Data Analysis Project

STAT 420, Fall 2024, C. Easton, A. Roh, T. Toter, A. Treptow

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Contents

Introduction:

In this data analysis study we appled the principles we learned during the semester to iterate on a linear regression model.

For our case study, we chose a "Wine Quality" dataset from the UC Irvine Machine Learning Repository. The data relates to red and white variants of the Portuguese vinho verde wine samples. We drew the data from the following site:

https://archive.ics.uci.edu/dataset/186/wine+quality

Each wine sample contains a record of 10 numerically measured physicochemical attributes, such as acidity, residual sugar, chlorides, and pH. We combined two datasets (one for white wine and one for red wine), resulting in an additional categorical variable for wine type.

The 11 attributes listed above served as our source predictor variables. A final attribute, measuring quality, served as our response variable. Each quality measurement is a subjectively assigned integer, ranging from 1 to 10. Our goal was to build a model that could use the objectively measured predictors as inputs to estimate how a human would rate the wine.

```
options(repos = c(CRAN = "https://cloud.r-project.org"))
```

load data

```
# Load Necessary Libraries
library(dplyr) # For data manipulation
```

```
##
## Attaching package: 'dplyr'

## The following objects are masked from 'package:stats':
##
##     filter, lag

## The following objects are masked from 'package:base':
##
##     intersect, setdiff, setequal, union
```

```r
# Load the Red Wine Data
red_wine = read.csv("winequality-red.csv", sep = ";")

# Load the White Wine Data
white_wine = read.csv("winequality-white.csv", sep = ";")

# Add a Categorical Variable for Wine Type
red_wine$type = "Red"
white_wine$type = "White"

# Combine the Two Datasets
wine_data = bind_rows(red_wine, white_wine)


# Convert 'type' to a Factor
wine_data$type = as.factor(wine_data$type)

# Categorize the 'alcohol' Predictor
#wine_data$alcohol_category = cut(
#  wine_data$alcohol,
#  breaks = c(-Inf, 10, 12, Inf), # Define the thresholds for "Low", "Medium", "High"
#  labels = c("Low", "Medium", "High")
#)

# Convert to a Factor
#wine_data$alcohol_category = as.factor(wine_data$alcohol_category)

# View(wine_data)
```

Data types

```r
str(wine_data)
```

```
## 'data.frame':    6497 obs. of  13 variables:
##  $ fixed.acidity       : num  7.4 7.8 7.8 11.2 7.4 7.4 7.9 7.3 7.8 7.5 ...
##  $ volatile.acidity    : num  0.7 0.88 0.76 0.28 0.7 0.66 0.6 0.65 0.58 0.5 ...
##  $ citric.acid         : num  0 0 0.04 0.56 0 0 0.06 0 0.02 0.36 ...
##  $ residual.sugar      : num  1.9 2.6 2.3 1.9 1.9 1.8 1.6 1.2 2 6.1 ...
##  $ chlorides           : num  0.076 0.098 0.092 0.075 0.076 0.075 0.069 0.065 0.073 0.071 ...
##  $ free.sulfur.dioxide : num  11 25 15 17 11 13 15 15 9 17 ...
```

```
##  $ total.sulfur.dioxide: num  34 67 54 60 34 40 59 21 18 102 ...
##  $ density             : num  0.998 0.997 0.997 0.998 0.998 ...
##  $ pH                  : num  3.51 3.2 3.26 3.16 3.51 3.51 3.3 3.39 3.36 3.35 ...
##  $ sulphates           : num  0.56 0.68 0.65 0.58 0.56 0.56 0.46 0.47 0.57 0.8 ...
##  $ alcohol             : num  9.4 9.8 9.8 9.8 9.4 9.4 9.4 10 9.5 10.5 ...
##  $ quality             : int  5 5 5 6 5 5 5 7 7 5 ...
##  $ type                : Factor w/ 2 levels "Red","White": 1 1 1 1 1 1 1 1 1 1 ...
```

```
res_sugar_6580 = which(wine_data$residual.sugar == 65.80)
free_sulf_dio_289 = which(wine_data$free.sulfur.dioxide == 289.0)
dens_10103 = which(wine_data$density == 1.0103)

remove_idx = c(res_sugar_6580, free_sulf_dio_289, dens_10103)
wine_data = wine_data[-remove_idx, ]
nrow(wine_data)
```

```
## [1] 6493
```

Fit additive Model

```
model = lm(quality ~ ., data = wine_data)
summary(model)
```

```
##
## Call:
## lm(formula = quality ~ ., data = wine_data)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -3.6211 -0.4695 -0.0416  0.4568  3.0248
##
## Coefficients:
##                         Estimate Std. Error t value Pr(>|t|)
## (Intercept)           1.255e+02  1.569e+01   7.995 1.52e-15 ***
## fixed.acidity         1.030e-01  1.667e-02   6.180 6.80e-10 ***
## volatile.acidity     -1.487e+00  8.118e-02 -18.324  < 2e-16 ***
## citric.acid          -6.694e-02  7.955e-02  -0.841   0.4001
## residual.sugar        6.784e-02  6.273e-03  10.815  < 2e-16 ***
## chlorides            -7.348e-01  3.337e-01  -2.202   0.0277 *
## free.sulfur.dioxide   5.702e-03  7.782e-04   7.327 2.63e-13 ***
## total.sulfur.dioxide -1.346e-03  3.244e-04  -4.149 3.38e-05 ***
## density              -1.249e+02  1.590e+01  -7.853 4.73e-15 ***
## pH                    5.701e-01  9.309e-02   6.125 9.63e-10 ***
## sulphates             7.477e-01  7.643e-02   9.782  < 2e-16 ***
## alcohol               1.985e-01  1.983e-02  10.013  < 2e-16 ***
## typeWhite            -4.152e-01  5.907e-02  -7.029 2.29e-12 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.7312 on 6480 degrees of freedom
## Multiple R-squared:  0.2995, Adjusted R-squared:  0.2983
## F-statistic: 230.9 on 12 and 6480 DF,  p-value: < 2.2e-16
```

VIF Values

```
if (!require(car)) install.packages("car")
```

```
## Loading required package: car
```

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

```
##
## Attaching package: 'car'
```

```
## The following object is masked from 'package:dplyr':
##
##     recode
```

```
library(car)

# Compute VIF Values
vif_values = vif(model)

# Display the VIF Values
vif_values
```

```
##        fixed.acidity     volatile.acidity          citric.acid
##             5.674492             2.165464             1.622715
##       residual.sugar            chlorides  free.sulfur.dioxide
##            10.453938             1.660500             2.242120
## total.sulfur.dioxide              density                   pH
##             4.062701            26.474789             2.720556
##            sulphates              alcohol                 type
##             1.570941             6.790581             7.865940
```

