Ohm's Law Example

Data from Handout

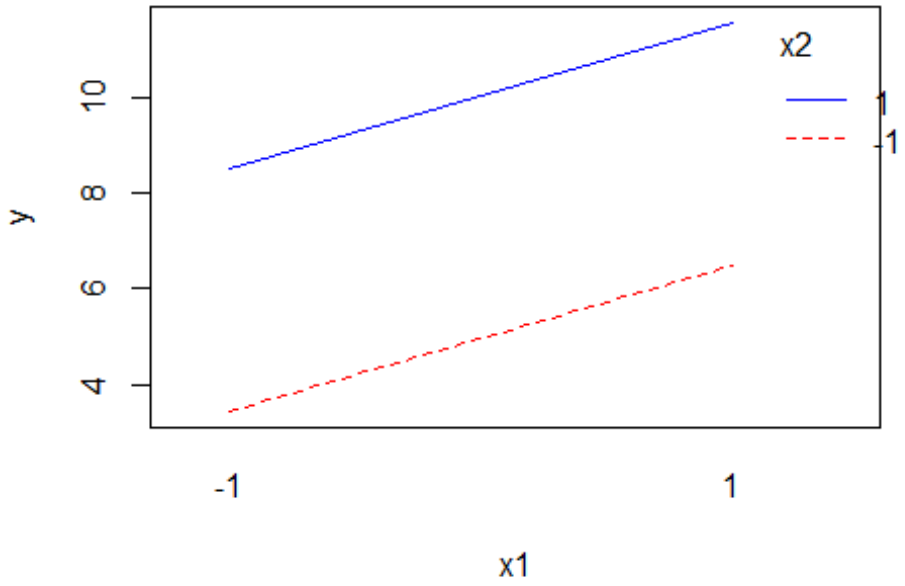
We are interested in modeling the effects of current flow (in amps) and resistance (in Ohms) on the voltage output (in volts).

:

