Final Project Code by Hubert Majewski

```
#Load required libraries
pacman::p_load(data.table, R.utils, tidyverse, skimr, mlr, rpart, rpart.plot,
missForest, randomForest, caret)

#Turn off warnings for presentation
options(warn = -1)

#Set randomization seed to make deterministic
set.seed(342)

#Load in the raw data
housing <-
fread("https://raw.githubusercontent.com/kapelner/QC_MATH_342W_Spring_2021/ma
ster/writing_assignments/housing_data_2016_2017.csv")

#Load it as a data.table object
housing <- data.table(housing)

#Summary of columns and table using skim
skim(housing)
```

*Data summary*

| | |
|---|---|
| Name | housing |
| Number of rows | 2230 |
| Number of columns | 55 |

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Column type frequency:

| | |
|---|---|
| character | 36 |
| logical | 5 |
| numeric | 14 |

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| | |
|---|---|
| Group variables | None |

**Variable type: character**

| skim_variable | n_missing | complete_rate | min | max | empty | n_unique | whitespace |
|---|---|---|---|---|---|---|---|
| HITId | 758 | 0.66 | 30 | 30 | 0 | 1472 | 0 |
| HITTypeId | 758 | 0.66 | 30 | 30 | 0 | 2 | 0 |
| Title | 758 | 0.66 | 69 | 69 | 0 | 1 | 0 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Description | 758 | 0.66 | 46 | 47 | 0 | 2 | 0 |
| Reward | 758 | 0.66 | 5 | 5 | 0 | 1 | 0 |
| CreationTime | 758 | 0.66 | 28 | 28 | 0 | 62 | 0 |
| RequesterAnnotation | 758 | 0.66 | 48 | 48 | 0 | 2 | 0 |
| Expiration | 758 | 0.66 | 28 | 28 | 0 | 62 | 0 |
| AssignmentId | 758 | 0.66 | 30 | 30 | 0 | 1472 | 0 |
| WorkerId | 758 | 0.66 | 13 | 14 | 0 | 73 | 0 |
| AssignmentStatus | 758 | 0.66 | 8 | 8 | 0 | 1 | 0 |
| AcceptTime | 758 | 0.66 | 28 | 28 | 0 | 1457 | 0 |
| SubmitTime | 758 | 0.66 | 28 | 28 | 0 | 1460 | 0 |
| AutoApprovalTime | 758 | 0.66 | 28 | 28 | 0 | 1460 | 0 |
| ApprovalTime | 758 | 0.66 | 23 | 23 | 0 | 929 | 0 |
| LifetimeApprovalRate | 758 | 0.66 | 10 | 14 | 0 | 32 | 0 |
| Last30DaysApprovalRate | 758 | 0.66 | 10 | 14 | 0 | 32 | 0 |
| Last7DaysApprovalRate | 758 | 0.66 | 10 | 14 | 0 | 32 | 0 |
| URL | 758 | 0.66 | 73 | 105 | 0 | 1450 | 0 |
| cats_allowed | 0 | 1.00 | 1 | 3 | 0 | 3 | 0 |
| common_charges | 1684 | 0.24 | 3 | 7 | 0 | 258 | 0 |
| coop_condo | 0 | 1.00 | 5 | 5 | 0 | 2 | 0 |
| date_of_sale | 1702 | 0.24 | 8 | 10 | 0 | 222 | 0 |
| dining_room_type | 448 | 0.80 | 4 | 11 | 0 | 5 | 0 |
| dogs_allowed | 0 | 1.00 | 2 | 5 | 0 | 3 | 0 |
| fuel_type | 112 | 0.95 | 3 | 8 | 0 | 6 | 0 |
| full_address_or_zip_code | 0 | 1.00 | 5 | 59 | 0 | 1177 | 0 |
| garage_exists | 1826 | 0.18 | 1 | 11 | 0 | 6 | 0 |
| kitchen_type | 16 | 0.99 | 4 | 19 | 0 | 13 | 0 |
| maintenance_cost | 623 | 0.72 | 4 | 7 | 0 | 609 | 0 |
| model_type | 40 | 0.98 | 1 | 40 | 0 | 875 | 0 |
| parking_charges | 1671 | 0.25 | 2 | 4 | 0 | 89 | 0 |
| sale_price | 1702 | 0.24 | 8 | 9 | 0 | 315 | 0 |
| total_taxes | 1646 | 0.26 | 3 | 7 | 0 | 293 | 0 |
| listing_price_to_nearest_1000 | 534 | 0.76 | 3 | 7 | 0 | 292 | 0 |
| url | 758 | 0.66 | 73 | 105 | 0 | 1450 | 0 |

**Variable type: logical**

| skim_variable | n_missing | complete_rate | mean | count |
|---|---|---|---|---|
| Keywords | 2230 | 0 | NaN | : |
| NumberOfSimilarHITs | 2230 | 0 | NaN | : |
| LifetimeInSeconds | 2230 | 0 | NaN | : |
| RejectionTime | 2230 | 0 | NaN | : |
| RequesterFeedback | 2230 | 0 | NaN | : |

**Variable type: numeric**

| skim_variable | n_missing | complete_rate | mean | sd | p0 | p25 | p50 | p75 | p100 | hist |
|---|---|---|---|---|---|---|---|---|---|---|
| MaxAssignments | 758 | 0.66 | 1.00 | 0.00 | 1 | 1 | 1 | 1 | 1 | ▁▁▁▁▁ |
| AssignmentDurationInSeconds | 758 | 0.66 | 900.00 | 0.00 | 900 | 900 | 900 | 900 | 900 | ▁▁▁▁▁ |
| AutoApprovalDelayInSeconds | 758 | 0.66 | 60.00 | 0.00 | 60 | 60 | 60 | 60 | 60 | ▁▁▁▁▁ |
| WorkTimeInSeconds | 758 | 0.66 | 162.39 | 111.69 | 22 | 89 | 127 | 197 | 815 | ▇▂▁▁▁ |
| approx_year_built | 40 | 0.98 | 1962.71 | 21.08 | 1893 | 1950 | 1958 | 1970 | 2017 | ▁▂▇▂▁ |
| community_district_num | 19 | 0.99 | 26.33 | 2.95 | 3 | 25 | 26 | 28 | 32 | ▁▁▁▁▆ |
| num_bedrooms | 115 | 0.95 | 1.65 | 0.74 | 0 | 1 | 2 | 2 | 6 | ▆▇▂▁▁ |
| num_floors_in_building | 650 | 0.71 | 7.79 | 7.52 | 1 | 3 | 6 | 7 | 34 | ▇▁▁▁▁ |
| num_full_bathrooms | 0 | 1.00 | 1.23 | 0.44 | 1 | 1 | 1 | 1 | 3 | ▇▁▂▁▁ |
| num_half_bathrooms | 2058 | 0.08 | 0.95 | 0.30 | 0 | 1 | 1 | 1 | 2 | ▁▁▇▁▁ |
| num_total_rooms | 2 | 1.00 | 4.14 | 1.35 | 0 | 3 | 4 | 5 | 14 | ▁▇▂▁▁ |
| pct_tax_deductibl | 1754 | 0.21 | 45.40 | 6.95 | 20 | 40 | 50 | 50 | 75 | ▁▂▇▁▁ |
| sq_footage | 1210 | 0.46 | 955.36 | 380.86 | 100 | 743 | 881 | 1100 | 6215 | ▇▁▁▁▁ |
| walk_score | 0 | 1.00 | 83.9 | 14.7 | 7 | 77 | 89 | 95 | 99 | ▁▁▁▂▇ |