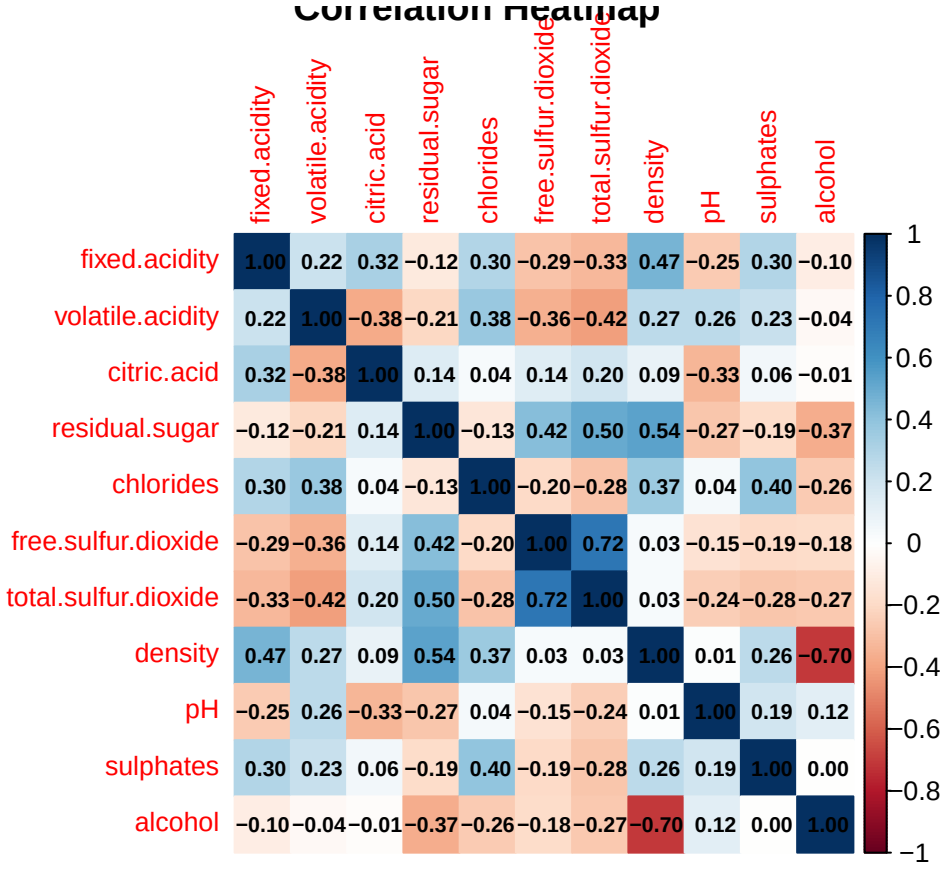
Visualize correlations through a heatmap

```
if (!require(corrplot)) install.packages("corrplot")
```

```
## Loading required package: corrplot
```

```
## corrplot 0.95 loaded
```

```
library(corrplot)
numeric_data = wine_data %>%
  select(-type, -quality) # Considers numeric predictors only
cor_matrix = cor(numeric_data, use = "complete.obs")


corrplot(cor_matrix, method = "color", addCoef.col = "black",
         tl.cex = 0.8, number.cex = 0.7, main = "Correlation Heatmap")
```



Fit interaction model

```
model = lm(quality ~ .^2, data = wine_data)
summary(model)
```

```
##
## Call:
## lm(formula = quality ~ .^2, data = wine_data)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -3.2817 -0.4634 -0.0226  0.4378  2.9827
##
## Coefficients:
##                                       Estimate Std. Error t value Pr(>|t|)
## (Intercept)                         -5.113e+02  2.908e+02  -1.758 0.078739
## fixed.acidity                        4.804e+00  7.175e+00   0.670 0.503145
## volatile.acidity                    -2.842e+01  1.142e+02  -0.249 0.803505
## citric.acid                         -8.157e+01  1.201e+02  -0.679 0.497164
## residual.sugar                       5.248e+00  1.256e+00   4.178 2.97e-05
## chlorides                           -1.105e+03  5.069e+02  -2.180 0.029289
## free.sulfur.dioxide                 -4.293e+00  1.376e+00  -3.119 0.001824
## total.sulfur.dioxide                 5.283e-01  4.911e-01   1.076 0.282030
```

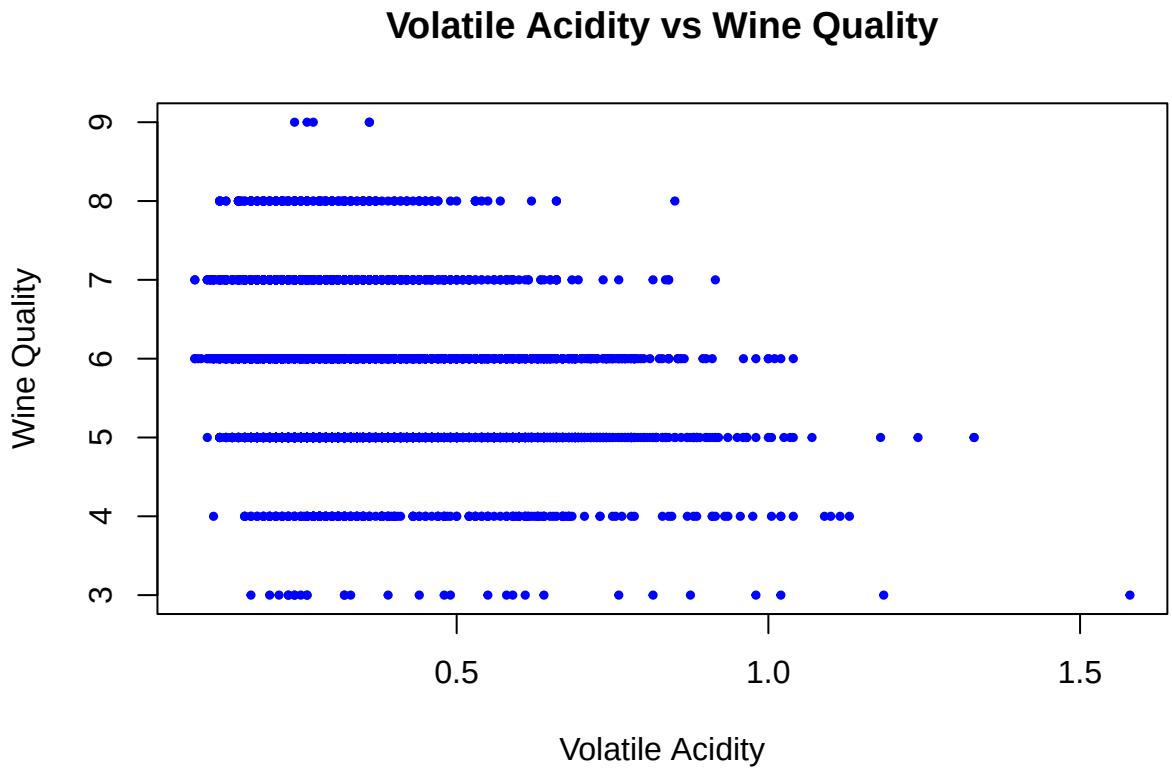
```
## density                                  5.246e+02  2.908e+02   1.804 0.071325
## pH                                       1.180e+02  7.404e+01   1.594 0.110878
## sulphates                                7.002e+01  1.168e+02   0.599 0.548874
## alcohol                                  1.996e+01  6.157e+00   3.242 0.001193
## typeWhite                                1.635e+02  6.045e+01   2.705 0.006848
## fixed.acidity:volatile.acidity          -5.610e-02  1.357e-01  -0.413 0.679347
## fixed.acidity:citric.acid               -8.851e-02  1.254e-01  -0.706 0.480142
## fixed.acidity:residual.sugar             8.185e-03  3.994e-03   2.049 0.040463
## fixed.acidity:chlorides                 -1.901e+00  5.482e-01  -3.468 0.000528
## fixed.acidity:free.sulfur.dioxide       -9.136e-04  1.423e-03  -0.642 0.520926
## fixed.acidity:total.sulfur.dioxide      -1.118e-04  5.631e-04  -0.198 0.842691
## fixed.acidity:density                   -5.383e+00  7.111e+00  -0.757 0.449053
## fixed.acidity:pH                         2.455e-01  6.643e-02   3.696 0.000221
## fixed.acidity:sulphates                  2.255e-01  1.199e-01   1.881 0.060014
## fixed.acidity:alcohol                   -1.515e-02  1.339e-02  -1.131 0.257945
## fixed.acidity:typeWhite                  7.880e-02  7.812e-02   1.009 0.313197
## volatile.acidity:citric.acid             1.059e+00  5.649e-01   1.875 0.060865
## volatile.acidity:residual.sugar         -6.485e-02  4.828e-02  -1.343 0.179264
## volatile.acidity:chlorides               2.535e+00  2.546e+00   0.996 0.319368
## volatile.acidity:free.sulfur.dioxide     9.882e-03  7.380e-03   1.339 0.180631
## volatile.acidity:total.sulfur.dioxide    5.365e-03  2.725e-03   1.969 0.049008
## volatile.acidity:density                 1.999e+01  1.160e+02   0.172 0.863171
## volatile.acidity:pH                      8.379e-01  8.029e-01   1.044 0.296708
## volatile.acidity:sulphates              -1.146e-01  6.550e-01  -0.175 0.861185
## volatile.acidity:alcohol                 4.455e-01  1.444e-01   3.085 0.002044
## volatile.acidity:typeWhite              -1.177e+00  4.008e-01  -2.937 0.003321
## citric.acid:residual.sugar              -5.847e-02  4.648e-02  -1.258 0.208482
## citric.acid:chlorides                    3.360e+00  2.271e+00   1.480 0.139036
## citric.acid:free.sulfur.dioxide          7.994e-03  6.348e-03   1.259 0.207979
## citric.acid:total.sulfur.dioxide        -1.314e-03  2.440e-03  -0.538 0.590327
## citric.acid:density                      7.932e+01  1.215e+02   0.653 0.513742
## citric.acid:pH                          -7.930e-02  7.443e-01  -0.107 0.915158
## citric.acid:sulphates                   -9.245e-01  7.022e-01  -1.317 0.187993
## citric.acid:alcohol                      3.035e-01  1.541e-01   1.970 0.048911
## citric.acid:typeWhite                    6.663e-01  4.565e-01   1.460 0.144449
## residual.sugar:chlorides                -6.104e-01  2.348e-01  -2.599 0.009361
## residual.sugar:free.sulfur.dioxide      -1.914e-03  5.435e-04  -3.522 0.000432
## residual.sugar:total.sulfur.dioxide      4.070e-04  2.034e-04   2.001 0.045475
## residual.sugar:density                  -5.061e+00  1.244e+00  -4.067 4.83e-05
## residual.sugar:pH                       -3.359e-02  2.970e-02  -1.131 0.258191
## residual.sugar:sulphates                 1.434e-03  4.808e-02   0.030 0.976208
## residual.sugar:alcohol                  -1.367e-03  4.324e-03  -0.316 0.751947
## residual.sugar:typeWhite                 1.061e-02  2.865e-02   0.370 0.711240
## chlorides:free.sulfur.dioxide            7.326e-03  2.821e-02   0.260 0.795102
## chlorides:total.sulfur.dioxide          -6.946e-03  1.525e-02  -0.455 0.648810
## chlorides:density                        1.163e+03  5.121e+02   2.271 0.023189
## chlorides:pH                            -1.164e+01  3.920e+00  -2.969 0.002997
## chlorides:sulphates                     -7.342e+00  1.961e+00  -3.744 0.000183
## chlorides:alcohol                        3.016e-01  7.056e-01   0.427 0.669037
## chlorides:typeWhite                     -4.112e-01  2.511e+00  -0.164 0.869931
## free.sulfur.dioxide:total.sulfur.dioxide -1.565e-04  1.413e-05 -11.078  < 2e-16
## free.sulfur.dioxide:density              4.262e+00  1.393e+00   3.059 0.002228
## free.sulfur.dioxide:pH                  -3.964e-03  7.628e-03  -0.520 0.603267
## free.sulfur.dioxide:sulphates            1.652e-02  6.351e-03   2.601 0.009321
```

```
## free.sulfur.dioxide:alcohol              6.427e-03  1.841e-03   3.492 0.000483
## free.sulfur.dioxide:typeWhite            3.487e-02  5.088e-03   6.854 7.83e-12
## total.sulfur.dioxide:density            -5.131e-01  4.988e-01  -1.029 0.303718
## total.sulfur.dioxide:pH                 -1.317e-03  3.272e-03  -0.402 0.687343
## total.sulfur.dioxide:sulphates          -1.204e-02  2.649e-03  -4.545 5.59e-06
## total.sulfur.dioxide:alcohol            -7.620e-04  6.589e-04  -1.157 0.247509
## total.sulfur.dioxide:typeWhite           2.150e-03  1.438e-03   1.495 0.135035
## density:pH                              -1.210e+02  7.382e+01  -1.639 0.101360
## density:sulphates                       -7.503e+01  1.181e+02  -0.635 0.525147
## density:alcohol                         -1.971e+01  6.294e+00  -3.131 0.001748
## density:typeWhite                       -1.703e+02  6.130e+01  -2.779 0.005469
## pH:sulphates                             1.993e+00  6.533e-01   3.051 0.002291
## pH:alcohol                              -7.377e-02  1.152e-01  -0.640 0.521966
## pH:typeWhite                             1.997e+00  5.163e-01   3.867 0.000111
## sulphates:alcohol                       -1.107e-01  1.417e-01  -0.781 0.434795
## sulphates:typeWhite                      1.417e-01  4.724e-01   0.300 0.764249
## alcohol:typeWhite                       -2.238e-01  8.722e-02  -2.566 0.010301
##
## (Intercept)                             .
## fixed.acidity
## volatile.acidity
## citric.acid
## residual.sugar                          ***
## chlorides                               *
## free.sulfur.dioxide                     **
## total.sulfur.dioxide
## density                                 .
## pH
## sulphates
## alcohol                                 **
## typeWhite                               **
## fixed.acidity:volatile.acidity
## fixed.acidity:citric.acid
## fixed.acidity:residual.sugar            *
## fixed.acidity:chlorides                 ***
## fixed.acidity:free.sulfur.dioxide
## fixed.acidity:total.sulfur.dioxide
## fixed.acidity:density
## fixed.acidity:pH                        ***
## fixed.acidity:sulphates                 .
## fixed.acidity:alcohol
## fixed.acidity:typeWhite
## volatile.acidity:citric.acid            .
## volatile.acidity:residual.sugar
## volatile.acidity:chlorides
## volatile.acidity:free.sulfur.dioxide
## volatile.acidity:total.sulfur.dioxide   *
## volatile.acidity:density
## volatile.acidity:pH
## volatile.acidity:sulphates
## volatile.acidity:alcohol                **
## volatile.acidity:typeWhite              **
## citric.acid:residual.sugar
## citric.acid:chlorides
```

