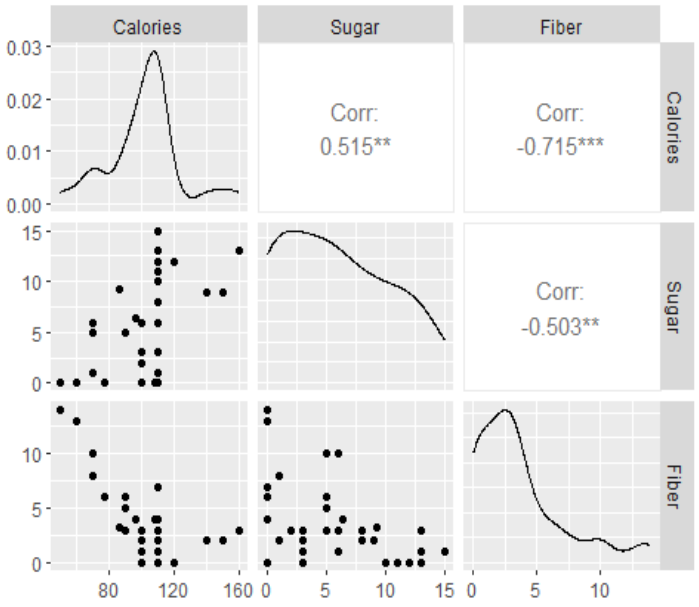
Homework 4

```
library(here)                                   ## File Path Management
library(statcalpolypackage)                     ## Data Extraction
library(gato365dsh2024)                         ## Data Extraction
library(dplyr)                                  ## Data Transformation
library(ggplot2)                                ## Data Visualization
library(GGally)                                 ## Data Visualization
library(broom)                                  ## Data Analysis
source(here("R","assessment_regression.R"))
```

`Cereal` dataset

The Cereal dataset contains nutritional information about different breakfast cereals, including variables like Calories, Sugar content, and Fiber. It allows us to explore how certain ingredients, like Sugar, are related to the overall calorie count of cereals. This dataset is useful for practicing regression, diagnostics, and understanding when transformations might be needed to better model relationships.

```
Cereal %>%
  select(-Cereal) %>%
  ggpairs()
```

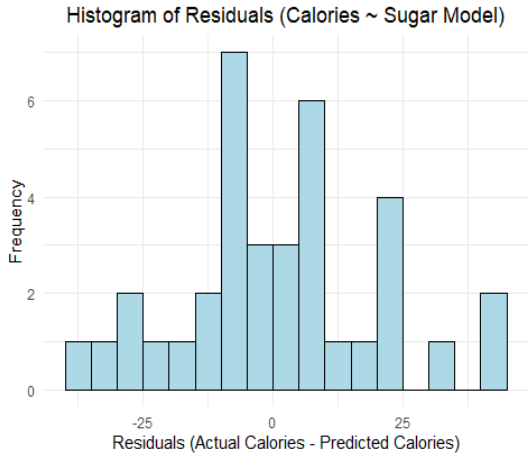


```r
# Fit the linear model using the lm() function
lm_cereal <- lm(Calories ~ Sugar, data = Cereal)
summary(lm_cereal)
```

