Task Three

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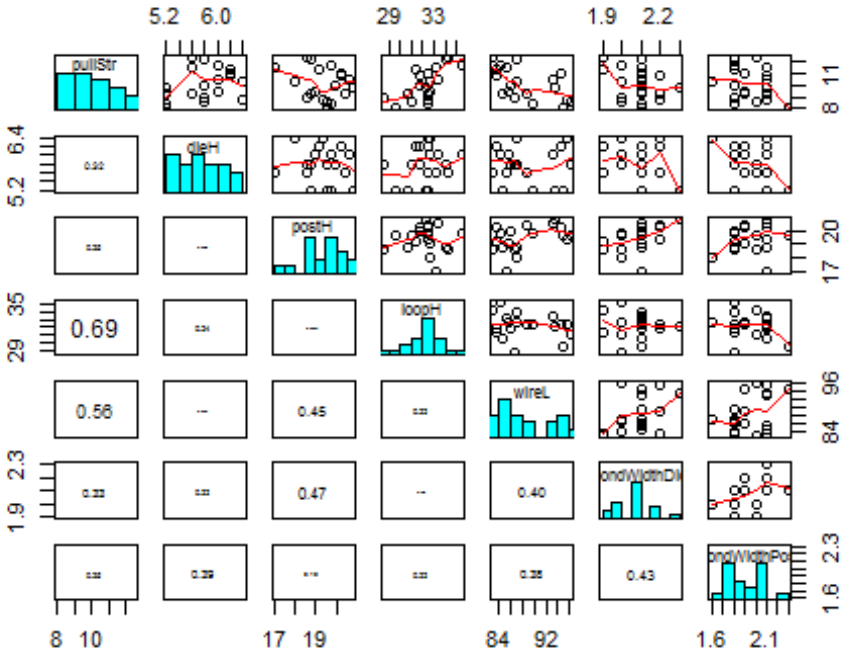
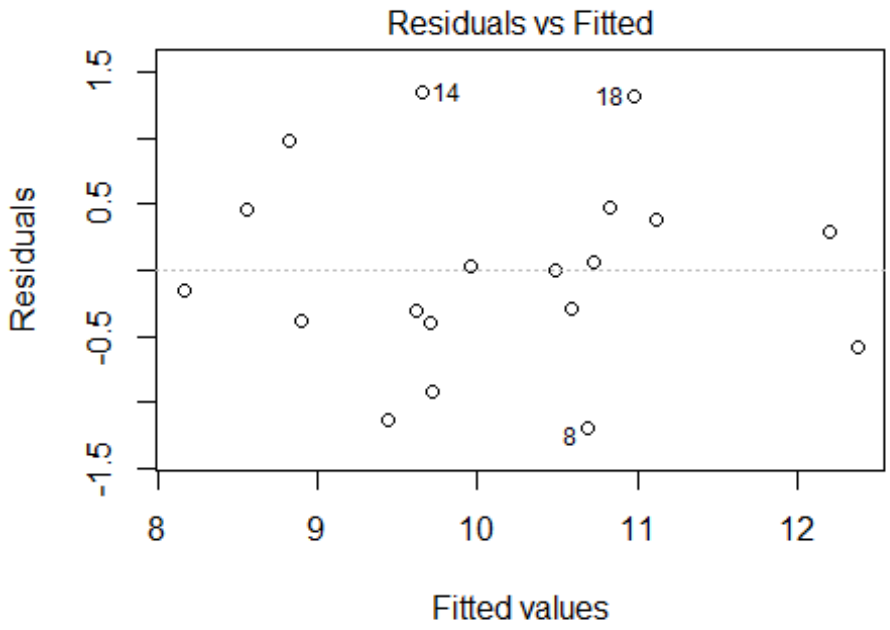
```
library(s20x)
setwd("C:/Users/Buzz/Desktop/Uni/MM3/AssignmentTwo")
wirebonds.df = read.table(file.choose(), header = TRUE) #read text file
pairs20x(wirebonds.df)
```




```
wirebonds.fit =lm(pullStr ~ dieH + postH + loopH + wireL + bondWidthDie + bon
dWidthPost, data = wirebonds.df)
eovcheck(wirebonds.fit)
```




```
summary(wirebonds.fit)

##
## Call:
## lm(formula = pullStr ~ dieH + postH + loopH + wireL + bondWidthDie +
##     bondWidthPost, data = wirebonds.df)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -1.19036 -0.39392  0.00724  0.41801  1.34725
##
## Coefficients:
##               Estimate Std. Error t value Pr(>|t|)
## (Intercept)    3.13682    8.10979   0.387  0.70568
## dieH           0.64443    0.58892   1.094  0.29532
## postH         -0.01042    0.26765  -0.039  0.96959
## loopH          0.50465    0.14234   3.545  0.00403 **
## wireL         -0.11967    0.05623  -2.128  0.05475 .
## bondWidthDie  -2.46177    2.59776  -0.948  0.36200
## bondWidthPost  1.50441    1.51936   0.990  0.34164
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.8941 on 12 degrees of freedom
## Multiple R-squared:  0.7113, Adjusted R-squared:  0.5669
## F-statistic: 4.927 on 6 and 12 DF,  p-value: 0.00921
```

```r
wirebonds.fit2 = lm(pullStr ~ dieH + loopH + wireL + bondWidthDie + bondWidth
Post, data = wirebonds.df)
summary(wirebonds.fit2)
```

```
##
## Call:
## lm(formula = pullStr ~ dieH + loopH + wireL + bondWidthDie +
##     bondWidthPost, data = wirebonds.df)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -1.18753 -0.39705 -0.00169  0.43064  1.34398
##
## Coefficients:
##               Estimate Std. Error t value Pr(>|t|)
## (Intercept)    3.08042    7.66677   0.402  0.69437
## dieH           0.64474    0.56580   1.140  0.27504
## loopH          0.50414    0.13619   3.702  0.00266 **
## wireL         -0.12041    0.05079  -2.371  0.03389 *
## bondWidthDie  -2.49765    2.33368  -1.070  0.30397
## bondWidthPost  1.50945    1.45456   1.038  0.31831
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.8591 on 13 degrees of freedom
## Multiple R-squared:  0.7112, Adjusted R-squared:  0.6001
## F-statistic: 6.403 on 5 and 13 DF,  p-value: 0.003282
```

```r
wirebonds.fit3 = lm(pullStr ~ dieH + loopH + wireL + bondWidthDie, data = wir
ebonds.df)
summary(wirebonds.fit3)
```

```
##
## Call:
## lm(formula = pullStr ~ dieH + loopH + wireL + bondWidthDie, data = wirebon
ds.df)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -1.4991 -0.5985  0.1322  0.5267  1.2611
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)   4.96439    7.46915   0.665  0.51707
## dieH          0.45370    0.53648   0.846  0.41194
## loopH         0.49090    0.13596   3.610  0.00284 **
## wireL        -0.10707    0.04927  -2.173  0.04743 *
## bondWidthDie -1.82178    2.24710  -0.811  0.43109
## ---
```

```
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.8614 on 14 degrees of freedom
## Multiple R-squared:  0.6873, Adjusted R-squared:  0.598
## F-statistic: 7.693 on 4 and 14 DF,  p-value: 0.001699
```

```
wirebonds.fit4 = lm(pullStr ~ dieH + loopH + wireL, data = wirebonds.df)
summary(wirebonds.fit4)
```