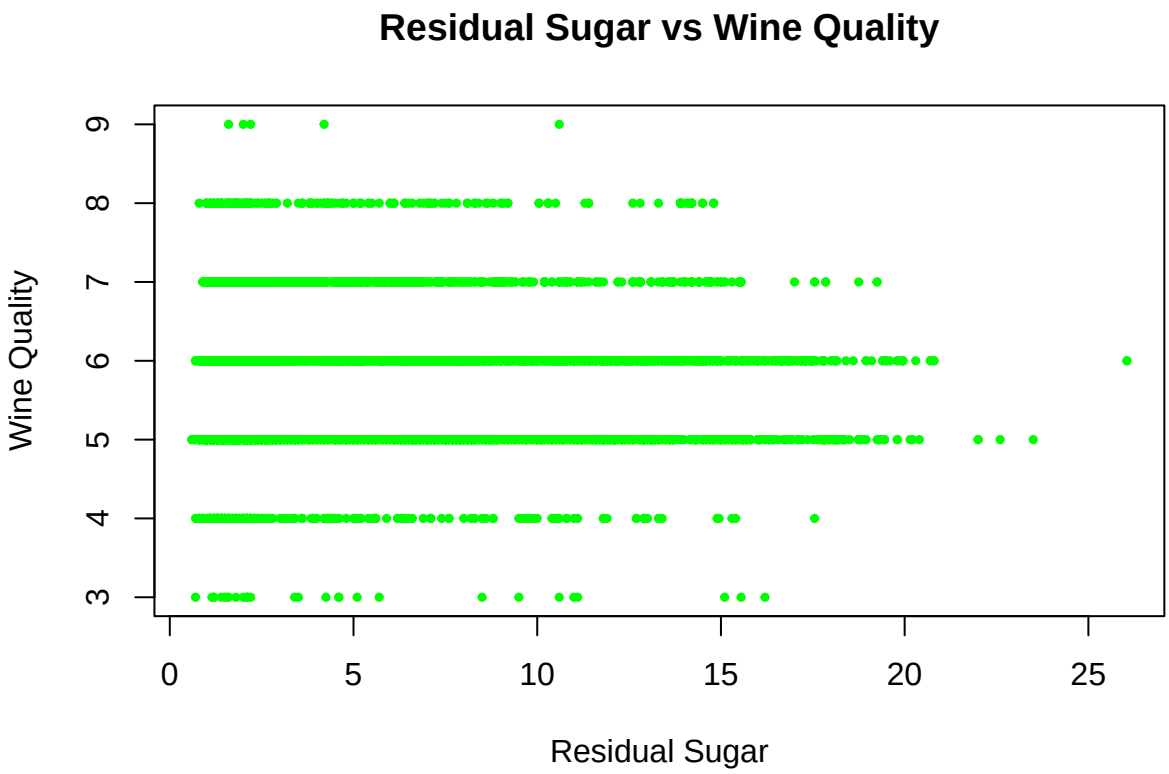
```
## citric.acid:free.sulfur.dioxide
## citric.acid:total.sulfur.dioxide
## citric.acid:density
## citric.acid:pH
## citric.acid:sulphates
## citric.acid:alcohol                       *
## citric.acid:typeWhite
## residual.sugar:chlorides                  **
## residual.sugar:free.sulfur.dioxide        ***
## residual.sugar:total.sulfur.dioxide       *
## residual.sugar:density                    ***
## residual.sugar:pH
## residual.sugar:sulphates
## residual.sugar:alcohol
## residual.sugar:typeWhite
## chlorides:free.sulfur.dioxide
## chlorides:total.sulfur.dioxide
## chlorides:density                         *
## chlorides:pH                              **
## chlorides:sulphates                       ***
## chlorides:alcohol
## chlorides:typeWhite
## free.sulfur.dioxide:total.sulfur.dioxide ***
## free.sulfur.dioxide:density               **
## free.sulfur.dioxide:pH
## free.sulfur.dioxide:sulphates             **
## free.sulfur.dioxide:alcohol               ***
## free.sulfur.dioxide:typeWhite             ***
## total.sulfur.dioxide:density
## total.sulfur.dioxide:pH
## total.sulfur.dioxide:sulphates            ***
## total.sulfur.dioxide:alcohol
## total.sulfur.dioxide:typeWhite
## density:pH
## density:sulphates
## density:alcohol                           **
## density:typeWhite                         **
## pH:sulphates                              **
## pH:alcohol
## pH:typeWhite                              ***
## sulphates:alcohol
## sulphates:typeWhite
## alcohol:typeWhite                         *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.6984 on 6414 degrees of freedom
## Multiple R-squared:  0.3673, Adjusted R-squared:  0.3597
## F-statistic: 47.75 on 78 and 6414 DF,  p-value: < 2.2e-16
```