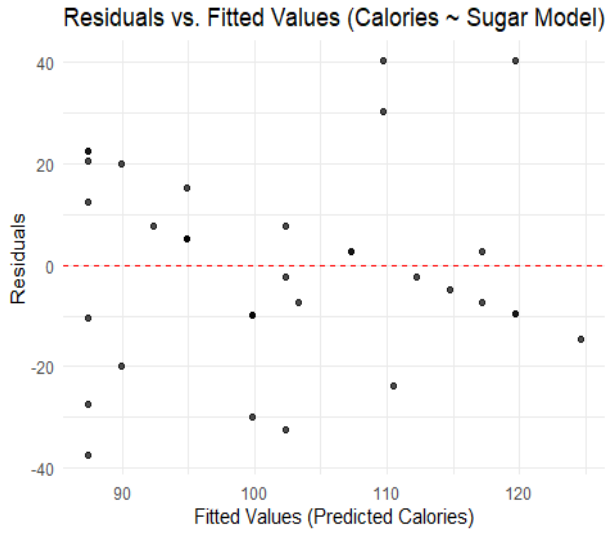
```
Call:
lm(formula = Calories ~ Sugar, data = Cereal)

Residuals:
    Min      1Q  Median      3Q     Max
-37.428  -9.832   0.245   8.909  40.322

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept)  87.4277     5.1627  16.935   <2e-16 ***
Sugar         2.4808     0.7074   3.507   0.0013 **
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 19.27 on 34 degrees of freedom
Multiple R-squared:  0.2656,    Adjusted R-squared:  0.244
F-statistic:  12.3 on 1 and 34 DF,  p-value: 0.001296
```

```r
augmented_cereal <- augment(lm_cereal)
```

```r
ggplot(augmented_cereal, aes(x =.resid)) +
  geom_histogram(binwidth = 5, fill = "lightblue", color = "black", boundary = 0) + # Adjusted binning
  labs(title = "Histogram of Residuals (Calories ~ Sugar Model)",
       x = "Residuals (Actual Calories - Predicted Calories)",
       y = "Frequency") +
  theme_minimal() +
  theme(plot.title = element_text(hjust = 0.5))
```




```r
ggplot(augmented_cereal, aes(x =.fitted, y =.resid)) +
  geom_point(alpha = 0.7) +
  geom_hline(yintercept = 0, linetype = "dashed", color = "red") + # Reference line at zero residual
  labs(title = "Residuals vs. Fitted Values (Calories ~ Sugar Model)",
       x = "Fitted Values (Predicted Calories)",
       y = "Residuals") +
  theme_minimal() +
  theme(plot.title = element_text(hjust = 0.5))
```



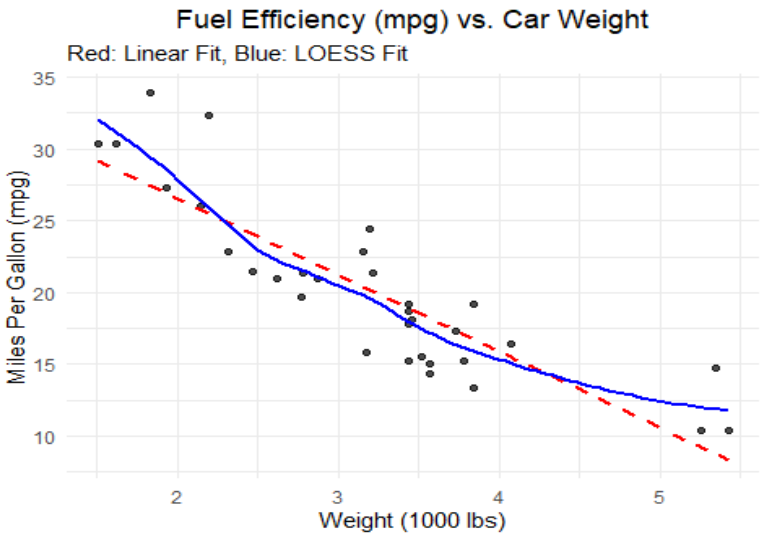
```r
augmented_cereal %>%
  arrange(desc(.cooksd)) %>%
  head(10) %>%
  round(3)
```

```
# A tibble: 10 × 8
   Calories Sugar .fitted .resid  .hat .sigma .cooksd .std.resid
      <dbl> <dbl>   <dbl>  <dbl> <dbl>  <dbl>   <dbl>      <dbl>
 1      160    13   120.    40.3 0.099   18.1   0.268      2.20
 2       50     0    87.4  -37.4 0.072   18.4   0.157     -2.02
 3      150     9   110.    40.2 0.042   18.2   0.101      2.13
 4       60     0    87.4  -27.4 0.072   18.9   0.084     -1.48
 5      110     0    87.4   22.6 0.072   19.1   0.057      1.22
 6      110     0    87.4   22.6 0.072   19.1   0.057      1.22
 7      140     9   110.    30.2 0.042   18.8   0.057      1.60
 8      110    15   125.   -14.6 0.144   19.4   0.057     -0.821
 9      108     0    87.4   20.6 0.072   19.2   0.047      1.11
10       70     6   102.   -32.3 0.028   18.7   0.041     -1.70
```