List-wise deletion attempt (if only it were this easy)

```
#Immediate List-wise deletion
LWhousing <- na.omit(housing)

rawCols <- ncol(LWhousing)
rawTotal <- nrow(LWhousing)

cat("Total LW columns", rawCols ,"\n", "Total LW tuples is", rawTotal, "\n")

## Total LW columns 55
##  Total LW tuples is 0

#It doesn't work so we need to first filter columns
```

Data Filtering

```
#Remove attributes which are not related with the cost of housing
housing2 <- housing %>%
    select(-HITId, -HITTypeId, -AssignmentStatus, -Title, -Description, -
AssignmentId, -AcceptTime, -SubmitTime, -URL, -url, -WorkerId, -date_of_sale,
-Keywords, -model_type, -NumberOfSimilarHITs, -community_district_num, -
LifetimeInSeconds, -AcceptTime, -ApprovalTime, -AutoApprovalTime, -
RejectionTime, -RequesterFeedback, -Reward, -MaxAssignments, -
RequesterAnnotation, -AssignmentDurationInSeconds, -
AutoApprovalDelayInSeconds, -Expiration, -Last30DaysApprovalRate, -
Last7DaysApprovalRate, -date_of_sale, -WorkTimeInSeconds, -model_type, -
LifetimeApprovalRate, -parking_charges, -MaxAssignments, -CreationTime, -
SubmitTime, -pct_tax_deductibl, -listing_price_to_nearest_1000, -
num_floors_in_building) #%>% select(-garage_exists) # I disagree with this.
May add value to the entire building/apartment if it is a part of it.


#Convert costs to continuous as it can be anything in between
housing2 <- housing2 %>% mutate(sale_price =
as.numeric(str_remove_all(sale_price, "[$,]" )))
housing2 <- housing2 %>% mutate(total_taxes =
as.numeric(str_remove_all(total_taxes, "[$,]" )))
housing2 <- housing2 %>% mutate(common_charges =
as.numeric(str_remove_all(common_charges, "[$,]" )))
housing2 <- housing2 %>% mutate(maintenance_cost =
as.numeric(str_remove_all(maintenance_cost, "[$,]" )))

#Convert address into zipcodes
zip_codes <- gsub("[^0-9.-]", "", housing2$full_address_or_zip_code)
housing2$zip_codes = str_sub(zip_codes, -5, -1)

#Specific cases
```

```r
housing2$zip_codes[housing2$zip_codes == "1367."] <- "11367" #Specific cases
where the initial zip code was malformed
housing2$zip_codes[housing2$zip_codes == ".1136"] <- "11369"
housing2$zip_codes[housing2$zip_codes == "1355."] <- "11355"

#Factor all attributes that are categories
housing2 <- housing2 %>%
  mutate(zip_codes = as.factor(case_when(
    zip_codes == "11361" | zip_codes == "11362" | zip_codes == "11363" |
zip_codes == "11364" ~ "Northeast Queens",
    zip_codes == "11354" | zip_codes == "11355" | zip_codes == "11356" |
zip_codes == "11357" | zip_codes == "11358" | zip_codes == "11359" |
zip_codes == "11360" ~ "North Queens",
    zip_codes == "11365" | zip_codes == "11366" | zip_codes == "11367" ~
"Central Queens",
    zip_codes == "11412" | zip_codes == "11423" | zip_codes == "11432" |
zip_codes == "11433" | zip_codes == "11434" | zip_codes == "11435" |
zip_codes == "11436" ~ "Jamaica",
    zip_codes == "11101" | zip_codes == "11102" | zip_codes == "11103" |
zip_codes == "11104" | zip_codes == "11105" | zip_codes == "11106" ~
"Northwest Queens",
    zip_codes == "11374" | zip_codes == "11375" | zip_codes == "11379" |
zip_codes == "11385" ~ "West Central Queens",
    zip_codes == "11004" | zip_codes == "11005" | zip_codes == "11411" |
zip_codes == "11413" | zip_codes == "11422" | zip_codes == "11426" |
zip_codes == "11427" | zip_codes == "11428" | zip_codes == "11429" ~
"Southeast Queens",
    zip_codes == "11414" | zip_codes == "11415" | zip_codes == "11416" |
zip_codes == "11417" | zip_codes == "11418" | zip_codes == "11419" |
zip_codes == "11420"  | zip_codes == "11421" ~ "Southwest Queens",
    zip_codes == "11368" | zip_codes == "11369" | zip_codes == "11370" |
zip_codes == "11372" | zip_codes == "11373" | zip_codes == "11377" |
zip_codes == "11378"  ~ "West Queens"
           )))

#Using website as city definition
https://www.walkscore.com/methodology.shtml#:~:text=Walk%20Score%20measures%2
0the%20walkability%20of%20any%20address%20using%20a,miles)%20are%20given%20ma
ximum%20points
housing2$walk_score <- ordered(as.factor(case_when(housing2$walk_score < 25 ~
"Car-Dependent",
                                                   housing2$walk_score
>= 25 & housing2$walk_score < 50 ~ "Car-Mostly-Dependent",
                                                   housing2$walk_score
>= 50 & housing2$walk_score < 70 ~ "Somewhat Walkable",
                                                   housing2$walk_score
>= 70 & housing2$walk_score < 90 ~ "Very Walkable",
                            housing2$walk_score >= 90 ~ "Walker's
Paradise")))
```

```r
#ordering the walk_score because it is that way
housing2$walk_score <- ordered(housing2$walk_score, levels = c("Car-
Dependent", "Car-Mostly-Dependent", "Somewhat Walkable", "Very Walkable",
"Walker's Paradise"))

housing2$approx_year_built <- as.integer(housing2$approx_year_built)

housing2 <- housing2 %>%
  mutate(kitchen_type = as.factor(case_when(
    kitchen_type == "efficiency" | kitchen_type == "efficiency kitchene" |
kitchen_type == "efficiency ktchen" | kitchen_type == "efficiency kitchen" |
kitchen_type == "efficiemcy" ~ "efficiency",
    kitchen_type == "Combo" | kitchen_type == "combo" ~ "combo",
    kitchen_type == "eat in" | kitchen_type == "Eat In" | kitchen_type ==
"eatin" | kitchen_type == "Eat in" ~ "eat-in")))

housing2$num_half_bathrooms <- ifelse(is.na(housing2$num_half_bathrooms), 0,
housing2$num_half_bathrooms)

housing2 <- housing2 %>%
  mutate(cats_allowed = as.factor(ifelse(cats_allowed == "no", 0, 1)))

housing2 <- housing2 %>%
  mutate(dogs_allowed = as.factor(ifelse(dogs_allowed == "no", 0, 1)))

housing2 <- housing2 %>%
  mutate(garage_exists = as.factor(ifelse(is.na(garage_exists), 0, 1)))

housing2 <- housing2 %>% mutate(fuel_type = as.factor(ifelse(fuel_type ==
"Other" | fuel_type == "none", "other", fuel_type)))

housing2 <- housing2 %>% mutate(dining_room_type =
as.factor(dining_room_type))

housing2 <- housing2 %>% mutate(maintenance_cost = ifelse(coop_condo ==
"condo", replace(maintenance_cost, is.na(maintenance_cost), 0),
maintenance_cost))

housing2 <- housing2 %>% mutate(total_taxes = replace(total_taxes,
is.na(total_taxes), 0 )) %>%
                                                  mutate(common_charges =
ifelse(coop_condo == "co-op", replace(common_charges, is.na(common_charges),
0), common_charges)) %>%
                                                  mutate(condoCharges =
ifelse(coop_condo == "condo", common_charges + (total_taxes / 12), 0))

housing2 <- housing2 %>% select(-total_taxes, -common_charges, -
full_address_or_zip_code)
```

```
housing <- housing2 %>% mutate(coop_condo = as.factor(coop_condo))

#Print cleaned
skim(housing)
```