Including Plots

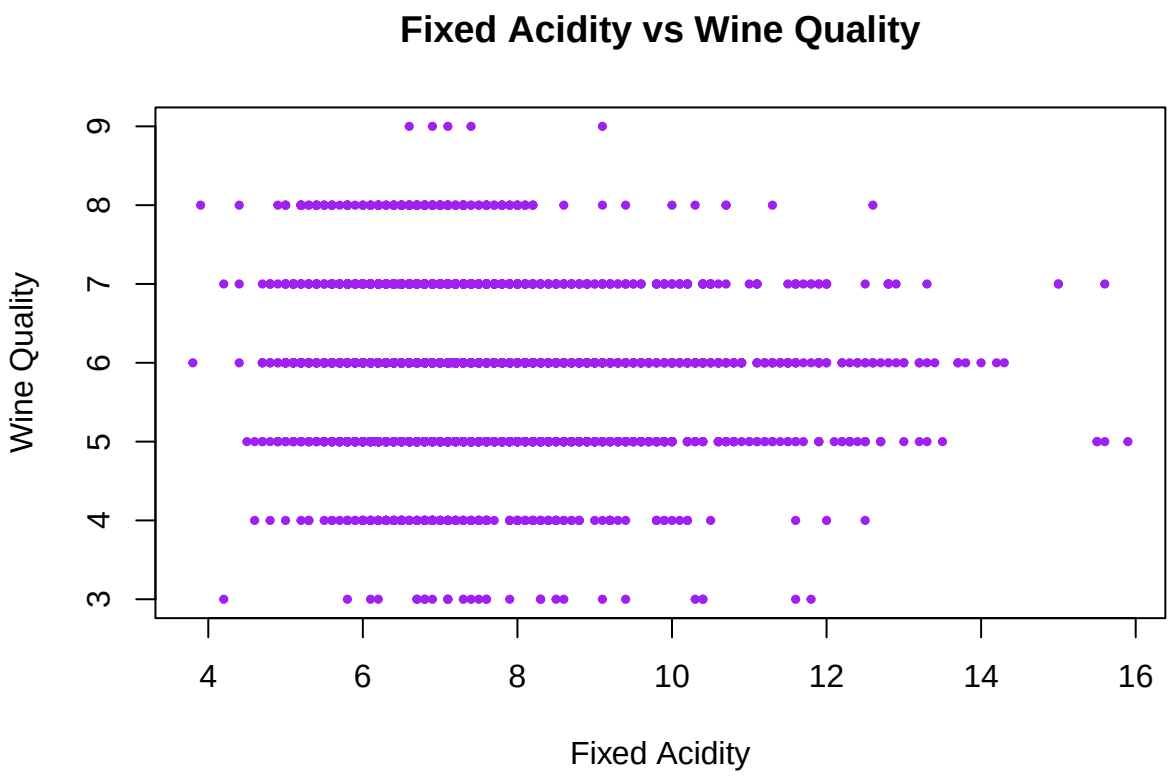
```
# Scatter plot: Volatile Acidity vs Quality
plot(wine_data$volatile.acidity, wine_data$quality,
     main = "Volatile Acidity vs Wine Quality",
     xlab = "Volatile Acidity",
     ylab = "Wine Quality",
     col = "blue", pch = 19, cex = 0.5)
```



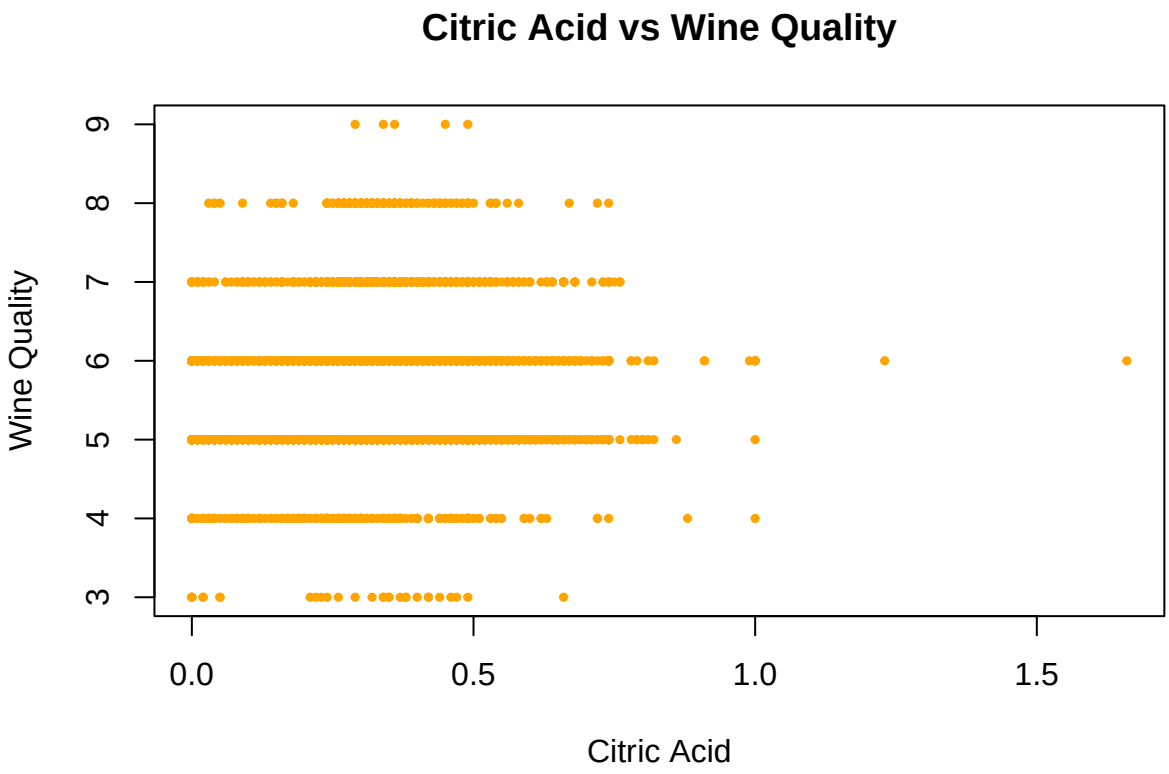

```
# Scatter plot: Residual Sugar vs Quality
plot(wine_data$residual.sugar, wine_data$quality,
     main = "Residual Sugar vs Wine Quality",
     xlab = "Residual Sugar",
     ylab = "Wine Quality",
     col = "green", pch = 19, cex = 0.5)
```



