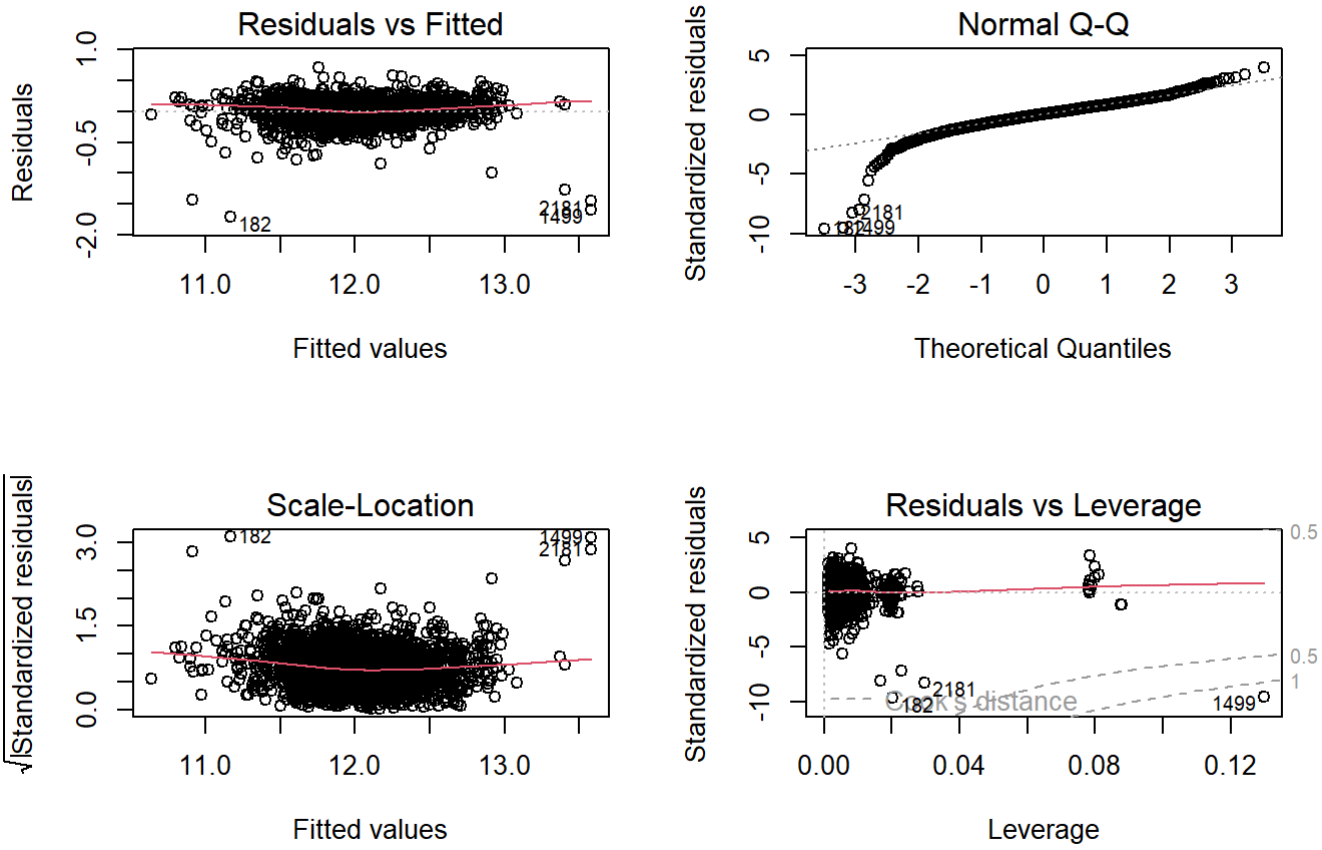
The first model we build is the full model. We then improve the model by removing insignificant variables.

```
Call:
lm(formula = log(SalePrice) ~ ., data = train)

Residuals:
     Min       1Q   Median       3Q      Max
-1.70702 -0.09049  0.01101  0.10726  0.70988

Coefficients:
```

```
               Estimate Std. Error t value Pr(>|t|)
(Intercept)    1.817e+01  7.482e+00   2.429  0.01523 *
Central.AirY   2.232e-01  1.674e-02  13.334  < 2e-16 ***
Lot.ShapeIR2   5.908e-02  2.524e-02   2.341  0.01932 *
Lot.ShapeIR3  -1.409e-01  5.068e-02  -2.781  0.00547 **
Lot.ShapeReg  -4.995e-02  8.550e-03  -5.841 5.95e-09 ***
Garage.Cars    6.232e-02  1.132e-02   5.502 4.18e-08 ***
Overall.Qual   1.393e-01  3.886e-03  35.854  < 2e-16 ***
TotRms.AbvGrd -1.477e-03  4.271e-03  -0.346  0.72961
Gr.Liv.Area    2.032e-04  1.556e-05  13.056  < 2e-16 ***
Garage.Area    1.532e-04  3.906e-05   3.922 9.06e-05 ***
Fireplaces     5.108e-02  6.997e-03   7.300 4.00e-13 ***
Yr.Sold       -3.828e-03  3.725e-03  -1.028  0.30418
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.18 on 2185 degrees of freedom
Multiple R-squared:  0.8055,    Adjusted R-squared:  0.8045
F-statistic: 822.7 on 11 and 2185 DF,  p-value: < 2.2e-16

Call:
lm(formula = log(SalePrice) ~ . - TotRms.AbvGrd - Yr.Sold, data = train)

Residuals:
     Min       1Q   Median       3Q      Max
-1.71281 -0.08994  0.01188  0.10828  0.71389

Coefficients:
               Estimate Std. Error t value Pr(>|t|)
(Intercept)   1.048e+01  2.337e-02 448.365  < 2e-16 ***
Central.AirY  2.237e-01  1.672e-02  13.375  < 2e-16 ***
Lot.ShapeIR2  5.990e-02  2.519e-02   2.378  0.01751 *
Lot.ShapeIR3 -1.390e-01  5.063e-02  -2.745  0.00609 **
Lot.ShapeReg -5.012e-02  8.547e-03  -5.864 5.22e-09 ***
Garage.Cars   6.200e-02  1.128e-02   5.497 4.32e-08 ***
Overall.Qual  1.396e-01  3.859e-03  36.171  < 2e-16 ***
Gr.Liv.Area   1.993e-04  9.991e-06  19.943  < 2e-16 ***
Garage.Area   1.548e-04  3.883e-05   3.988 6.89e-05 ***
Fireplaces    5.109e-02  6.970e-03   7.330 3.23e-13 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.1799 on 2187 degrees of freedom
Multiple R-squared:  0.8054,    Adjusted R-squared:  0.8046
F-statistic:  1006 on 9 and 2187 DF,  p-value: < 2.2e-16

Analysis of Variance Table

Model 1: log(SalePrice) ~ (Central.Air + Lot.Shape + Garage.Cars + Overall.Qual +
    TotRms.AbvGrd + Gr.Liv.Area + Garage.Area + Fireplaces +
    Yr.Sold) - TotRms.AbvGrd - Yr.Sold
Model 2: log(SalePrice) ~ Central.Air + Lot.Shape + Garage.Cars + Overall.Qual +
    TotRms.AbvGrd + Gr.Liv.Area + Garage.Area + Fireplaces +
    Yr.Sold
```

```
  Res.Df    RSS Df Sum of Sq      F Pr(>F)
1   2187 70.804
2   2185 70.766  2  0.037812 0.5837 0.5579
```