*Data summary*

| | |
|---|---|
| Name | housing |
| Number of rows | 2230 |
| Number of columns | 18 |

_____

Column type frequency:

| | |
|---|---|
| factor | 9 |
| numeric | 9 |

_____

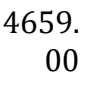
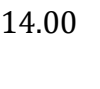
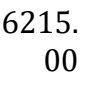
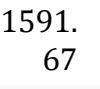
| | |
|---|---|
| Group variables | None |

**Variable type: factor**

| skim_variable | n_missing | complete_rate | ordered | n_unique | top_counts |
|---|---|---|---|---|---|
| cats_allowed | 0 | 1.00 | FALSE | 2 | 0: 1402, 1: 828 |
| coop_condo | 0 | 1.00 | FALSE | 2 | co-: 1661, con: 569 |
| dining_room_type | 448 | 0.80 | FALSE | 5 | com: 957, for: 620, oth: 201, din: 2 |
| dogs_allowed | 0 | 1.00 | FALSE | 2 | 0: 1684, 1: 546 |
| fuel_type | 112 | 0.95 | FALSE | 4 | gas: 1348, oil: 664, ele: 62, oth: 44 |
| garage_exists | 0 | 1.00 | FALSE | 2 | 0: 1826, 1: 404 |
| kitchen_type | 40 | 0.98 | FALSE | 3 | eat: 942, eff: 849, com: 399 |
| walk_score | 0 | 1.00 | TRUE | 5 | Wal: 1089, Ver: 821, Som: 243, Car: 67 |
| zip_codes | 13 | 0.99 | FALSE | 9 | Nor: 551, Wes: 455, Wes: 337, Sou: 205 |

**Variable type: numeric**

| skim_variable | n_missing | complete_rate | mean | sd | p0 | p25 | p50 | p75 | p100 | hist |
|---|---|---|---|---|---|---|---|---|---|---|
| approx_year_built | 40 | 0.98 | 1962.71 | 21.08 | 1893 | 1950 | 1958 | 1970 | 2017.00 | ▁▂▇▁▂ |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| maintenance_cost | 109 | 0.95 | 650.73 | 498.20 | 0 | 310 | 673 | 900 | 4659.00 |  |
| num_bedrooms | 115 | 0.95 | 1.65 | 0.74 | 0 | 1 | 2 | 2 | 6.00 |  |
| num_full_bathrooms | 0 | 1.00 | 1.23 | 0.44 | 1 | 1 | 1 | 1 | 3.00 |  |
| num_half_bathrooms | 0 | 1.00 | 0.07 | 0.27 | 0 | 0 | 0 | 0 | 2.00 |  |
| num_total_rooms | 2 | 1.00 | 4.14 | 1.35 | 0 | 3 | 4 | 5 | 14.00 |  |
| sale_price | 1702 | 0.24 | 314956.56 | 179526.60 | 55000 | 171500 | 259500 | 428875 | 9999999.00 |  |
| sq_footage | 1210 | 0.46 | 955.36 | 380.86 | 100 | 743 | 881 | 1100 | 6215.00 |  |
| condoCharges | 84 | 0.96 | 133.49 | 281.76 | 0 | 0 | 0 | 0 | 1591.67 |  |

```
head(housing)

##    approx_year_built cats_allowed coop_condo dining_room_type dogs_allowed
## 1:              1955            0      co-op            combo            0
## 2:              1955            0      co-op           formal            0
## 3:              2004            0      condo            combo            0
## 4:              2002            0      condo            combo            0
## 5:              1949            1      co-op            combo            1
## 6:              1938            1      co-op            combo            1
##    fuel_type garage_exists kitchen_type maintenance_cost num_bedrooms
## 1:       gas             0       eat-in               NA            2
## 2:       oil             0       eat-in              604            1
## 3:      <NA>             0   efficiency                0            1
## 4:       gas             0       eat-in                0            3
## 5:       gas             0       eat-in              660            2
## 6:       oil             0       eat-in              932            2
##    num_full_bathrooms num_half_bathrooms num_total_rooms sale_price
sq_footage
## 1:                  1                  0              5     228000
NA
## 2:                  1                  0              4     235500
890
## 3:                  1                  0              3     137550
550
## 4:                  2                  0              5     545000
NA
## 5:                  1                  0              4     241700
675
## 6:                  1                  0              4     250000
```

```
1000
##           walk_score        zip_codes condoCharges
## 1:     Very Walkable     North Queens       0.0000
## 2:     Very Walkable     North Queens       0.0000
## 3: Walker's Paradise      West Queens     625.3333
## 4: Walker's Paradise     North Queens     463.3333
## 5:     Very Walkable Southeast Queens       0.0000
## 6: Walker's Paradise Southwest Queens       0.0000
```