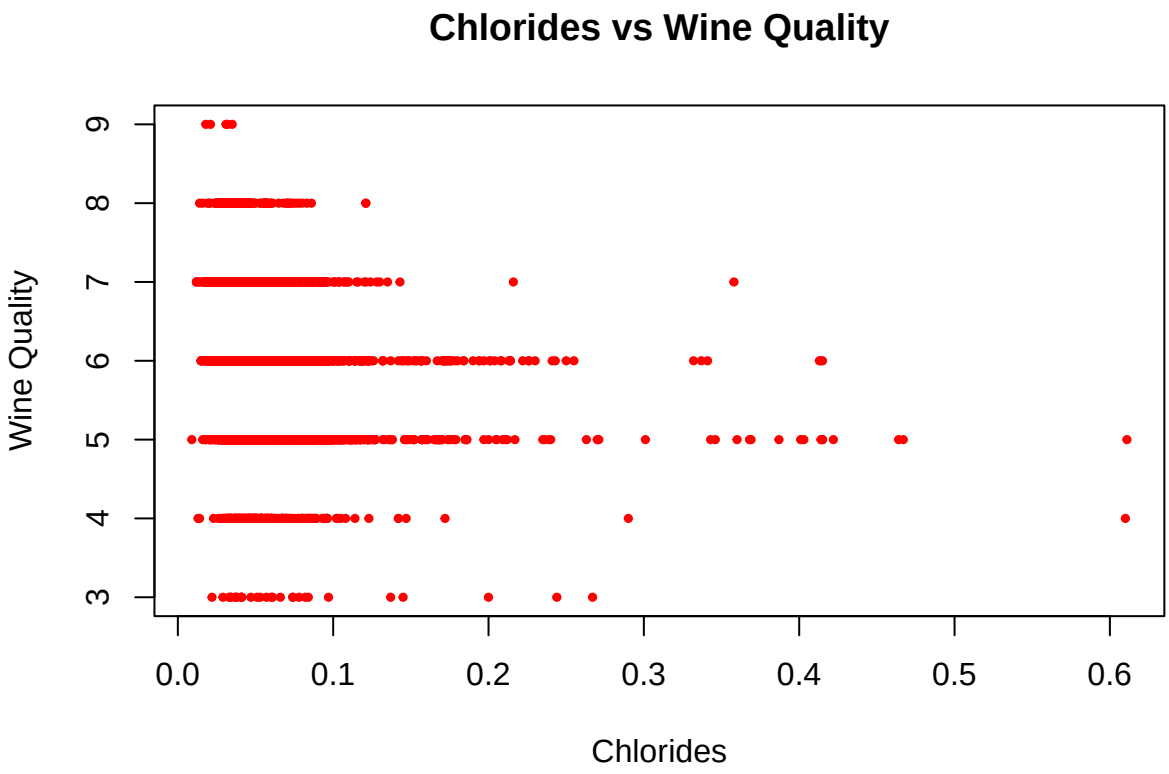

```r
# Scatter plot: Fixed Acidity vs Quality
plot(wine_data$fixed.acidity, wine_data$quality,
     main = "Fixed Acidity vs Wine Quality",
     xlab = "Fixed Acidity",
     ylab = "Wine Quality",
     col = "purple", pch = 19, cex = 0.5)
```



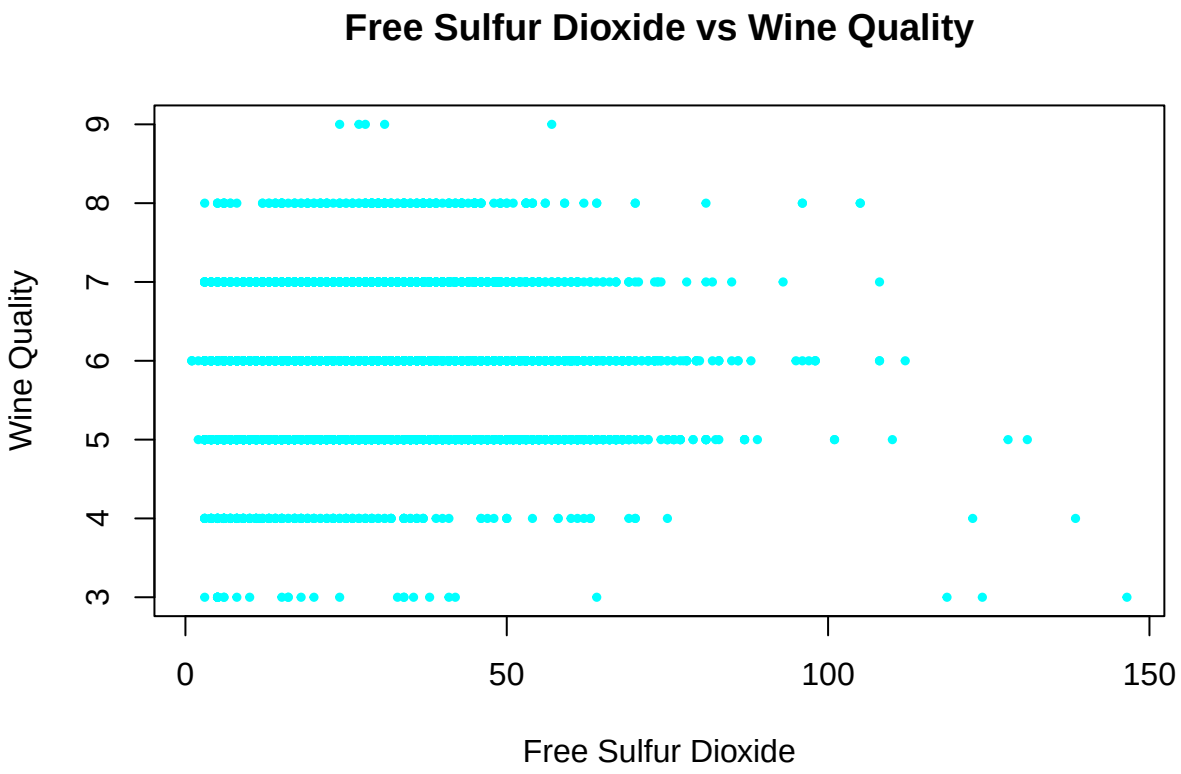

```r
# Scatter plot: Citric Acid vs Quality
plot(wine_data$citric.acid, wine_data$quality,
     main = "Citric Acid vs Wine Quality",
     xlab = "Citric Acid",
     ylab = "Wine Quality",
     col = "orange", pch = 19, cex = 0.5)
```



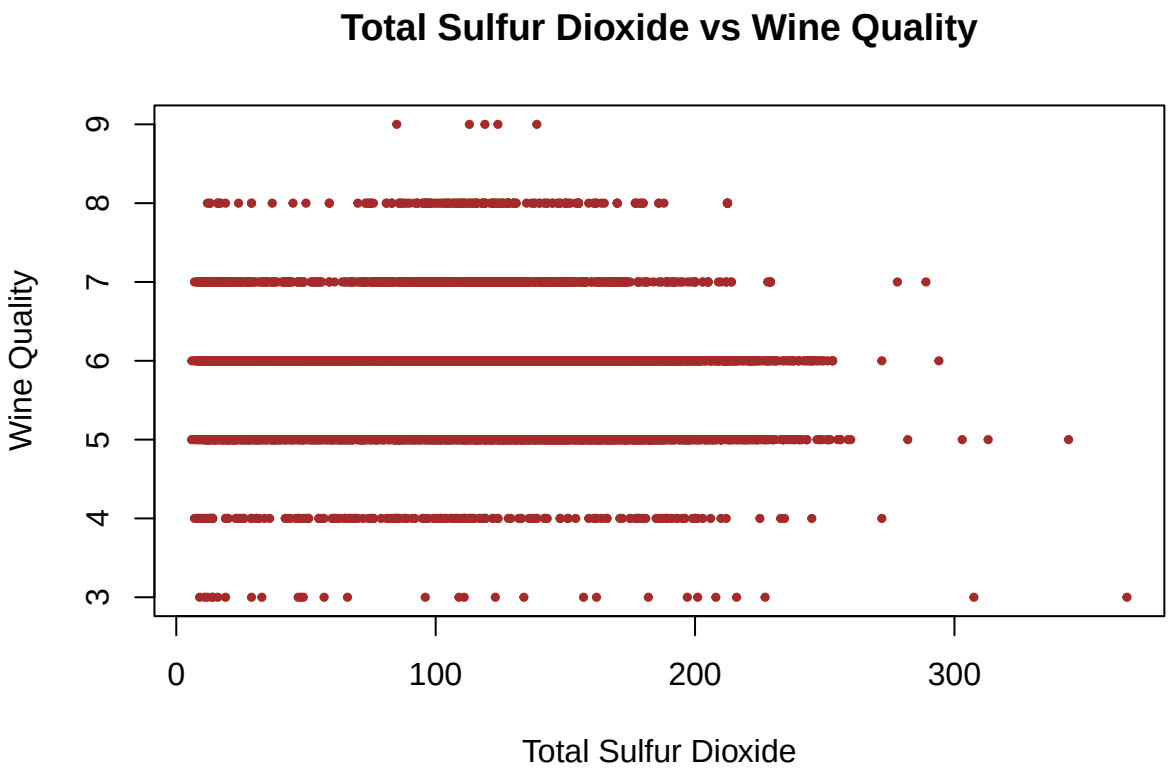

```r
# Scatter plot: Chlorides vs Quality
plot(wine_data$chlorides, wine_data$quality,
     main = "Chlorides vs Wine Quality",
     xlab = "Chlorides",
     ylab = "Wine Quality",
     col = "red", pch = 19, cex = 0.5)
```