`mtcars` dataset

The `mtcars` dataset is a classic and widely used dataset in R that contains specifications and performance data for 32 different car models from the 1974 Motor Trend magazine. Each row represents a unique vehicle, and each column records a specific attribute related to engine performance, design, or efficiency. Some key variables include `mpg` (miles per gallon), `hp` (gross horsepower), `wt` (weight in 1000 lbs), `drat` (rear axle ratio), and `qsec` (quarter-mile time). Additionally, the dataset includes categorical variables encoded as numeric values, such as `cyl` (number of cylinders), `am` (transmission type), and `gear` (number of forward gears).

```
ggplot(mtcars, aes(x = wt, y = mpg)) +
  geom_point(alpha = 0.7) +
  geom_smooth(method = "lm", se = FALSE, color = "red", linetype = "dashed")
+ # Add linear trend
  geom_smooth(method = "loess", se = FALSE, color = "blue") + # Add non-
linear trend (LOESS)
  labs(title = "Fuel Efficiency (mpg) vs. Car Weight",
       subtitle = "Red: Linear Fit, Blue: LOESS Fit",
       x = "Weight (1000 lbs)",
       y = "Miles Per Gallon (mpg)") +
  theme_minimal() +
  theme(plot.title = element_text(hjust = 0.5))
```



LOESS (Locally Estimated Scatterplot Smoothing) fits many small, simple models to localized sections of the data instead of assuming one global line.
It creates a smooth curve that captures bends and changes in the relationship between variables. LOESS is important because it helps reveal patterns that a simple linear model might miss, especially when the true relationship is nonlinear.

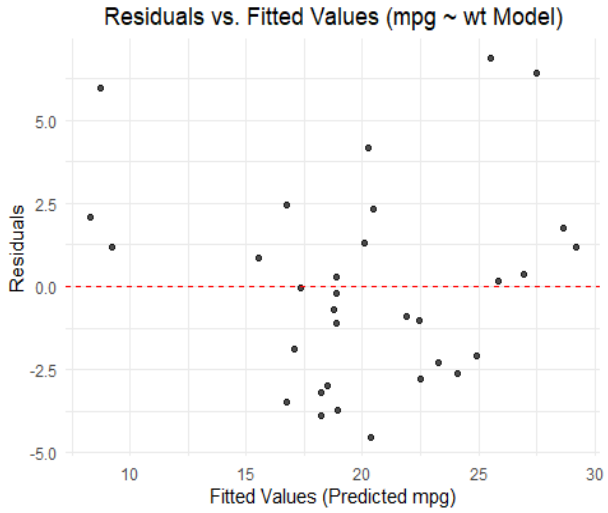
```r
# Fit the initial linear model
lm_mtcars_orig <- lm(mpg ~ wt, data = mtcars_data)

# Display the model summary
summary(lm_mtcars_orig)
```

```
Call:
lm(formula = mpg ~ wt, data = mtcars_data)

Residuals:
    Min      1Q  Median      3Q     Max 
-4.5432 -2.3647 -0.1252  1.4096  6.8727 

Coefficients:
            Estimate Std. Error t value Pr(>|t|)    
(Intercept)  37.2851     1.8776  19.858  < 2e-16 ***
wt           -5.3445     0.5591  -9.559 1.29e-10 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 3.046 on 30 degrees of freedom
Multiple R-squared:  0.7528,    Adjusted R-squared:  0.7446 
F-statistic: 91.38 on 1 and 30 DF,  p-value: 1.294e-10
```

```r
summarize_reg_model(lm_mtcars_orig,"mpg ~ wt Model")
```

```
            type    RSS  RSE   R2 Adj_R2   AIC   BIC
1 mpg ~ wt Model 278.32 3.05 0.75   0.74 71.22 72.68
```