Dealing with missingness

```
#Record the nulls into their own columns
M <- tibble::as_tibble(apply(is.na(housing), 2, as.numeric))
colnames(M) = paste(colnames(housing), "_missing", sep = "")
M <- tibble::as_tibble(t(unique(t(M))))
m <- M %>%
  select_if(function(x){sum(x) > 0})

housing2 <- cbind(M, housing)


#Prep for missing forest
housing2NA = housing2 %>%
  filter(is.na(sale_price))
housing2 = housing2 %>%
  filter(!is.na(sale_price))

#Split
n = nrow(housing2)
k = 5

test_indices <- sample(1 : n, 1 / k * n)
train_indices <- setdiff(1 : n, test_indices)

training <- housing2[train_indices, ]
testing <- housing2[test_indices, ]

XTest <- testing %>%
  mutate(sale_price = NA)
yTest <- testing$sale_price

#Print a summary of the data before imputation
summary(housing2)
```

```
##  approx_year_built_missing cats_allowed_missing dining_room_type_missing
##  Min.   :0.00000           Min.   :0            Min.   :0.0000
##  1st Qu.:0.00000           1st Qu.:0            1st Qu.:0.0000
##  Median :0.00000           Median :0            Median :0.0000
##  Mean   :0.01136           Mean   :0            Mean   :0.2273
##  3rd Qu.:0.00000           3rd Qu.:0            3rd Qu.:0.0000
```

```
##  Max.   :1.00000           Max.   :0            Max.   :1.0000
##
##  fuel_type_missing kitchen_type_missing maintenance_cost_missing
##  Min.   :0.00000   Min.   :0.00000      Min.   :0.00000
##  1st Qu.:0.00000   1st Qu.:0.00000      1st Qu.:0.00000
##  Median :0.00000   Median :0.00000      Median :0.00000
##  Mean   :0.04545   Mean   :0.01326      Mean   :0.03977
##  3rd Qu.:0.00000   3rd Qu.:0.00000      3rd Qu.:0.00000
##  Max.   :1.00000   Max.   :1.00000      Max.   :1.00000
##
##  num_bedrooms_missing num_total_rooms_missing sale_price_missing
##  Min.   :0            Min.   :0               Min.   :0
##  1st Qu.:0            1st Qu.:0               1st Qu.:0
##  Median :0            Median :0               Median :0
##  Mean   :0            Mean   :0               Mean   :0
##  3rd Qu.:0            3rd Qu.:0               3rd Qu.:0
##  Max.   :0            Max.   :0               Max.   :0
##
##  sq_footage_missing zip_codes_missing condoCharges_missing
approx_year_built
##  Min.   :0.0000     Min.   :0         Min.   :0.00000      Min.   :1915
##  1st Qu.:0.0000     1st Qu.:0         1st Qu.:0.00000      1st Qu.:1950
##  Median :1.0000     Median :0         Median :0.00000      Median :1957
##  Mean   :0.5966     Mean   :0         Mean   :0.01894      Mean   :1962
##  3rd Qu.:1.0000     3rd Qu.:0         3rd Qu.:0.00000      3rd Qu.:1968
##  Max.   :1.0000     Max.   :0         Max.   :1.00000      Max.   :2016
##                                                            NA's   :6
##  cats_allowed coop_condo     dining_room_type dogs_allowed    fuel_type
##  0:285        co-op:399   combo      :241     0:381        electric: 11
##  1:243        condo:129   dining area:  2     1:147        gas     :301
##                           formal     :116                  oil     :180
##                           none       :  0                  other   : 12
##                           other      : 49                  NA's    : 24
##                           NA's       :120
##
##  garage_exists     kitchen_type maintenance_cost  num_bedrooms
##  0:434         combo     : 81   Min.   :   0.0   Min.   :0.000
##  1: 94         eat-in    :209   1st Qu.: 387.0   1st Qu.:1.000
##                efficiency:231   Median : 670.0   Median :1.000
##                NA's      :  7   Mean   : 625.7   Mean   :1.538
##                                 3rd Qu.: 827.0   3rd Qu.:2.000
##                                 Max.   :4659.0   Max.   :3.000
##                                 NA's   :21
##  num_full_bathrooms num_half_bathrooms num_total_rooms   sale_price
##  Min.   :1.000      Min.   :0.00000    Min.   :1.000   Min.   : 55000
##  1st Qu.:1.000      1st Qu.:0.00000    1st Qu.:3.000   1st Qu.:171500
##  Median :1.000      Median :0.00000    Median :4.000   Median :259500
##  Mean   :1.205      Mean   :0.05871    Mean   :4.025   Mean   :314957
##  3rd Qu.:1.000      3rd Qu.:0.00000    3rd Qu.:5.000   3rd Qu.:428875
##  Max.   :3.000      Max.   :2.00000    Max.   :8.000   Max.   :999999
```

```
##
##    sq_footage                   walk_score                zip_codes
##  Min.   : 375.0   Car-Dependent       :  2   North Queens       :113
##  1st Qu.: 750.0   Car-Mostly-Dependent:  9   West Central Queens: 93
##  Median : 874.0   Somewhat Walkable   : 61   Northeast Queens   : 72
##  Mean   : 965.3   Very Walkable       :237   West Queens        : 69
##  3rd Qu.:1010.0   Walker's Paradise   :219   Southwest Queens   : 59
##  Max.   :6215.0                              Central Queens     : 34
##  NA's   :315                                 (Other)            : 88
##   condoCharges
##  Min.   :   0.0
##  1st Qu.:   0.0
##  Median :   0.0
##  Mean   : 135.3
##  3rd Qu.:   0.0
##  Max.   :1500.9
##  NA's   :10
```

```
skim(housing2)
```

*Data summary*

| | |
|---|---|
| Name | housing2 |
| Number of rows | 528 |
| Number of columns | 30 |

_____

Column type frequency:

| | |
|---|---|
| factor | 9 |
| numeric | 21 |

_____

| | |
|---|---|
| Group variables | None |

**Variable type: factor**

| skim_variable | n_missing | complete_rate | ordered | n_unique | top_counts |
|---|---|---|---|---|---|
| cats_allowed | 0 | 1.00 | FALSE | 2 | 0: 285, 1: 243 |
| coop_condo | 0 | 1.00 | FALSE | 2 | co-: 399, con: 129 |
| dining_room_type | 120 | 0.77 | FALSE | 4 | com: 241, for: 116, oth: 49, din: 2 |
| dogs_allowed | 0 | 1.00 | FALSE | 2 | 0: 381, 1: 147 |
| fuel_type | 24 | 0.95 | FALSE | 4 | gas: 301, oil: 180, oth: 12, ele: 11 |
| garage_exists | 0 | 1.00 | FALSE | 2 | 0: 434, 1: 94 |

| | | | | | |
|---|---|---|---|---|---|
| kitchen_type | 7 | 0.99 | FALSE | 3 | eff: 231, eat: 209, com: 81 |
| walk_score | 0 | 1.00 | TRUE | 5 | Ver: 237, Wal: 219, Som: 61, Car: 9 |
| zip_codes | 0 | 1.00 | FALSE | 9 | Nor: 113, Wes: 93, Nor: 72, Wes: 69 |

**Variable type: numeric**

| skim_variable | n_missing | complete_rate | mean | sd | p0 | p25 | p50 | p75 | p100 | hist |
|---|---|---|---|---|---|---|---|---|---|---|
| approx_year_built_missing | 0 | 1.00 | 0.01 | 0.11 | 0 | 0 | 0 | 0 | 1.00 |  |
| cats_allowed_missing | 0 | 1.00 | 0.00 | 0.00 | 0 | 0 | 0 | 0 | 0.00 |  |
| dining_room_type_missing | 0 | 1.00 | 0.23 | 0.42 | 0 | 0 | 0 | 0 | 1.00 |  |
| fuel_type_missing | 0 | 1.00 | 0.05 | 0.21 | 0 | 0 | 0 | 0 | 1.00 |  |
| kitchen_type_missing | 0 | 1.00 | 0.01 | 0.11 | 0 | 0 | 0 | 0 | 1.00 |  |
| maintenance_cost_missing | 0 | 1.00 | 0.04 | 0.20 | 0 | 0 | 0 | 0 | 1.00 |  |
| num_bedrooms_missing | 0 | 1.00 | 0.00 | 0.00 | 0 | 0 | 0 | 0 | 0.00 |  |
| num_total_rooms_missing | 0 | 1.00 | 0.00 | 0.00 | 0 | 0 | 0 | 0 | 0.00 |  |
| sale_price_missing | 0 | 1.00 | 0.00 | 0.00 | 0 | 0 | 0 | 0 | 0.00 |  |
| sq_footage_missing | 0 | 1.00 | 0.60 | 0.49 | 0 | 0 | 1 | 1 | 1.00 |  |
| zip_codes_missing | 0 | 1.00 | 0.00 | 0.00 | 0 | 0 | 0 | 0 | 0.00 |  |
| condoCharges_missing | 0 | 1.00 | 0.02 | 0.14 | 0 | 0 | 0 | 0 | 1.00 |  |
| approx_year_built | 6 | 0.99 | 1962.38 | 20.56 | 1915 | 1950 | 1957 | 1968 | 2016.00 |  |
| maintenance_cost | 21 | 0.96 | 625.71 | 481.80 | 0 | 387 | 670 | 827 | 4659.00 |  |
| num_bedroom | 0 | 1.00 | 1.54 | 0.75 | 0 | 1 | 1 | 2 | 3.00 |  |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| s | | | | | | | | | | ▇▂ |
| num_full_bathrooms | 0 | 1.00 | 1.20 | 0.42 | 1 | 1 | 1 | 1 | 3.00 | ▇▁▂▁▁▁ |
| num_half_bathrooms | 0 | 1.00 | 0.06 | 0.24 | 0 | 0 | 0 | 0 | 2.00 | ▇▁▁▁▁▁ |
| num_total_rooms | 0 | 1.00 | 4.02 | 1.20 | 1 | 3 | 4 | 5 | 8.00 | ▁▅▇▃▁ |
| sale_price | 0 | 1.00 | 314956.56 | 179526.60 | 55000 | 171500 | 259500 | 428875 | 999999.00 | ▇▃▂▁▁▁ |
| sq_footage | 315 | 0.40 | 965.28 | 490.42 | 375 | 750 | 874 | 1010 | 6215.00 | ▇▁▁▁▁▁ |
| condoCharges | 10 | 0.98 | 135.26 | 284.11 | 0 | 0 | 0 | 0 | 1500.92 | ▇▁▁▁▁▁ |

```
#Fill in missingness
housing3 <- missForest(rbind(training, XTest, housing2NA))$ximp

##   missForest iteration 1 in progress...done!
##   missForest iteration 2 in progress...done!
##   missForest iteration 3 in progress...done!
##   missForest iteration 4 in progress...done!

#Remove origional y that was missing for modeling
housing3 <- housing3 %>% filter(sale_price_missing == 0) %>%
    select(-sale_price_missing)

#Remove origional zipcodes that was missing (about 1 tuple?)
#housing3 <- housing3 %>% filter(zip_codes_missing == 0) %>%
#   select(-zip_codes_missing)

#Compute imputed costs on tuple
housing3 <- housing3 %>%
  mutate(total_cost = maintenance_cost + condoCharges) %>%
  select(-maintenance_cost, -condoCharges)

#Retain linear independence
#Note: REMOVES NUMERIC AND FACTORS FROM TABLE AND SETS THEM AS CHARACTERS DUE
TO COL COMPARISONS
housing3 <- cbind(housing3[, -(1:11)],
tibble::as_tibble(t(unique(t(housing3[, (1:11)])))))
#housing3 <- housing3[, qr(housing3)$pivot[seq_len(qr(housing3)$rank)]]
#housing3 <- cbind(housing3[, -(1:ncol(housing3))],
tbl_df(t(unique(t(housing3[, (1:ncol(housing3))])))))
#housing3 <- sapply(1:ncol(housing3), function (x) qr(housing3[,-x])$rank)
#which(rankifremoved == max(rankifremoved))
```

```r
#Reinsert the yTest into the testing dataset
train <- housing3[1:as.integer(n - as.integer(1 / k * n)), ]
test <- housing3[(as.integer(n - as.integer(1 / k * n)) + 1):n, ]
test$sale_price <- yTest

#Print filled
skim(housing3)
```