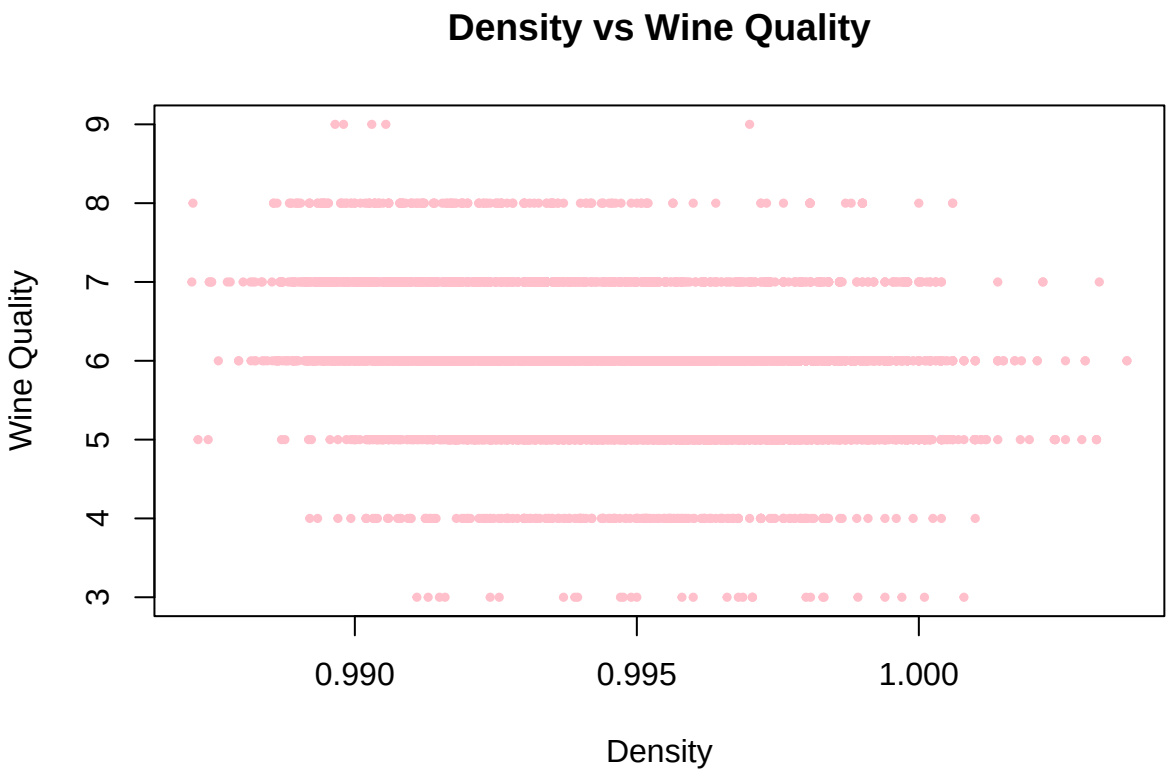

```r
# Scatter plot: Free Sulfur Dioxide vs Quality
plot(wine_data$free.sulfur.dioxide, wine_data$quality,
     main = "Free Sulfur Dioxide vs Wine Quality",
     xlab = "Free Sulfur Dioxide",
     ylab = "Wine Quality",
     col = "cyan", pch = 19, cex = 0.5)
```



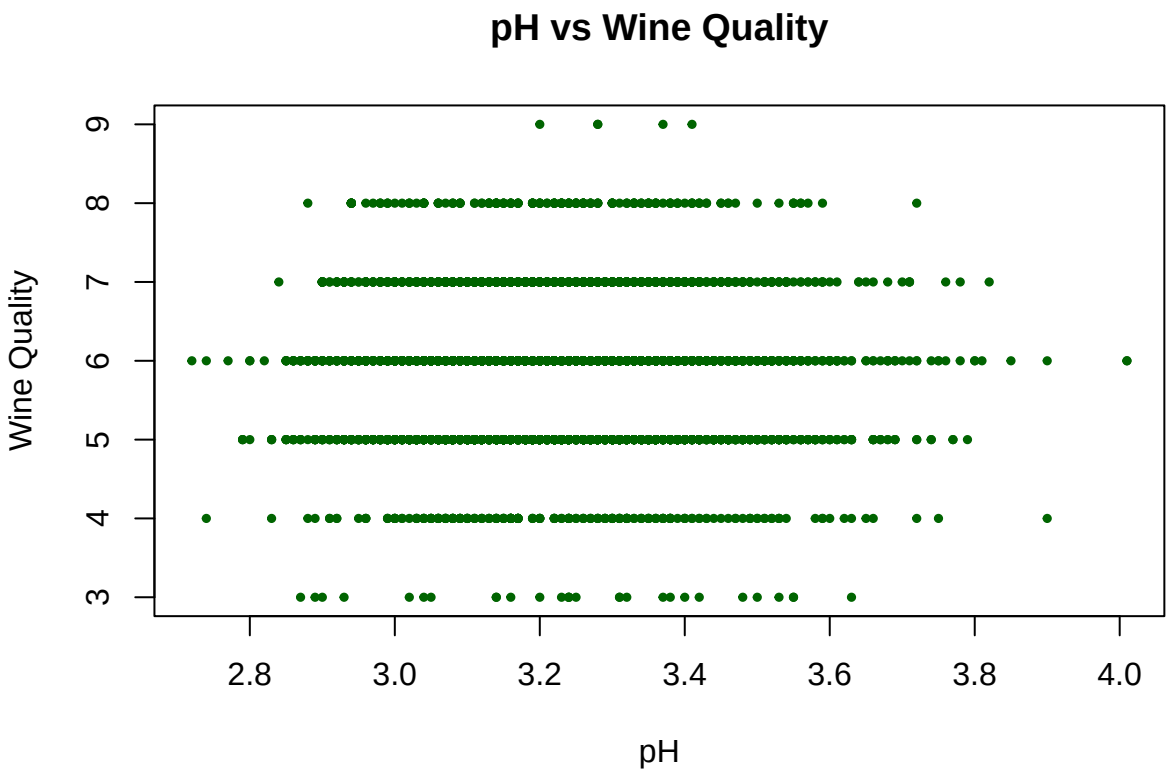

```r
# Scatter plot: Total Sulfur Dioxide vs Quality
plot(wine_data$total.sulfur.dioxide, wine_data$quality,
     main = "Total Sulfur Dioxide vs Wine Quality",
     xlab = "Total Sulfur Dioxide",
     ylab = "Wine Quality",
     col = "brown", pch = 19, cex = 0.5)
```



