Linear Regression

Contents

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1 Importing Libraries

```
install.packages('pastecs')
```

```
## Installing package into '/home/james/R/x86_64-pc-linux-gnu-library/3.6'
## (as 'lib' is unspecified)
```

2 Basics

Reading the data in R.

```
library(pastecs)
kalama = read.table("kalama.txt", header=T)
attach(kalama)
kalama
```

```
##    age height
## 1   18   76.1
## 2   19   77.0
## 3   20   78.1
## 4   21   78.2
## 5   22   78.8
## 6   23   79.7
## 7   24   79.9
## 8   25   81.1
## 9   26   81.2
## 10  27   81.8
## 11  28   82.8
## 12  29   83.5
```

Descriptive statistics in R.

```
options(digits=2)
descrip.kalama = stat.desc(kalama[,c("age","height")],basic=TRUE, desc=TRUE)
descrip.kalama
```

```
##                  age  height
## nbr.val        12.00  12.000
## nbr.null        0.00   0.000
## nbr.na          0.00   0.000
## min            18.00  76.100
## max            29.00  83.500
## range          11.00   7.400
## sum           282.00 958.200
## median         23.50  79.800
## mean           23.50  79.850
## SE.mean         1.04   0.665
## CI.mean.0.95    2.29   1.463
## var            13.00   5.301
## std.dev         3.61   2.302
## coef.var        0.15   0.029
```

Estimating Correlations in R.

```
cov.age.height = cov(age, height)
corr.age.height = cor(age, height)
cov.age.height
```

```
## [1] 8.3
```

```
corr.age.height
```

```
## [1] 0.99
```

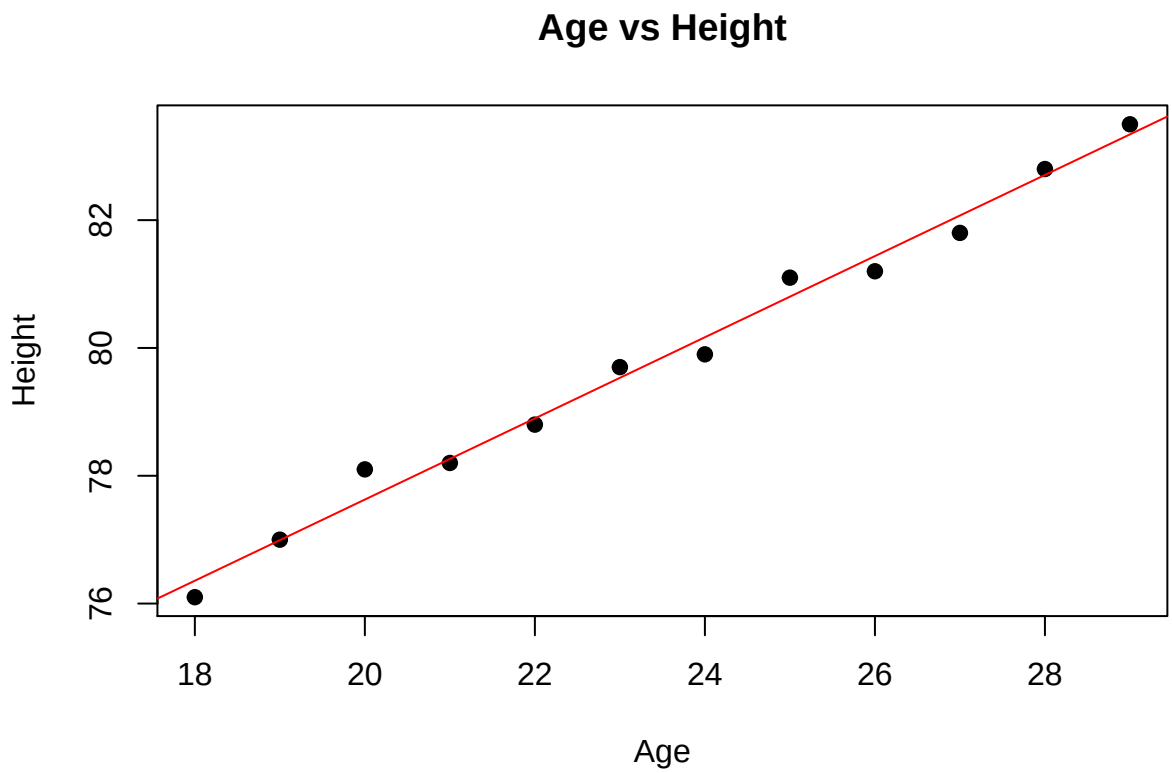
Testing if the population correlation is zero.

```r
corr.age.height.test = cor.test(age, height, alternative="two.sided", method="pearson")
corr.age.height.test
```

```
##
##  Pearson's product-moment correlation
##
## data:  age and height
## t = 30, df = 10, p-value = 4e-11
## alternative hypothesis: true correlation is not equal to 0
## 95 percent confidence interval:
##  0.98 1.00
## sample estimates:
##  cor
## 0.99
```