*Data summary*

| | |
|---|---|
| Name | housing3 |
| Number of rows | 528 |
| Number of columns | 25 |

_____

Column type frequency:

| | |
|---|---|
| factor | 9 |
| numeric | 16 |

_____

| | |
|---|---|
| Group variables | None |

**Variable type: factor**

| skim_variable | n_missing | complete_rate | ordered | n_unique | top_counts |
|---|---|---|---|---|---|
| cats_allowed | 0 | 1 | FALSE | 2 | 0: 285, 1: 243 |
| coop_condo | 0 | 1 | FALSE | 2 | co-: 399, con: 129 |
| dining_room_type | 0 | 1 | FALSE | 4 | com: 330, for: 135, oth: 60, din: 3 |
| dogs_allowed | 0 | 1 | FALSE | 2 | 0: 381, 1: 147 |
| fuel_type | 0 | 1 | FALSE | 4 | gas: 312, oil: 192, oth: 13, ele: 11 |
| garage_exists | 0 | 1 | FALSE | 2 | 0: 434, 1: 94 |
| kitchen_type | 0 | 1 | FALSE | 3 | eff: 233, eat: 213, com: 82 |
| walk_score | 0 | 1 | TRUE | 5 | Ver: 237, Wal: 219, Som: 61, Car: 9 |
| zip_codes | 0 | 1 | FALSE | 9 | Nor: 113, Wes: 93, Nor: 72, Wes: 69 |

**Variable type: numeric**

| skim_variable | n_missing | complete_rate | mean | sd | p0 | p25 | p50 | p75 | p100 | hist |
|---|---|---|---|---|---|---|---|---|---|---|

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| approx_year_built | 0 | 1 | 1962.28 | 20.47 | 1915.00 | 1950.00 | 1956.00 | 1966.50 | 2016 |  |
| num_bedrooms | 0 | 1 | 1.54 | 0.75 | 0.00 | 1.00 | 1.00 | 2.00 | 3 |  |
| num_full_bathrooms | 0 | 1 | 1.20 | 0.42 | 1.00 | 1.00 | 1.00 | 1.00 | 3 |  |
| num_half_bathrooms | 0 | 1 | 0.06 | 0.24 | 0.00 | 0.00 | 0.00 | 0.00 | 2 |  |
| num_total_rooms | 0 | 1 | 4.02 | 1.20 | 1.00 | 3.00 | 4.00 | 5.00 | 8 |  |
| sale_price | 0 | 1 | 314264.84 | 170472.90 | 55000.00 | 173750.00 | 262000.00 | 430000.00 | 950000 |  |
| sq_footage | 0 | 1 | 894.67 | 359.42 | 375.00 | 711.03 | 828.81 | 984.27 | 6215 |  |
| total_cost | 0 | 1 | 774.36 | 367.60 | 148.92 | 584.00 | 713.00 | 869.25 | 4659 |  |
| approx_year_built_missing | 0 | 1 | 0.01 | 0.11 | 0.00 | 0.00 | 0.00 | 0.00 | 1 |  |
| cats_allowed_missing | 0 | 1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0 |  |
| dining_room_type_missing | 0 | 1 | 0.23 | 0.42 | 0.00 | 0.00 | 0.00 | 0.00 | 1 |  |
| fuel_type_missing | 0 | 1 | 0.05 | 0.21 | 0.00 | 0.00 | 0.00 | 0.00 | 1 |  |
| kitchen_type_missing | 0 | 1 | 0.01 | 0.11 | 0.00 | 0.00 | 0.00 | 0.00 | 1 |  |
| maintenance_cost_missing | 0 | 1 | 0.04 | 0.20 | 0.00 | 0.00 | 0.00 | 0.00 | 1 |  |
| sq_footage_missing | 0 | 1 | 0.60 | 0.49 | 0.00 | 0.00 | 1.00 | 1.00 | 1 |  |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| condoCharges_missing | 0 | 1 | 0.02 | 0.14 | 0.00 | 0.00 | 0.00 | 0.00 | 1 | ▉▉▉ |

```
head(housing3)

##   approx_year_built cats_allowed coop_condo dining_room_type dogs_allowed
## 1              1955            0      co-op            combo            0
## 2              1955            0      co-op           formal            0
## 3              2004            0      condo            combo            0
## 4              2002            0      condo            combo            0
## 5              1949            1      co-op            combo            1
## 6              1938            1      co-op            combo            1
##   fuel_type garage_exists kitchen_type num_bedrooms num_full_bathrooms
## 1       gas             0       eat-in            2                  1
## 2       oil             0       eat-in            1                  1
## 3       gas             0   efficiency            1                  1
## 4       gas             0       eat-in            3                  2
## 5       gas             0       eat-in            2                  1
## 6       oil             0       eat-in            2                  1
##   num_half_bathrooms num_total_rooms sale_price sq_footage
walk_score
## 1                  0              5     228000   878.7562     Very
Walkable
## 2                  0              4     235500   890.0000     Very
Walkable
## 3                  0              3     137550   550.0000 Walker's
Paradise
## 4                  0              5     545000  1077.9034 Walker's
Paradise
## 5                  0              4     241700   675.0000     Very
Walkable
## 6                  0              4     250000  1000.0000 Walker's
Paradise
##          zip_codes total_cost approx_year_built_missing
cats_allowed_missing
## 1     North Queens   845.8436                         0
0
## 2     North Queens   604.0000                         0
0
## 3      West Queens   625.3333                         0
0
## 4     North Queens   463.3333                         0
0
## 5 Southeast Queens   660.0000                         0
0
## 6 Southwest Queens   932.0000                         0
0
##   dining_room_type_missing fuel_type_missing kitchen_type_missing
```

```
## 1                          0                 0                     0
## 2                          0                 0                     0
## 3                          0                 1                     0
## 4                          0                 0                     0
## 5                          0                 0                     0
## 6                          0                 0                     0
##   maintenance_cost_missing sq_footage_missing condoCharges_missing
## 1                        1                  1                     0
## 2                        0                  0                     0
## 3                        0                  0                     0
## 4                        0                  1                     0
## 5                        0                  0                     0
## 6                        0                  0                     0
```