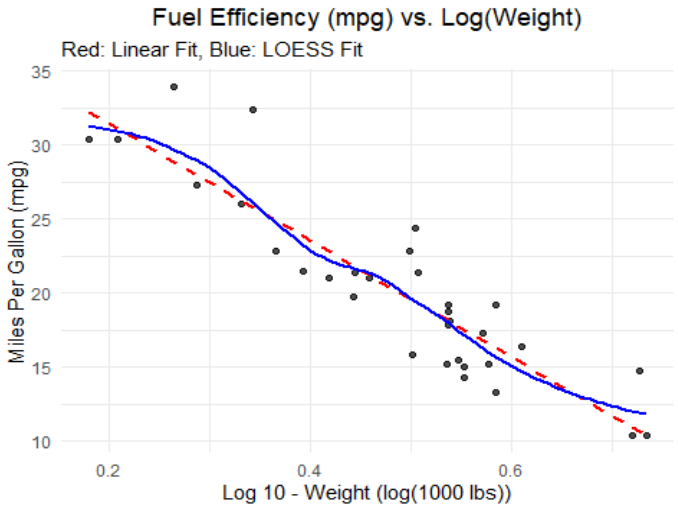
```r
augmented_mtcars <- augment(lm_mtcars_orig)

ggplot(augmented_mtcars, aes(x =.fitted, y =.resid)) +
  geom_point(alpha = 0.7) +
  geom_hline(yintercept = 0, linetype = "dashed", color = "red") +
  labs(title = "Residuals vs. Fitted Values (mpg ~ wt Model)",
       x = "Fitted Values (Predicted mpg)",
       y = "Residuals") +
  theme_minimal() +
  theme(plot.title = element_text(hjust = 0.5))
```




```r
augmented_mtcars %>%
  arrange(desc(.cooksd)) %>%
  head(10) %>%
  round(3)
```