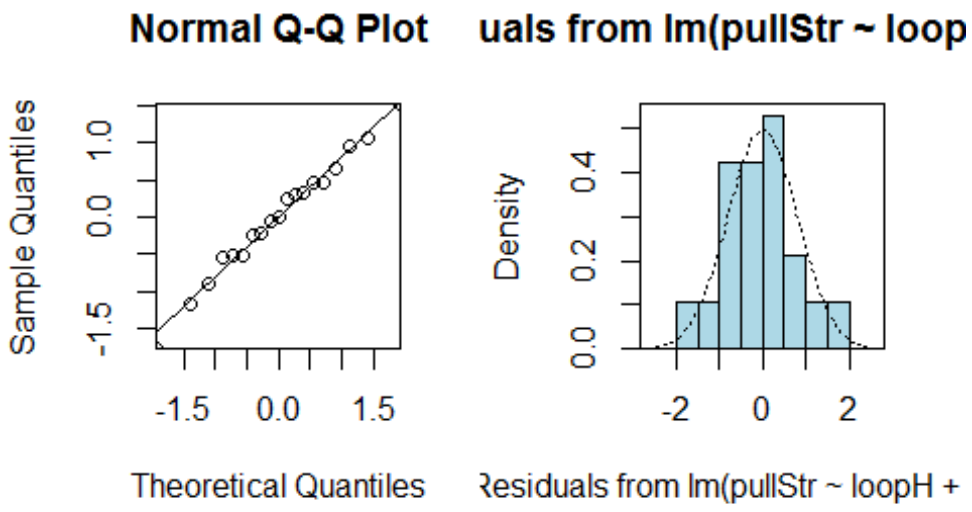
```
##
## Call:
## lm(formula = pullStr ~ dieH + loopH + wireL, data = wirebonds.df)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -1.44704 -0.52223  0.01011  0.61165  1.29218
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)  2.41933    6.69954   0.361  0.72305
## dieH         0.55297    0.51632   1.071  0.30110
## loopH        0.47898    0.13361   3.585  0.00271 **
## wireL       -0.12338    0.04446  -2.775  0.01415 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.8515 on 15 degrees of freedom
## Multiple R-squared:  0.6726, Adjusted R-squared:  0.6071
## F-statistic: 10.27 on 3 and 15 DF,  p-value: 0.0006303
```

```
wirebonds.fit5 = lm(pullStr ~ loopH + wireL, data = wirebonds.df)
summary(wirebonds.fit5)
```