Scatterplot with line.

```r
plot(age, height, main="Age vs Height", xlab="Age", ylab="Height", pch=19)
abline(lm(height~age), col="red")
```



3 Simple Linear Regression

```
res = lm(height~age, data=kalama)
kalama.anova = anova(res)
kalama.summary = summary(res)
kalama.anova
```

```
## Analysis of Variance Table
##
## Response: height
##           Df Sum Sq Mean Sq F value  Pr(>F)
## age        1   57.7    57.7     880 4.4e-11 ***
## Residuals 10    0.7     0.1
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
kalama.summary
```

```
##
## Call:
## lm(formula = height ~ age, data = kalama)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -0.2724 -0.2425 -0.0276  0.1601  0.4724
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)  64.9283     0.5084   127.7  < 2e-16 ***
## age           0.6350     0.0214    29.7  4.4e-11 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.26 on 10 degrees of freedom
## Multiple R-squared:  0.989,  Adjusted R-squared:  0.988
## F-statistic:  880 on 1 and 10 DF,  p-value: 4.43e-11
```

4 Multiple Linear Regression

4.1 Reading in the data

```
satisfaction = read.table("satisfaction.txt", header=T)
attach(satisfaction)
```

```
## The following object is masked from kalama:
##
##     age
```

```
satisfaction
```

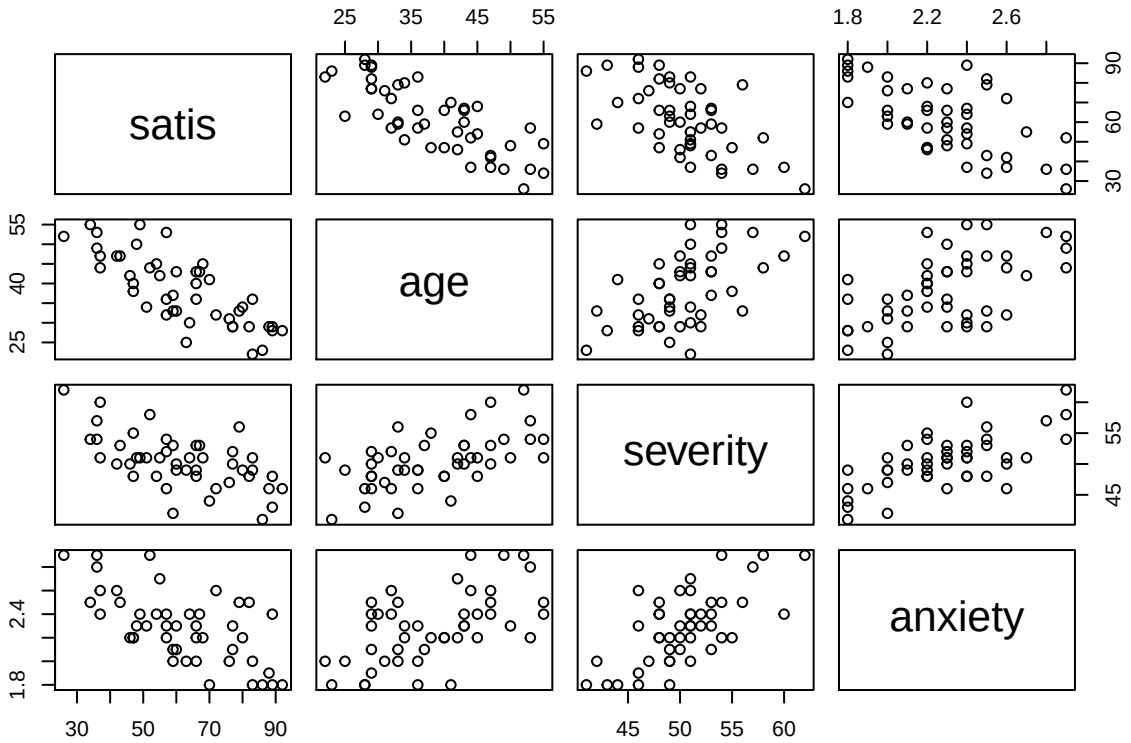
```
##    satis age severity anxiety
## 1     48  50       51     2.3
## 2     57  36       46     2.3
## 3     66  40       48     2.2
## 4     70  41       44     1.8
## 5     89  28       43     1.8
## 6     36  49       54     2.9
## 7     46  42       50     2.2
## 8     54  45       48     2.4
## 9     26  52       62     2.9
## 10    77  29       50     2.1
## 11    89  29       48     2.4
## 12    67  43       53     2.4
## 13    47  38       55     2.2
## 14    51  34       51     2.3
## 15    57  53       54     2.2
## 16    66  36       49     2.0
## 17    79  33       56     2.5
## 18    88  29       46     1.9
## 19    60  33       49     2.1
## 20    49  55       51     2.4
## 21    77  29       52     2.3
## 22    52  44       58     2.9
## 23    60  43       50     2.3
## 24    86  23       41     1.8
## 25    43  47       53     2.5
## 26    34  55       54     2.5
## 27    63  25       49     2.0
## 28    72  32       46     2.6
## 29    57  32       52     2.4
## 30    55  42       51     2.7
## 31    59  33       42     2.0
## 32    83  36       49     1.8
## 33    76  31       47     2.0
## 34    47  40       48     2.2
## 35    36  53       57     2.8
## 36    80  34       49     2.2
## 37    82  29       48     2.5
## 38    64  30       51     2.4
## 39    37  47       60     2.4
## 40    42  47       50     2.6
## 41    66  43       53     2.3
## 42    83  22       51     2.0
## 43    37  44       51     2.6
## 44    68  45       51     2.2
## 45    59  37       53     2.1
## 46    92  28       46     1.8
```

