1. Sums of squares and mean squares.

\[ SS_{\text{Residual}} = \sum (y - \hat{y})^2 \quad SS_{\text{Regression}} = \sum (\hat{y} - \bar{y})^2 \quad SS_{\text{Total}} = \sum (y - \bar{y})^2 \]

\[ MS_{\text{Total}} = \frac{SS_{\text{Total}}}{n - 1} \quad MS_{\text{Residual}} = \frac{SS_{\text{Residual}}}{n - (k + 1)} \quad MS_{\text{Regression}} = \frac{SS_{\text{Regression}}}{k} \]

2. \( F \)-tests. An \( F \)-test is a test of model utility. \( F \) tests compare explained variation to unexplained variation.

\[ F = \frac{\text{variation explained by model}}{\text{variation not explained explained by model}} \]

In our case, \( A \) is the model with regression coefficients and \( B \) is the model without (the constant model).

3. \( F \)-test first and then \( t \)-test on individual coefficients.

   (a) Null hypothesis: \( H_0 : \beta_1 = \cdots = \beta_k = 0 \).

   (b) Statistic: \( F = \frac{MS_{\text{Regression}}}{MS_{\text{Residual}}} \).

   (c) Reject \( H_0 \) if \( F \) is large. (If \( H_0 \) is true, the expected value of \( F \) is 1.)


   (a) Plot residuals against fitted values: \[ \text{plot(residuals(l)~fitted(l))} \]

   (b) Plot a histogram of residuals: \[ \text{hist(residuals(l))} \]

   (c) A normal probability plot of residuals: \[ \text{qqnorm(residuals(l))} \]

5. Categorical variables on the right-hand side. Indicator variables.

   (a) Parallel lines.

   (b) Different slopes – interaction terms.

Homework

1. Read Chapter 31, 813–819

2. The dataset \texttt{cats} in the M243 package has data on 144 adult cats used in a medical experiment. The dataset includes the sex, heart weight in grams, and body weight in kilograms.

   (a) Write a linear model for predicting heart weight from body weight. (A cat would appreciate your using your model to approximate its heart weight rather than attempting to measure it exactly.)

   (b) Comment on the suitability of using your model to predict heart weight from body weight.

   (c) Can the linear model be improved by adding the sex of the cat to the model? Use a linear model and an indicator for sex.

   (d) Use your models in (a) and (c) to predict the heart weight of a 3 kg male cat and a 3 kg female cat.
```r
plot(Gas~Temp,subset=(Insul=='Before'),pch='B',data=whiteside)
points(Gas~Temp,subset=(Insul=='After'),pch='A',data=whiteside)
ltemp=lm(Gas~Temp,data=whiteside)
ltemp

Coefficients:
(Intercept) Temp
  5.4862 -0.2902

linsul=lm(Gas~Insul,data=whiteside)
linsul

Coefficients:
(Intercept) InsulAfter
  4.750 -1.267

ltempinsul=lm(Gas~Temp+Insul,data=whiteside)
ltempinsul

Coefficients:
(Intercept) Temp InsulAfter
  6.5513 -0.3367 -1.5652

lfull=lm(Gas~Temp+Insul+Temp*Insul,data=whiteside)
lfull

Coefficients:
(Intercept) Temp InsulAfter Temp:InsulAfter
  6.8538 -0.3932 -2.1300 0.1153

summary(lfull)

Call:
  lm(formula = Gas ~ Temp + Insul + Temp * Insul, data = whiteside)

Residuals:
  Min   1Q Median   3Q  Max
-0.97802 -0.18011  0.03757  0.20930  0.63803

Coefficients:
  Estimate Std. Error t value Pr(>|t|)
(Intercept)  6.85383   0.13596  50.409  < 2e-16 ***
Temp         -0.39324   0.02249  -17.487  < 2e-16 ***
InsulAfter   -2.12998   0.18009  -11.827  2.32e-16 ***
Temp:InsulAfter  0.11530   0.03211   3.591  0.00073 ***

---
Signif. codes:  0 *** 0.001 ** 0.01 * 0.05 . 0.1 1

Residual standard error: 0.323 on 52 degrees of freedom
Multiple R-squared:  0.9277,  Adjusted R-squared:  0.9235
F-statistic: 222.3 on 3 and 52 DF,  p-value: < 2.2e-16
```