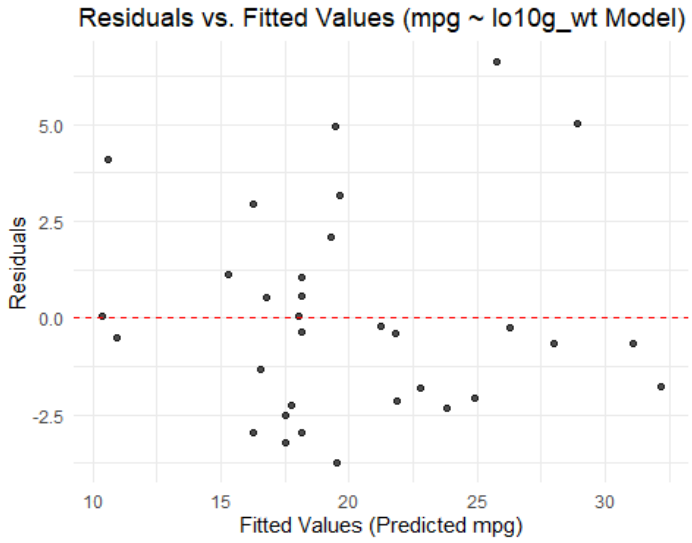
```
# A tibble: 10 × 8
     mpg    wt .fitted .resid  .hat .sigma .cooksd .std.resid
   <dbl> <dbl>   <dbl>  <dbl> <dbl>  <dbl>   <dbl>      <dbl>
 1  14.7  5.34    8.72   5.98 0.184   2.84   0.532       2.17
 2  33.9  1.84   27.5    6.42 0.096   2.83   0.26        2.22
 3  32.4  2.2    25.5    6.87 0.066   2.80   0.193       2.34
 4  10.4  5.42    8.30   2.10 0.195   3.07   0.072       0.77
 5  15.8  3.17   20.3   -4.54 0.031   2.98   0.037      -1.52
 6  13.3  3.84   16.8   -3.46 0.044   3.03   0.031      -1.16
 7  14.3  3.57   18.2   -3.90 0.035   3.01   0.031      -1.31
 8  24.4  3.19   20.2    4.16 0.031   3.00   0.031       1.39
 9  15.2  3.44   18.9   -3.73 0.033   3.02   0.026      -1.24
10  30.4  1.62   28.7    1.75 0.118   3.08   0.025       0.61
```

```r
mtcars_data <- mtcars %>%
  mutate(log10_wt = log10(wt))

ggplot(mtcars_data, aes(x = log10_wt, y = mpg)) +
  geom_point(alpha = 0.7) +
  geom_smooth(method = "lm", se = FALSE, color = "red", linetype = "dashed") +
  geom_smooth(method = "loess", se = FALSE, color = "blue") +
  labs(title = "Fuel Efficiency (mpg) vs. Log(Weight)",
       subtitle = "Red: Linear Fit, Blue: LOESS Fit",
       x = "Log 10 - Weight (log(1000 lbs))",
       y = "Miles Per Gallon (mpg)") +
  theme_minimal() +
  theme(plot.title = element_text(hjust = 0.5))
```



```r
lm_mtcars_transformed <- lm(mpg ~ log10_wt, data = mtcars_data)

summary(lm_mtcars_transformed)
Call:
lm(formula = mpg ~ log10_wt, data = mtcars_data)

Residuals:
    Min      1Q  Median      3Q     Max 
-3.7440 -2.0954 -0.3672  1.0709  6.6150 

Coefficients:
            Estimate Std. Error t value Pr(>|t|)    
(Intercept)   39.257      1.758   22.32  < 2e-16 ***
log10_wt     -39.342      3.477  -11.31 2.39e-12 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 2.669 on 30 degrees of freedom
Multiple R-squared:  0.8101,    Adjusted R-squared:  0.8038 
F-statistic:   128 on 1 and 30 DF,  p-value: 2.391e-12

summarize_reg_model(lm_mtcars_transformed, "mpg ~ log10_wt Model")

                  type    RSS  RSE   R2 Adj_R2   AIC   BIC
1 mpg ~ log10_wt Model 213.78 2.67 0.81    0.8 62.77 64.24
```

```r
augmented_mtcars_transformed <- augment(lm_mtcars_transformed)
ggplot(augmented_mtcars_transformed, aes(x =.fitted, y =.resid)) +
  geom_point(alpha = 0.7) +
  geom_hline(yintercept = 0, linetype = "dashed", color = "red") +
  labs(title = "Residuals vs. Fitted Values (mpg ~ lo10g_wt Model)",
       x = "Fitted Values (Predicted mpg)",
       y = "Residuals") +
  theme_minimal() +
  theme(plot.title = element_text(hjust = 0.5))
```




```r
augmented_mtcars_transformed %>%
  select(-.rownames) %>%
  arrange(desc(.cooksd)) %>%
  head(10) %>%
  round(3)
```

```
# A tibble: 10 × 8
     mpg log10_wt .fitted .resid  .hat .sigma .cooksd .std.resid
   <dbl>    <dbl>   <dbl>  <dbl> <dbl>  <dbl>   <dbl>      <dbl>
 1  33.9    0.264    28.9   5.01 0.116   2.53   0.262      2.00
 2  32.4    0.342    25.8   6.62 0.067   2.40   0.235      2.56
 3  14.7    0.728    10.6   4.08 0.13    2.59   0.2        1.64
 4  30.4    0.18     32.2  -1.78 0.191   2.69   0.065     -0.742
 5  24.4    0.504    19.4   4.96 0.032   2.55   0.058      1.89
 6  15.8    0.501    19.5  -3.74 0.032   2.62   0.033     -1.42
 7  13.3    0.584    16.3  -2.97 0.047   2.66   0.032     -1.14
 8  19.2    0.585    16.2   2.95 0.047   2.66   0.032      1.13
 9  14.3    0.553    17.5  -3.21 0.039   2.65   0.03      -1.23
10  15.2    0.536    18.2  -2.97 0.035   2.66   0.023     -1.13
```