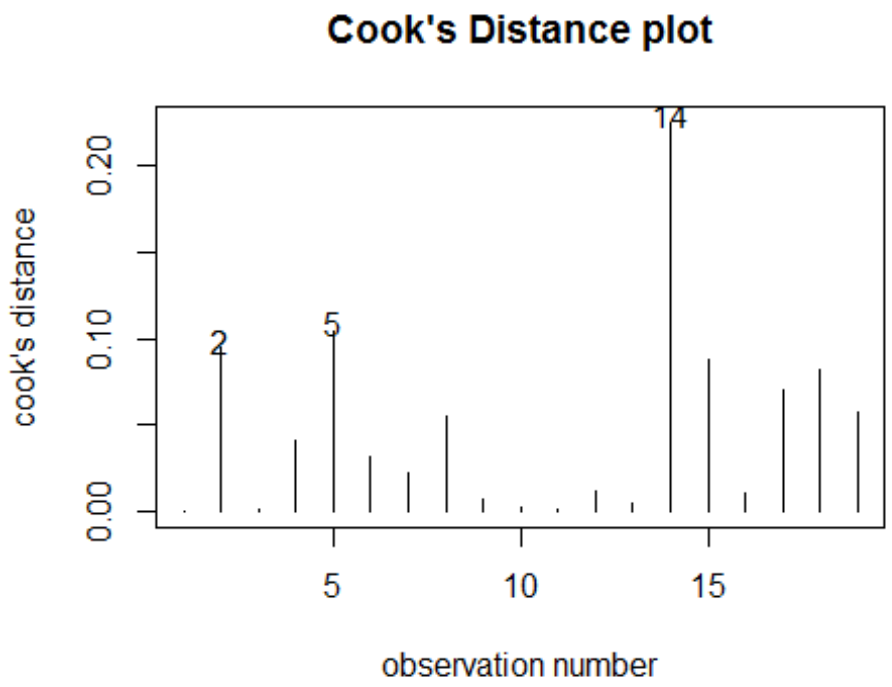
```
##
## Call:
## lm(formula = pullStr ~ loopH + wireL, data = wirebonds.df)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -1.78402 -0.51140 -0.00655  0.45487  1.51206
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)  4.65631    6.39482   0.728  0.47705
## loopH        0.51133    0.13075   3.911  0.00125 **
## wireL       -0.12418    0.04466  -2.781  0.01336 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.8554 on 16 degrees of freedom
```

```
## Multiple R-squared:  0.6476, Adjusted R-squared:  0.6035
## F-statistic:  14.7 on 2 and 16 DF,  p-value: 0.0002379
```

```
normcheck(wirebonds.fit5)
```




```
cooks20x(wirebonds.fit5)
```




```
confint(wirebonds.fit5)
```

```
##                   2.5 %      97.5 %
## (Intercept) -8.9001042 18.21271482
## loopH        0.2341413  0.78851037
## wireL       -0.2188498 -0.02951686
```

Method and Assumption Checks

As we have multiple explanatory variables, we have fitted a multiple linear regression model to the data.

The model was simplified by dropping the statistically least significant variables, one at a time. Post height (p-value = 0.96959), die height (p-value = 0.30110), bond width on the die (p-value = 0.43109) and bond width on the post (p-value = 0.31831) were all dropped from the model. After this, the remaining variables are all statistically significant.

We assume that wire bonds are independent of one another. The assumptions of equality of variance and Normality appear to be satisfied by the final model, and there were no unduly influential observations.

Our final model is:

$$pullStr_i = \beta_0 + (\beta_1 \text{ x } loopH_i) + (\beta_2 \times wireL_i) + \varepsilon_i \text{ where } \varepsilon_i \overset{iid}{\sim} N(0, \sigma^2).$$

Executive Summary

We are interested in explaining the pull strength of a wire bond as a function of other measured characteristics.

The final model used loop height and wire length to explain the pull strength of the wire bond. Die height, post height, bond width on the die and bond width on the post were found to be of no further assistance in explaining the pull strength of the wire bond.

We find that the longer the loop height is, the greater the pull strength of the wire bond. However, the longer the wire length, the less the pull strength of the wire bond.

Our model only explained about 65% of the pull strength of the wire bond.

We estimate that, holding everything else constant:

- a unit increase in loop height results in an average increase in the pull strength between 0.2 and 0.8 units.
- a unit increase in the wire length results in an average decrease in the pull strength between 0.03 and 0.2 units.