4.2 Exploring the data

```
cor(satisfaction)
```

```
##           satis   age severity anxiety
## satis      1.00 -0.79    -0.60   -0.64
## age       -0.79  1.00     0.57    0.57
## severity -0.60  0.57     1.00    0.67
## anxiety  -0.64  0.57     0.67    1.00
```

```
plot(satisfaction)
```



Descriptive statistics

```
options(digits=2)
descrip.satisfaction = stat.desc(satisfaction,basic=TRUE, desc=TRUE)
descrip.satisfaction
```

```
##                satis     age severity anxiety
## nbr.val        46.00   46.00  4.6e+01  46.000
## nbr.null        0.00    0.00  0.0e+00   0.000
## nbr.na          0.00    0.00  0.0e+00   0.000
## min            26.00   22.00  4.1e+01   1.800
## max            92.00   55.00  6.2e+01   2.900
```

```
## range          66.00   33.00  2.1e+01   1.100
## sum          2832.00 1766.00  2.3e+03 105.200
## median         60.00   37.50  5.0e+01   2.300
## mean           61.57   38.39  5.0e+01   2.287
## SE.mean         2.54    1.31  6.4e-01   0.044
## CI.mean.0.95    5.12    2.65  1.3e+00   0.089
## var           297.10   79.53  1.9e+01   0.090
## std.dev        17.24    8.92  4.3e+00   0.299
## coef.var        0.28    0.23  8.6e-02   0.131
```

4.3 Fitting the model

```
satisfaction.lm = lm(satis~age+severity+anxiety, data=satisfaction)
satisfaction.summary = summary(satisfaction.lm)
satisfaction.summary
```

```
##
## Call:
## lm(formula = satis ~ age + severity + anxiety, data = satisfaction)
##
## Residuals:
##    Min     1Q Median     3Q    Max
## -18.35  -6.42   0.52   8.37  17.16
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)  158.491     18.126    8.74  5.3e-11 ***
## age           -1.142      0.215   -5.31  3.8e-06 ***
## severity      -0.442      0.492   -0.90    0.374
## anxiety      -13.470      7.100   -1.90    0.065 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 10 on 42 degrees of freedom
## Multiple R-squared:  0.682,  Adjusted R-squared:  0.659
## F-statistic: 30.1 on 3 and 42 DF,  p-value: 1.54e-10
```

4.4 Likelihood ratio test null model versus full model

```
satisfaction.lm.int = lm(satis~1, data=satisfaction) # Null model
anova(satisfaction.lm.int,satisfaction.lm) # Null versus full
```

```
## Analysis of Variance Table
##
## Model 1: satis ~ 1
## Model 2: satis ~ age + severity + anxiety
##   Res.Df   RSS Df Sum of Sq    F  Pr(>F)
## 1     45 13369
## 2     42  4249  3      9120 30.1 1.5e-10 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

4.5 Sequential building of the model

```
satisfaction.anova = anova(satisfaction.lm)
satisfaction.anova
```

```
## Analysis of Variance Table
##
## Response: satis
##           Df Sum Sq Mean Sq F value  Pr(>F)
## age        1   8275    8275   81.80 2.1e-11 ***
## severity   1    481     481    4.75   0.035 *
## anxiety    1    364     364    3.60   0.065 .
## Residuals 42   4249     101
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

4.6 Final Model

```
satisfaction.lm.final = lm(satis~age+anxiety, data=satisfaction)
satisfaction.final.summary = summary(satisfaction.lm.final)
satisfaction.final.summary
```

```
##
## Call:
## lm(formula = satis ~ age + anxiety, data = satisfaction)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -19.445  -7.328   0.673   8.513  18.053
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)  145.941     11.525   12.66  4.2e-16 ***
## age           -1.200      0.204   -5.88  5.4e-07 ***
## anxiety      -16.742      6.081   -2.75   0.0086 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 10 on 43 degrees of freedom
## Multiple R-squared:  0.676,  Adjusted R-squared:  0.661
## F-statistic: 44.9 on 2 and 43 DF,  p-value: 2.98e-11
```

4.7 Predicting a new observation

```
newdata = data.frame(age=43, anxiety=2.7)
pred.w.plim = predict(satisfaction.lm.final, newdata, interval="predict")
pred.w.clim = predict(satisfaction.lm.final, newdata, interval = "confidence")
pred.w.plim
```

```
##   fit lwr upr
## 1  49  28  70
```

```
pred.w.clim
```

```
##   fit lwr upr
## 1  49  44  54
```