Regression Tree Model

```
#Create one Regression Tree (anova -> regression)
rtModel <- rpart(train$sale_price ~ ., data = train %>% select(-sale_price),
method = "anova", control = list(cp = 0, xval = 10))

png("Regression_Tree_Model_Plot.png",width = 5888, height = 3312, res = 250)
rpart.plot(rtModel, tweak = 1.235, fallen.leaves = TRUE, type = 5, faclen =
2, digits = 3)
dev.off()

## png
##   2

#plotcp(rtModel)
rtModel

## n= 423
##
## node), split, n, deviance, yval
##       * denotes terminal node
##
##    1) root 423 1.302784e+13 313311.3
##      2) num_full_bathrooms< 1.5 340 5.707659e+12 257218.0
##        4) coop_condo=co-op 288 2.508365e+12 224205.3
##          8) sq_footage< 867.322 196 6.066295e+11 182076.2
##           16) sq_footage< 765.906 132 2.286658e+11 162556.6
##             32) zip_codes=Jamaica,Southwest Queens 31 2.468297e+10
130967.7
##               64) approx_year_built>=1960.5 7 6.807429e+09 108714.3 *
##               65) approx_year_built< 1960.5 24 1.339796e+10 137458.3
##                130) kitchen_type=efficiency 17 4.572941e+09 132058.8 *
##                131) kitchen_type=combo,eat-in 7 7.125714e+09 150571.4 *
##             33) zip_codes=Central Queens,North Queens,Northeast
Queens,Northwest Queens,Southeast Queens,West Central Queens,West Queens 101
1.635547e+11 172252.2
##               66) sq_footage< 734.8331 83 1.121606e+11 164261.2
```

```
##                132) num_total_rooms>=3.5 22 2.446729e+10 143413.6
##                  264) cats_allowed=0 15 9.438229e+09 130593.3 *
##                  265) cats_allowed=1 7 7.280649e+09 170885.7 *
##                133) num_total_rooms< 3.5 61 7.468318e+10 171780.0
##                  266) zip_codes=Central Queens,Northeast Queens,West
Central Queens 34 2.315201e+10 159691.2
##                    532) num_total_rooms< 2.5 10 3.804500e+09 141000.0 *
##                    533) num_total_rooms>=2.5 24 1.439824e+10 167479.2
##                     1066) zip_codes=Central Queens 7 7.162857e+09 157142.9
*
##                     1067) zip_codes=Northeast Queens,West Central Queens
17 6.179559e+09 171735.3 *
##                    267) zip_codes=North Queens,Southeast Queens,West Queens
27 4.030558e+10 187002.9
##                    534) total_cost< 517.5 11 5.405833e+09 167925.2 *
##                    535) total_cost>=517.5 16 2.814378e+10 200118.8 *
##               67) sq_footage>=734.8331 18 2.165436e+10 209100.0 *
##           17) sq_footage>=765.906 64 2.239399e+11 222335.1
##             34) zip_codes=Jamaica,Southwest Queens 14 1.200886e+10
152285.7 *
##             35) zip_codes=Central Queens,North Queens,Northeast
Queens,Northwest Queens,Southeast Queens,West Central Queens,West Queens 50
1.239990e+11 241949.0
##               70) zip_codes=Central Queens,North Queens,Northeast
Queens,West Queens 29 6.316092e+10 223758.2
##                140) sq_footage< 830.281 15 2.719203e+10 200732.6 *
##                141) sq_footage>=830.281 14 1.949543e+10 248428.6 *
##               71) zip_codes=Northwest Queens,Southeast Queens,West Central
Queens 21 3.799003e+10 267069.5
##                142) total_cost< 753.5 13 7.366118e+09 245920.0 *
##                143) total_cost>=753.5 8 1.535972e+10 301437.5 *
##          9) sq_footage>=867.322 92 8.127418e+11 313958.6
##           18) zip_codes=Central Queens,Jamaica,North Queens,Northeast
Queens,Southwest Queens 54 2.586232e+11 269172.2
##             36) walk_score=Very Walkable,Walker's Paradise 46 1.689628e+11
254006.5
##               72) sq_footage< 930.947 14 3.132250e+10 199000.0 *
##               73) sq_footage>=930.947 32 7.674772e+10 278071.9
##                146) zip_codes=Central Queens,Jamaica,Northeast
Queens,Southwest Queens 20 1.153196e+10 260790.0
##                  292) zip_codes=Central Queens,Jamaica,Southwest Queens 12
9.385667e+09 253833.3 *
##                  293) zip_codes=Northeast Queens 8 6.944350e+08 271225.0 *
##                147) zip_codes=North Queens 12 4.928706e+10 306875.0 *
##             37) walk_score=Car-Dependent,Car-Mostly-Dependent,Somewhat
Walkable 8 1.824588e+10 356375.0 *
##           19) zip_codes=Northwest Queens,Southeast Queens,West Central
Queens,West Queens 38 2.918845e+11 377602.3
##             38) total_cost< 863 19 1.238806e+11 329546.7 *
##             39) total_cost>=863 19 8.024903e+10 425657.9 *
```

```
##        5) coop_condo=condo 52 1.147037e+12 440058.0
##         10) sq_footage< 737.5752 19 3.138451e+11 337444.1 *
##         11) sq_footage>=737.5752 33 5.179420e+11 499138.7
##           22) zip_codes=Central Queens,Jamaica,Southwest Queens,West
Central Queens,West Queens 15 1.275730e+11 431479.2 *
##           23) zip_codes=North Queens,Northeast Queens,Northwest Queens 18
2.644794e+11 555521.6 *
##      3) num_full_bathrooms>=1.5 83 1.868090e+12 543091.0
##        6) sq_footage< 1253.179 49 7.567748e+11 478490.8
##         12) approx_year_built< 1966.5 15 1.219071e+11 350870.0 *
##         13) approx_year_built>=1966.5 34 2.827796e+11 534794.1
##           26) zip_codes=Central Queens,Jamaica,Southwest Queens,West
Central Queens,West Queens 21 1.916778e+11 502095.2
##             52) approx_year_built< 2007.5 11 8.497164e+10 453181.8 *
##             53) approx_year_built>=2007.5 10 5.143890e+10 555900.0 *
##           27) zip_codes=North Queens,Northeast Queens 13 3.237708e+10
587615.4 *
##        7) sq_footage>=1253.179 34 6.121290e+11 636191.2
##         14) zip_codes=North Queens,Northeast Queens 18 2.776612e+11
595972.2 *
##         15) zip_codes=Northwest Queens,Southeast Queens,West Central
Queens,West Queens 16 2.725959e+11 681437.5 *
```

```
#RMSE IS
predictions <- rtModel %>% predict(train %>% select(-sale_price))
RMSE(predictions, train$sale_price)
```

```
## [1] 69597.16
```

```
R2(predictions, train$sale_price)
```

```
## [1] 0.8427281
```