Analyzing the model of full and significant variables through the Partial F test, we found that the p value is much greater than 0, which shows that we cannot reject the null hypothesis and there is not much difference in the performance of the two models. But in terms of the number of variables, we still choose the model with significant variables.



plot model

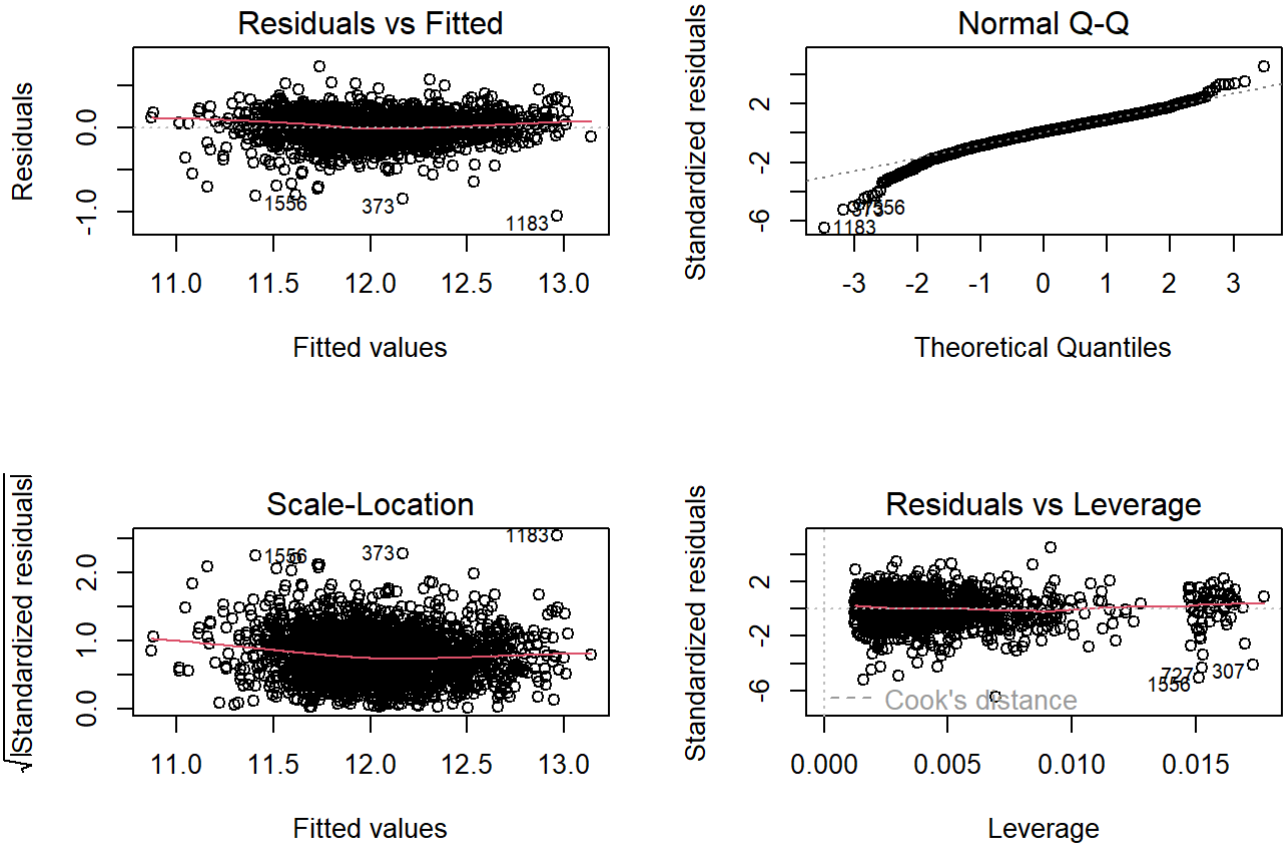
The residual test found that both ends of the QQ graph deviated greatly from the straight line and were affected by special points such as outliers and leverage points. So, in order to further improve the performance of model fitting, we will delete special points from the training set.

After deleting special points such as level points, a new model was refitted.

```
Call:
lm(formula = log(SalePrice) ~ . - TotRms.AbvGrd - Yr.Sold, data = new_train)

Residuals:
     Min       1Q   Median       3Q      Max
-1.04702 -0.08837  0.01205  0.10368  0.72952

Coefficients:
               Estimate Std. Error t value Pr(>|t|)
(Intercept)   1.052e+01  2.629e-02 399.959  < 2e-16 ***
Central.AirY  1.622e-01  2.087e-02   7.771 1.23e-14 ***
```

```
Lot.ShapeReg -4.749e-02  7.957e-03  -5.968 2.83e-09 ***
Garage.Cars   3.296e-02  1.230e-02   2.679  0.00744 **
Overall.Qual  1.319e-01  3.806e-03  34.657  < 2e-16 ***
Gr.Liv.Area   2.276e-04  1.064e-05  21.382  < 2e-16 ***
Garage.Area   3.237e-04  4.289e-05   7.547 6.73e-14 ***
Fireplaces    5.164e-02  6.616e-03   7.805 9.47e-15 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.1623 on 2009 degrees of freedom
Multiple R-squared:  0.8228,    Adjusted R-squared:  0.8222
F-statistic:  1332 on 7 and 2009 DF,  p-value: < 2.2e-16
```