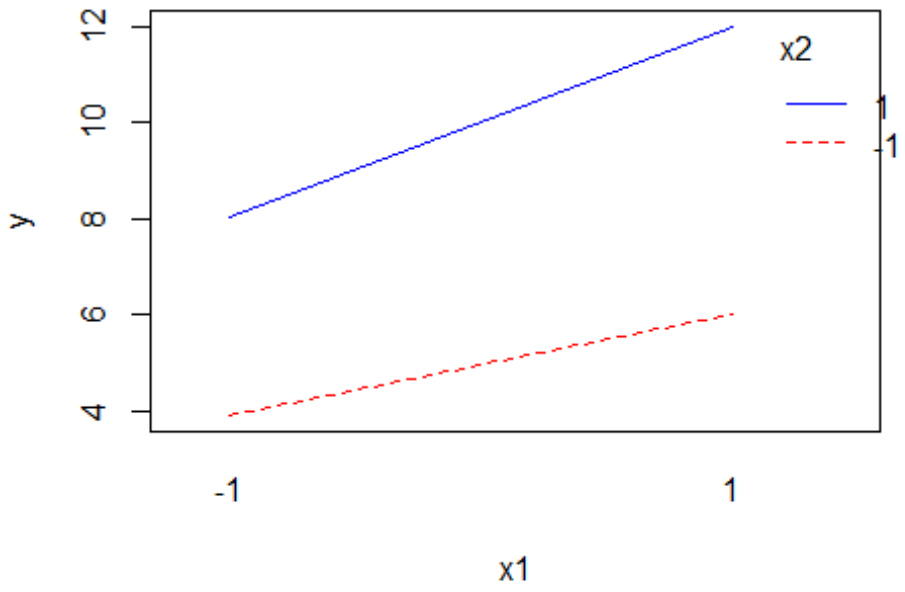
```
flow = c(4,4,6,6,4,4,6,6)
resistance = c(1,1,1,1,2,2,2,2)
voltage = c(3.802,4.013,6.065,5.992,7.934,8.159,11.865,12.138)

ohms.dat = data.frame(flow,resistance,voltage)

ohms.dat$x1 = 2*(ohms.dat$flow - mean(ohms.dat$flow)) /
(range(ohms.dat$flow)[2]-range(ohms.dat$flow)[1])

ohms.dat$x2 = 2*(ohms.dat$resistance - mean(ohms.dat$resistance)) /
(range(ohms.dat$resistance)[2]-range(ohms.dat$resistance)[1])

ohms.dat$y = ohms.dat$voltage

ohms.dat
```

```
##   flow resistance voltage x1 x2      y
## 1    4          1   3.802 -1 -1  3.802
## 2    4          1   4.013 -1 -1  4.013
## 3    6          1   6.065  1 -1  6.065
## 4    6          1   5.992  1 -1  5.992
## 5    4          2   7.934 -1  1  7.934
## 6    4          2   8.159 -1  1  8.159
## 7    6          2  11.865  1  1 11.865
## 8    6          2  12.138  1  1 12.138
```

```r
additive.mod = lm(y ~ x1+x2,data=ohms.dat)
summary(additive.mod)
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)   7.4960     0.2103  35.642 3.27e-07 ***
## x1            1.5190     0.2103   7.223 0.000794 ***
## x2            2.5280     0.2103  12.020 7.03e-05 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.5949 on 5 degrees of freedom
## Multiple R-squared:  0.9752, Adjusted R-squared:  0.9653
## F-statistic: 98.32 on 2 and 5 DF,  p-value: 9.681e-05

pred.add = predict(additive.mod)

interaction.plot(ohms.dat$x1,ohms.dat$x2,pred.add, col =
c("red","blue"),trace.label = "x2",xlab = "x1",ylab = "y")
```



```
interaction.mod = lm(y ~ x1+x2+I(x1*x2),data=ohms.dat)
summary(interaction.mod)
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)  7.49600    0.05229 143.349 1.42e-08 ***
## x1           1.51900    0.05229  29.049 8.36e-06 ***
## x2           2.52800    0.05229  48.344 1.10e-06 ***
## I(x1 * x2)   0.45850    0.05229   8.768 0.000933 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.1479 on 4 degrees of freedom
## Multiple R-squared:  0.9988, Adjusted R-squared:  0.9979
## F-statistic:  1086 on 3 and 4 DF,  p-value: 2.818e-06

interaction.plot(ohms.dat$x1,ohms.dat$x2,ohms.dat$y, col =
c("red","blue"),trace.label = "x2",xlab = "x1",ylab = "y")
```




```
b0 = interaction.mod$coefficients[1]
b1 = interaction.mod$coefficients[2]
b2 = interaction.mod$coefficients[3]
b12 = interaction.mod$coefficients[4]
```

```r
reg.estimates.x1 = matrix(c(b0+b2,b0,b0-b2,b1+b12,b1,b1-b12),nrow = 3)
dimnames(reg.estimates.x1) = list(c("x2=+1","x2=0","x2=-1"),
c("intercept","slope"))

reg.estimates.x1
```

```
##       intercept  slope
## x2=+1    10.024 1.9775
## x2=0      7.496 1.5190
## x2=-1     4.968 1.0605
```

```r
original.mod = lm(voltage ~ flow*resistance,data=ohms.dat)
summary(original.mod)
```

```
##
## Call:
## lm(formula = voltage ~ flow * resistance, data = ohms.dat)
##
## Residuals:
##       1       2       3       4       5       6       7       8
## -0.1055  0.1055  0.0365 -0.0365 -0.1125  0.1125 -0.1365  0.1365
##
## Coefficients:
##                 Estimate Std. Error t value Pr(>|t|)
## (Intercept)      -0.8055     0.8432  -0.955 0.393518
## flow              0.1435     0.1654   0.868 0.434467
## resistance        0.4710     0.5333   0.883 0.427003
## flow:resistance   0.9170     0.1046   8.768 0.000933 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.1479 on 4 degrees of freedom
## Multiple R-squared:  0.9988, Adjusted R-squared:  0.9979
## F-statistic:  1086 on 3 and 4 DF,  p-value: 2.818e-06
```