Linear Model

```
#Creating one linear model with intercept
lmModel = lm(train$sale_price ~ ., train %>% select(-sale_price))
lmModel
```

```
##
## Call:
## lm(formula = train$sale_price ~ ., data = train %>% select(-sale_price))
##
## Coefficients:
##                   (Intercept)             approx_year_built
##                     -871200.29                        402.10
##                 cats_allowed1               coop_condocondo
##                      13237.38                     195813.57
##  dining_room_typedining area        dining_room_typeformal
##                      -12854.59                      19282.43
##        dining_room_typeother                 dogs_allowed1
```

```
##                     18864.24                      6377.21
##                 fuel_typegas                  fuel_typeoil
##                      7724.92                      7157.50
##               fuel_typeother                garage_exists1
##                     47194.56                     13462.51
##          kitchen_typeeat-in       kitchen_typeefficiency
##                     -9506.04                    -21892.16
##                 num_bedrooms           num_full_bathrooms
##                     31794.83                     74037.57
##          num_half_bathrooms              num_total_rooms
##                     -8693.49                      5694.28
##                   sq_footage                 walk_score.L
##                        37.47                     -8519.54
##                 walk_score.Q                 walk_score.C
##                     61888.07                     -9866.65
##                 walk_score^4             zip_codesJamaica
##                     45591.92                    -36085.44
##       zip_codesNorth Queens    zip_codesNortheast Queens
##                     45962.55                     44014.75
##    zip_codesNorthwest Queens    zip_codesSoutheast Queens
##                    160123.29                     31995.52
##    zip_codesSouthwest Queens  zip_codesWest Central Queens
##                    -39895.82                     53642.44
##         zip_codesWest Queens                   total_cost
##                     51714.08                       155.96
##    approx_year_built_missing         cats_allowed_missing
##                     31849.71                           NA
##     dining_room_type_missing            fuel_type_missing
##                     -4597.05                      3219.34
##         kitchen_type_missing     maintenance_cost_missing
##                    -68239.88                    -24954.69
##           sq_footage_missing         condoCharges_missing
##                     -8167.27                     48631.03
```

```
#in-sample stats to report
lmModelSum <- summary(lmModel)
lmModelSum
```

```
##
## Call:
## lm(formula = train$sale_price ~ ., data = train %>% select(-sale_price))
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -304722  -37652   -5250   38896  291323
##
## Coefficients: (1 not defined because of singularities)
##                               Estimate Std. Error t value Pr(>|t|)
## (Intercept)                 -871200.29  618314.59  -1.409 0.159647
## approx_year_built              402.10     317.17   1.268 0.205637
```

```
## cats_allowed1                   13237.38   11610.70   1.140 0.254955
## coop_condocondo                195813.57   14943.78  13.103  < 2e-16 ***
## dining_room_typedining area   -12854.59   56693.30  -0.227 0.820747
## dining_room_typeformal         19282.43   10272.25   1.877 0.061257 .
## dining_room_typeother          18864.24   13710.98   1.376 0.169670
## dogs_allowed1                   6377.21   12808.55   0.498 0.618849
## fuel_typegas                    7724.92   31767.65   0.243 0.808004
## fuel_typeoil                    7157.50   32295.12   0.222 0.824721
## fuel_typeother                 47194.56   42494.76   1.111 0.267437
## garage_exists1                 13462.51   10618.03   1.268 0.205605
## kitchen_typeeat-in             -9506.04   12179.22  -0.781 0.435570
## kitchen_typeefficiency        -21892.16   11940.86  -1.833 0.067520 .
## num_bedrooms                   31794.83    8898.93   3.573 0.000398 ***
## num_full_bathrooms             74037.57   14499.74   5.106 5.19e-07 ***
## num_half_bathrooms             -8693.49   20039.84  -0.434 0.664670
## num_total_rooms                 5694.28    6319.11   0.901 0.368089
## sq_footage                        37.47      14.38   2.606 0.009519 **
## walk_score.L                   -8519.54   53762.61  -0.158 0.874173
## walk_score.Q                   61888.07   45647.66   1.356 0.175967
## walk_score.C                   -9866.65   34027.89  -0.290 0.772005
## walk_score^4                   45591.92   21206.46   2.150 0.032187 *
## zip_codesJamaica              -36085.44   22569.27  -1.599 0.110671
## zip_codesNorth Queens          45962.55   18967.42   2.423 0.015844 *
## zip_codesNortheast Queens      44014.75   20323.41   2.166 0.030948 *
## zip_codesNorthwest Queens     160123.29   30136.70   5.313 1.83e-07 ***
## zip_codesSoutheast Queens      31995.52   22727.27   1.408 0.159998
## zip_codesSouthwest Queens     -39895.82   19734.84  -2.022 0.043912 *
## zip_codesWest Central Queens   53642.44   19750.58   2.716 0.006906 **
## zip_codesWest Queens           51714.08   20198.64   2.560 0.010841 *
## total_cost                       155.96      16.60   9.396  < 2e-16 ***
## approx_year_built_missing      31849.71   35437.75   0.899 0.369349
## cats_allowed_missing                 NA         NA      NA       NA
## dining_room_type_missing       -4597.05    9892.39  -0.465 0.642406
## fuel_type_missing               3219.34   19184.57   0.168 0.866822
## kitchen_type_missing          -68239.88   38940.93  -1.752 0.080504 .
## maintenance_cost_missing      -24954.69   19771.33  -1.262 0.207655
## sq_footage_missing             -8167.27    8523.15  -0.958 0.338542
## condoCharges_missing           48631.03   32307.49   1.505 0.133080
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 77530 on 384 degrees of freedom
## Multiple R-squared:  0.8228, Adjusted R-squared:  0.8053
## F-statistic: 46.93 on 38 and 384 DF,  p-value: < 2.2e-16

#RMSE IS
predictions <- lmModel %>% predict(train %>% select(-sale_price))
RMSE(predictions, train$sale_price)

## [1] 73867.23
```

```
R2(predictions, train$sale_price)

## [1] 0.8228376

#RMSE OOS
predictions <- lmModel %>% predict(test %>% select(-sale_price))
RMSE(predictions, test$sale_price)

## [1] 80213.91

R2(predictions, test$sale_price)

## [1] 0.8346043
```