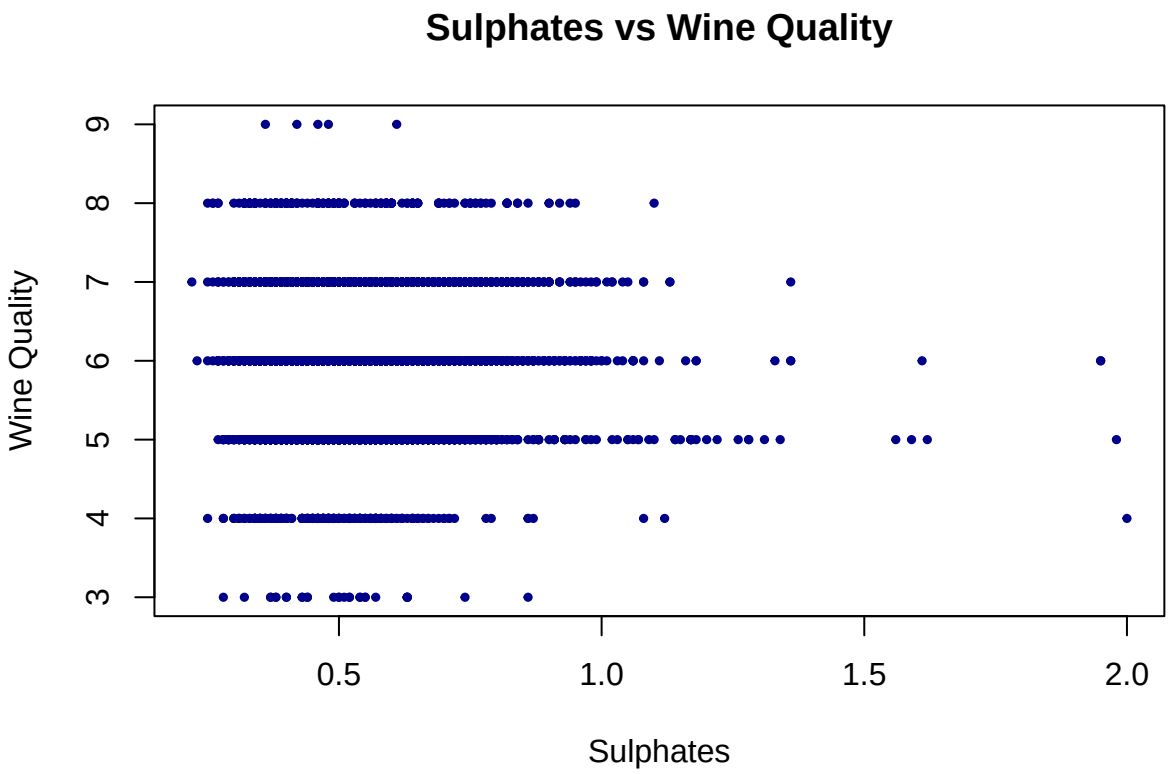

```
# Scatter plot: Density vs Quality
plot(wine_data$density, wine_data$quality,
     main = "Density vs Wine Quality",
     xlab = "Density",
     ylab = "Wine Quality",
     col = "pink", pch = 19, cex = 0.5)
```




```r
# Scatter plot: pH vs Quality
plot(wine_data$pH, wine_data$quality,
     main = "pH vs Wine Quality",
     xlab = "pH",
     ylab = "Wine Quality",
     col = "darkgreen", pch = 19, cex = 0.5)
```

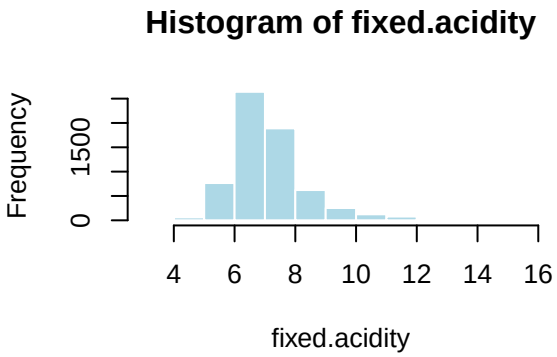


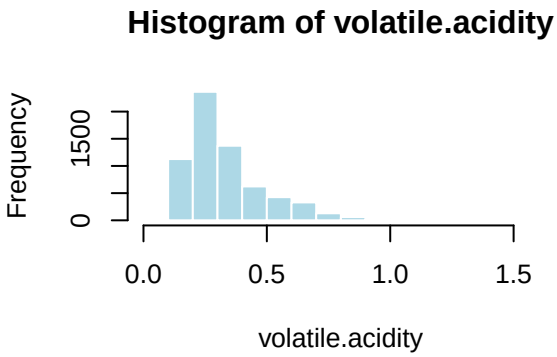

```r
# Scatter plot: Sulphates vs Quality
plot(wine_data$sulphates, wine_data$quality,
     main = "Sulphates vs Wine Quality",
     xlab = "Sulphates",
     ylab = "Wine Quality",
     col = "darkblue", pch = 19, cex = 0.5)
```

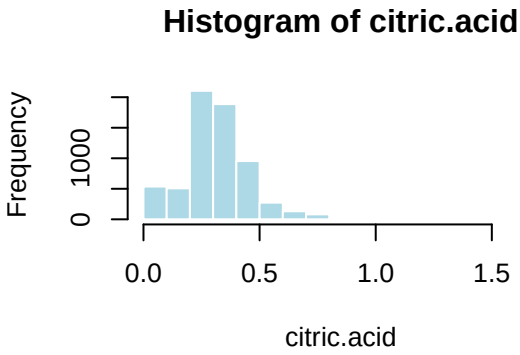


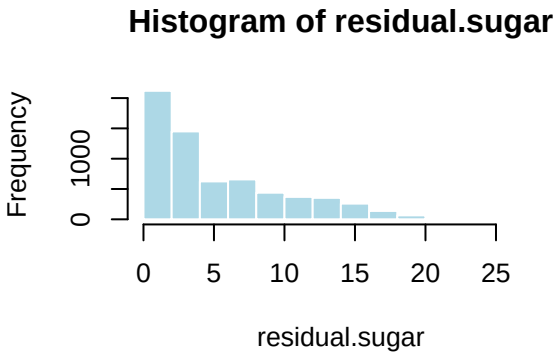
Logs

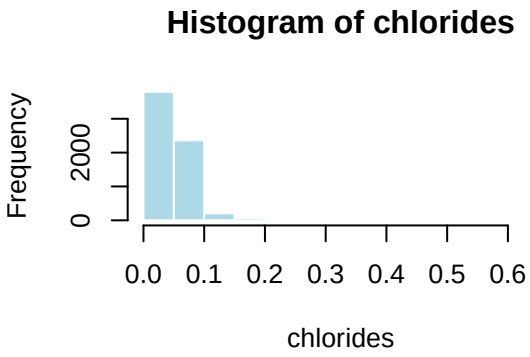
```
##model = lm(quality ~ .^2, data = wine_data)
##summary(model)


# Select only numeric columns
numeric_columns <- wine_data[sapply(wine_data, is.numeric)]

# Create histograms for each numeric column
par(mfrow = c(2, 2))  # Layout for multiple plots
sapply(names(numeric_columns), function(column) {
  hist(numeric_columns[[column]], main = paste("Histogram of", column),
       xlab = column, col = "lightblue", border = "white")
})
```