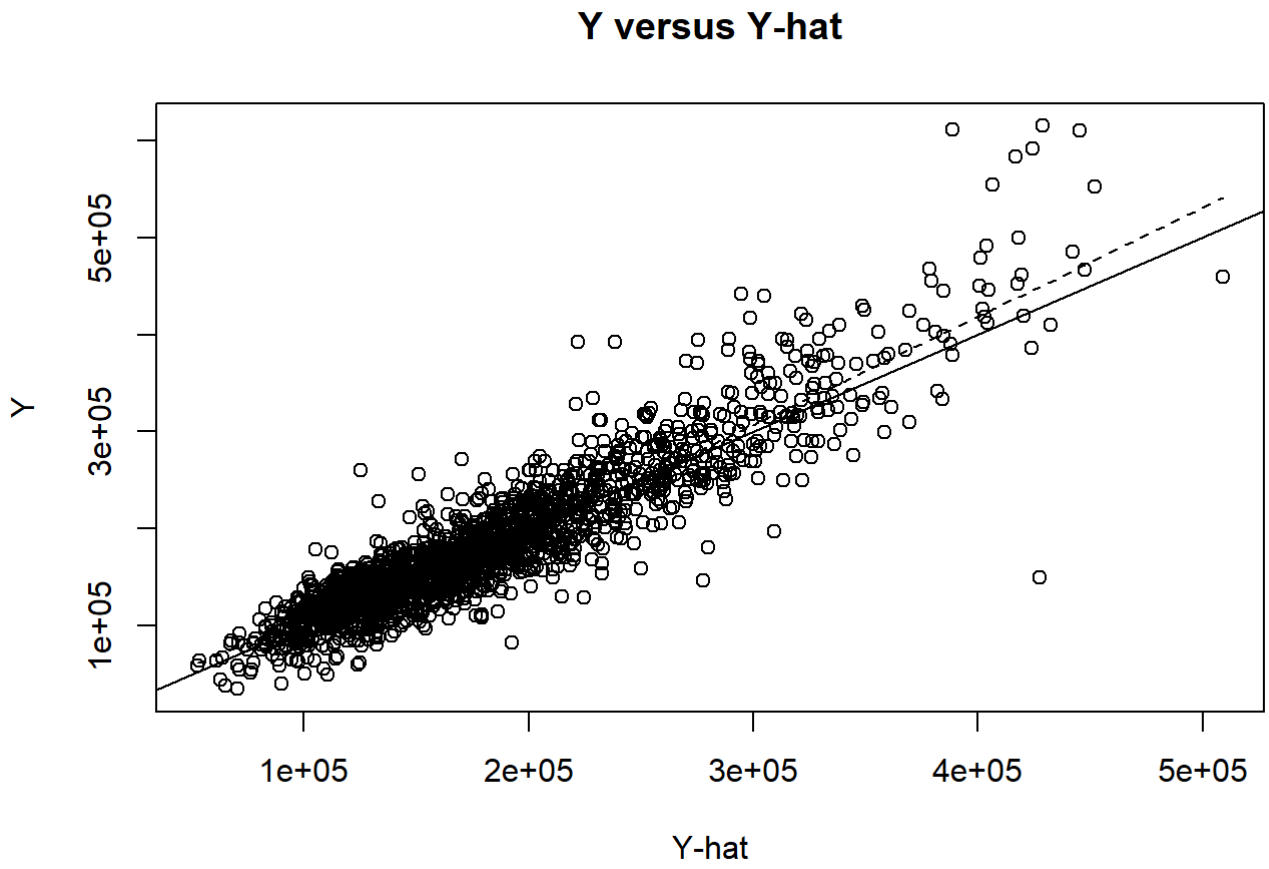
3.1.1 Model justification



plot model 2

Clearly the model has improved.

3.1.1.1 A1:Linearity of the Relationship



plot y hat

The above scatter plot fits the relationship between the predicted value and the actual value. You can see that these points are almost on or close to the line, so we can say that a linear relationship is satisfied.

3.1.1.2 A2.Covariance of Errors

3.1.1.3 A3.Common Error variance

homoskedasticity

3.1.1.4 A4. Normality of Error

4 Results

```
Call:
lm(formula = log(SalePrice) ~ . - TotRms.AbvGrd - Yr.Sold, data = new_train)

Residuals:
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```

```
Central.AirY  1.622e-01  2.087e-02   7.771 1.23e-14 ***
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Overall.Qual  1.319e-01  3.806e-03  34.657  < 2e-16 ***
Gr.Liv.Area   2.276e-04  1.064e-05  21.382  < 2e-16 ***
Garage.Area   3.237e-04  4.289e-05   7.547 6.73e-14 ***
Fireplaces    5.164e-02  6.616e-03   7.805 9.47e-15 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.1623 on 2009 degrees of freedom
Multiple R-squared:  0.8228,    Adjusted R-squared:  0.8222
F-statistic:  1332 on 7 and 2009 DF,  p-value: < 2.2e-16
```

1. When other factors remain unchanged, having central air conditioning increases the sales price of a house by 16.22%.

5 Discussion

5.1 First discussion point

5.2 Second discussion point

5.3 Third discussion point

5.4 Weaknesses and next steps

Weaknesses and next steps should also be included.

Appendix

6 Additional data details

7 Model details

7.1 Posterior predictive check

7.2 Diagnostics

8 References