Hyperparameter Tuning for random forest

```
#Random Forest MLR
housing_Xcomplete <- train %>% select(-sale_price)
y_salesprice <- train$sale_price

data = cbind(y_salesprice, housing_Xcomplete)
colnames(data)[1] = "sales_price"

task = makeRegrTask(data = data, target = "sales_price")

## Warning in makeTask(type = type, data = data, weights = weights, blocking
=
## blocking, : Empty factor levels were dropped for columns: dining_room_type

parms = makeParamSet(
    #Must have atleast 1 of everthing. Mtry cannot be larger than the number
of columns present
  makeIntegerParam("mtry", lower = 1, upper = ncol(housing_Xcomplete)),
  makeIntegerParam("ntree", lower = 1, upper = 1000),
  makeIntegerParam("nodesize", lower = 1, upper = 1000)
)

desc <- makeResampleDesc("Bootstrap", iters = 30)

ctrl <- makeTuneControlRandom(maxit = 30)

mlr_ret <- tuneParams("regr.randomForest", task = task, resampling = desc,
par.set = parms, control = ctrl, measures = list(rmse))

## [Tune] Started tuning learner regr.randomForest for parameter set:

##             Type len Def     Constr Req Tunable Trafo
## mtry     integer   -   -    1 to 24   -    TRUE     -
## ntree    integer   -   - 1 to 1e+03   -    TRUE     -
## nodesize integer   -   - 1 to 1e+03   -    TRUE     -

## With control class: TuneControlRandom
```

```
## Imputation value: Inf
## [Tune-x] 1: mtry=23; ntree=865; nodesize=645
## [Tune-y] 1: rmse.test.rmse=129545.0654666; time: 0.1 min
## [Tune-x] 2: mtry=4; ntree=707; nodesize=3
## [Tune-y] 2: rmse.test.rmse=83353.7686475; time: 0.2 min
## [Tune-x] 3: mtry=9; ntree=2; nodesize=334
## [Tune-y] 3: rmse.test.rmse=131649.3940247; time: 0.0 min
## [Tune-x] 4: mtry=17; ntree=352; nodesize=531
## [Tune-y] 4: rmse.test.rmse=127429.2035513; time: 0.0 min
## [Tune-x] 5: mtry=14; ntree=763; nodesize=595
## [Tune-y] 5: rmse.test.rmse=126318.0111683; time: 0.1 min
## [Tune-x] 6: mtry=7; ntree=598; nodesize=997
## [Tune-y] 6: rmse.test.rmse=128210.2057682; time: 0.0 min
## [Tune-x] 7: mtry=12; ntree=176; nodesize=19
## [Tune-y] 7: rmse.test.rmse=82510.6222085; time: 0.1 min
## [Tune-x] 8: mtry=5; ntree=466; nodesize=77
## [Tune-y] 8: rmse.test.rmse=94428.9631364; time: 0.1 min
## [Tune-x] 9: mtry=6; ntree=174; nodesize=771
## [Tune-y] 9: rmse.test.rmse=129684.4163061; time: 0.0 min
## [Tune-x] 10: mtry=10; ntree=209; nodesize=627
## [Tune-y] 10: rmse.test.rmse=126164.3897233; time: 0.0 min
## [Tune-x] 11: mtry=1; ntree=310; nodesize=68
## [Tune-y] 11: rmse.test.rmse=125641.3085135; time: 0.0 min
## [Tune-x] 12: mtry=5; ntree=400; nodesize=739
## [Tune-y] 12: rmse.test.rmse=131835.4844586; time: 0.0 min
## [Tune-x] 13: mtry=22; ntree=675; nodesize=451
## [Tune-y] 13: rmse.test.rmse=129109.7189636; time: 0.1 min
## [Tune-x] 14: mtry=11; ntree=395; nodesize=243
```

```
## [Tune-y] 14: rmse.test.rmse=105316.7349310; time: 0.0 min
## [Tune-x] 15: mtry=8; ntree=924; nodesize=430
## [Tune-y] 15: rmse.test.rmse=126941.2995949; time: 0.1 min
## [Tune-x] 16: mtry=11; ntree=918; nodesize=126
## [Tune-y] 16: rmse.test.rmse=98838.8128998; time: 0.1 min
## [Tune-x] 17: mtry=6; ntree=609; nodesize=682
## [Tune-y] 17: rmse.test.rmse=129266.3946418; time: 0.0 min
## [Tune-x] 18: mtry=9; ntree=22; nodesize=311
## [Tune-y] 18: rmse.test.rmse=113904.1910302; time: 0.0 min
## [Tune-x] 19: mtry=20; ntree=108; nodesize=821
## [Tune-y] 19: rmse.test.rmse=128749.3162588; time: 0.0 min
## [Tune-x] 20: mtry=11; ntree=728; nodesize=879
## [Tune-y] 20: rmse.test.rmse=125797.3869341; time: 0.1 min
## [Tune-x] 21: mtry=22; ntree=884; nodesize=848
## [Tune-y] 21: rmse.test.rmse=129195.8047492; time: 0.1 min
## [Tune-x] 22: mtry=13; ntree=182; nodesize=458
## [Tune-y] 22: rmse.test.rmse=125919.5809180; time: 0.0 min
## [Tune-x] 23: mtry=22; ntree=465; nodesize=154
## [Tune-y] 23: rmse.test.rmse=102967.4489259; time: 0.1 min
## [Tune-x] 24: mtry=1; ntree=738; nodesize=18
## [Tune-y] 24: rmse.test.rmse=120192.8752707; time: 0.1 min
## [Tune-x] 25: mtry=2; ntree=136; nodesize=83
## [Tune-y] 25: rmse.test.rmse=106609.0524688; time: 0.0 min
## [Tune-x] 26: mtry=19; ntree=695; nodesize=845
## [Tune-y] 26: rmse.test.rmse=128313.7575757; time: 0.1 min
## [Tune-x] 27: mtry=8; ntree=307; nodesize=162
## [Tune-y] 27: rmse.test.rmse=101865.1278355; time: 0.0 min
## [Tune-x] 28: mtry=22; ntree=806; nodesize=504
```

```
## [Tune-y] 28: rmse.test.rmse=129190.8710698; time: 0.1 min

## [Tune-x] 29: mtry=16; ntree=855; nodesize=357

## [Tune-y] 29: rmse.test.rmse=125628.7978122; time: 0.1 min

## [Tune-x] 30: mtry=12; ntree=17; nodesize=499

## [Tune-y] 30: rmse.test.rmse=127170.7898171; time: 0.0 min

## [Tune] Result: mtry=12; ntree=176; nodesize=19 :
rmse.test.rmse=82510.6222085

#Optimal hyperparameter result
mlr_ret$x

## $mtry
## [1] 12
##
## $ntree
## [1] 176
##
## $nodesize
## [1] 19
```

RandomForest Model

```
#Model
rfModel = randomForest(housing_Xcomplete, y_salesprice, mtry =
as.integer(mlr_ret$x[1]), num_trees = as.integer(mlr_ret$x[2]), nodesize =
as.integer(mlr_ret$x[3]))
rfModel

##
## Call:
##  randomForest(x = housing_Xcomplete, y = y_salesprice, mtry =
as.integer(mlr_ret$x[1]),      nodesize = as.integer(mlr_ret$x[3]), num_trees
= as.integer(mlr_ret$x[2]))
##                Type of random forest: regression
##                      Number of trees: 500
## No. of variables tried at each split: 12
##
##           Mean of squared residuals: 6032153605
##                     % Var explained: 80.41

yhat = predict(rfModel,  train %>% select(-sale_price))
is_rmse = sqrt(mean((train$sale_price - yhat)^2))
is_rsq = 1 - sum((train$sale_price - yhat)^2)/sum((train$sale_price -
mean(y_salesprice))^2)
is_rmse

## [1] 51096.27
```

```
is_rsq
```

```
## [1] 0.9152292
```

```
#Compute errors using model of entire dataset
#Once this is evaluated, there is no going back, otherwise it is cheating!
#Run and submit, there is no going back.
yhat = predict(rfModel,  test %>% select(-sale_price))
oos_rmse = sqrt(mean((test$sale_price - yhat)^2))
oos_rsq = 1 - sum((test$sale_price - yhat)^2)/sum((test$sale_price -
mean(y_salesprice))^2)
oos_rmse
```

```
## [1] 76131.56
```

```
oos_rsq
```

```
## [1] 0.8462672
```