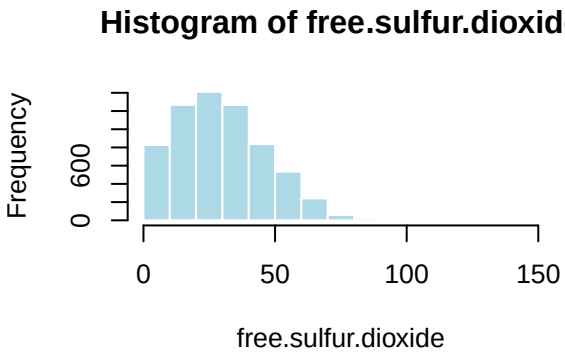

Histogram of fixed.acidity
Frequency
0
1500
4
6
8
10
12
14
16
fixed.acidity

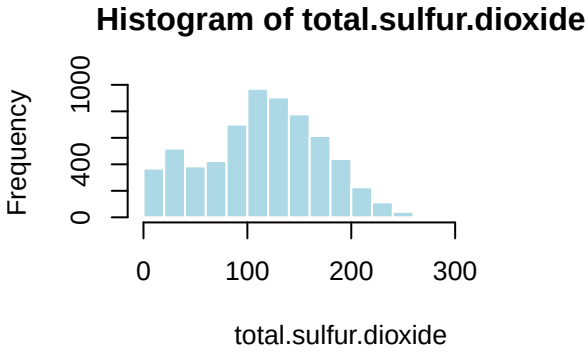

Histogram of volatile.acidity
Frequency
0
1500
0.0
0.5
1.0
1.5
volatile.acidity

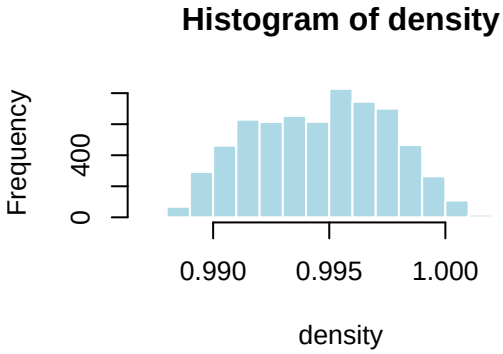

Histogram of citric.acid
Frequency
0
1000
0.0
0.5
1.0
1.5
citric.acid

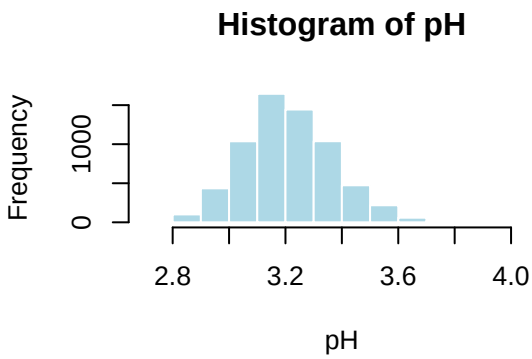

Histogram of residual.sugar
Frequency
0
1000
0
5
10
15
20
25
residual.sugar

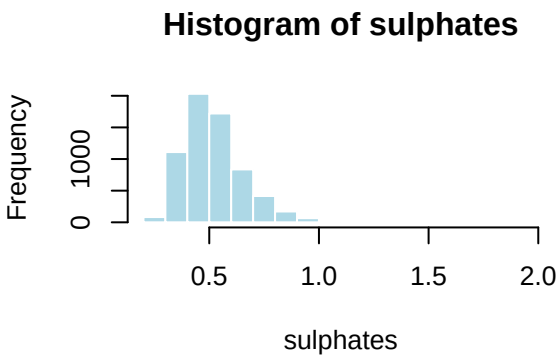

Histogram of chlorides
Frequency
0
2000
0.0
0.1
0.2
0.3
0.4
0.5
0.6
chlorides

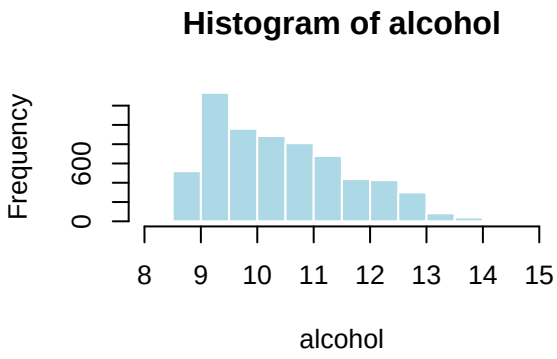

Histogram of free.sulfur.dioxide
Frequency
0
600
0
50
100
150
free.sulfur.dioxide

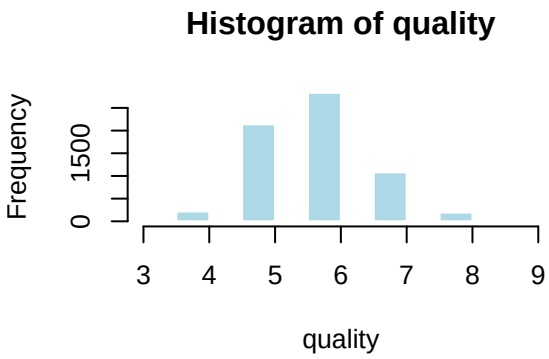

Histogram of total.sulfur.dioxide
Frequency
0
400
1000
0
100
200
300
total.sulfur.dioxide


Histogram of density
Frequency
0
400
0.990
0.995
1.000
density










```
##          fixed.acidity                volatile.acidity
## breaks   integer,14                    numeric,17
## counts   integer,13                    integer,16
## density  numeric,13                    numeric,16
## mids     numeric,13                    numeric,16
## xname    "numeric_columns[[column]]" "numeric_columns[[column]]"
## equidist TRUE                          TRUE
##          citric.acid                   residual.sugar
## breaks   numeric,18                    numeric,15
## counts   integer,17                    integer,14
## density  numeric,17                    numeric,14
## mids     numeric,17                    numeric,14
## xname    "numeric_columns[[column]]" "numeric_columns[[column]]"
## equidist TRUE                          TRUE
##          chlorides                     free.sulfur.dioxide
## breaks   numeric,14                    numeric,16
## counts   integer,13                    integer,15
## density  numeric,13                    numeric,15
## mids     numeric,13                    numeric,15
## xname    "numeric_columns[[column]]" "numeric_columns[[column]]"
## equidist TRUE                          TRUE
##          total.sulfur.dioxide          density
## breaks   numeric,20                    numeric,18
## counts   integer,19                    integer,17
## density  numeric,19                    numeric,17
## mids     numeric,19                    numeric,17
```

```
## xname    "numeric_columns[[column]]" "numeric_columns[[column]]"
## equidist TRUE                        TRUE
##          pH                          sulphates
## breaks   numeric,15                  numeric,19
## counts   integer,14                  integer,18
## density  numeric,14                  numeric,18
## mids     numeric,14                  numeric,18
## xname    "numeric_columns[[column]]" "numeric_columns[[column]]"
## equidist TRUE                        TRUE
##          alcohol                     quality
## breaks   numeric,15                  numeric,13
## counts   integer,14                  integer,12
## density  numeric,14                  numeric,12
## mids     numeric,14                  numeric,12
## xname    "numeric_columns[[column]]" "numeric_columns[[column]]"
## equidist TRUE                        TRUE
```

Logs

```
names(wine_data)
```

```
##  [1] "fixed.acidity"        "volatile.acidity"     "citric.acid"
##  [4] "residual.sugar"       "chlorides"            "free.sulfur.dioxide"
##  [7] "total.sulfur.dioxide" "density"              "pH"
## [10] "sulphates"            "alcohol"              "quality"
## [13] "type"
```

```
model_add = lm(quality ~ ., data = wine_data)
model_log = lm(quality ~ fixed.acidity + log(volatile.acidity) + citric.acid + residual.sugar + chloride

model_log_int = lm(quality ~ (fixed.acidity + log(volatile.acidity) + citric.acid + residual.sugar + ch

summary(model_add)$adj.r.squared
```

```
## [1] 0.2982511
```

```
summary(model_log)$adj.r.squared
```

```
## [1] 0.3091152
```

```
summary(model)$adj.r.squared
```

```
## [1] 0.359651
```

```
summary(model_log_int)$adj.r.squared
```

```
## [1] 0.3682492
```

```r
model_bac_aic = step(model_log_int, trace = 0)
model_bac_bic = step(model_log_int, k = log(nrow(wine_data)), trace = 0)
model_both_aic = step(model_log_int, direction = "both", trace = 0)
summary(model_bac_aic)$adj.r.squared
```

```
## [1] 0.3694712
```

```r
summary(model_bac_bic)$adj.r.squared
```

```
## [1] 0.3659214
```

```r
summary(model_both_aic)$adj.r.squared
```

```
## [1] 0.3694712
```

```r
#model_bac_aic = step(model_add, trace = 0)
#model_bac_bic = step(model_add, k = log(nrow(wine_data)), trace = 0)
#model_both_aic = step(model_add, direction = "both", trace = 0)
#summary(model_bac_aic)$adj.r.squared
#summary(model_bac_bic)$adj.r.squared
#summary(model_both_aic)$adj.r.squared
```