0528 演習課

```
options(scipen=999)
setwd("C:/Users/User/Desktop/R/R-project/R Statistics/data")
#### ANOVA 分析 ####
### 單因子 ANOVA 分析 ###
```

我們將使用 Monegomery (2009) 積體電路生產過程中的電漿蝕刻 (plasmaetching) 資料，來示範如何使用 R 軟體分析一因子設計資料。在這組資料中，產生電漿的電極功率有 4 種設定值：160W、180W、200W、220W，所以 a = 4，另外每個處理中有 n = 5，個觀察值。

電極功率	觀察值：Etch Rate (A/min)				
	1	2	3	4	5
160W	575	542	530	539	570
180W	565	593	590	579	610
200W	600	651	610	637	629
220W	725	700	715	685	710

```
Y1 <- c(575,542,530,539,570)
Y2 <- c(565,593,590,579,610)
Y3 <- c(600,651,610,637,629)
Y4 <- c(725,700,715,685,710)
Y <- c(Y1,Y2,Y3,Y4); Y
```

```
##  [1] 575 542 530 539 570 565 593 590 579 610 600 651 610 637 629 725
 700 715 685
## [20] 710
```

```
# Treatment
A <- as.factor(rep(c("160w","180w","200w","220w"),each=5)); A
```

```
##  [1] 160w 160w 160w 160w 160w 180w 180w 180w 180w 180w 200w 200w 200
w 200w 200w
## [16] 220w 220w 220w 220w 220w
## Levels: 160w 180w 200w 220w
```

```
#
data.frame(Y, A)
```

```
##      Y    A
## 1  575 160w
## 2  542 160w
## 3  530 160w
## 4  539 160w
```

```
## 5  570 160w
## 6  565 180w
## 7  593 180w
## 8  590 180w
## 9  579 180w
## 10 610 180w
## 11 600 200w
## 12 651 200w
## 13 610 200w
## 14 637 200w
## 15 629 200w
## 16 725 220w
## 17 700 220w
## 18 715 220w
## 19 685 220w
## 20 710 220w
```

```
a1 <- aov(Y ~ A)
summary(a1)
```

```
##             Df Sum Sq Mean Sq F value        Pr(>F)
## A            3  66871   22290    66.8 0.00000000288 ***
## Residuals   16   5339     334
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
tab1 <- tidy(a1) #製成表格
model.tables(a1,type="effects") #各類別對Y的估計量
```

```
## Tables of effects
##
##  A
## A
##   160w   180w   200w   220w
## -66.55 -30.35   7.65  89.25
```

```
model.tables(a1,type="means") #各類別時的平均估計值
```

```
## Tables of means
## Grand mean
##
## 617.75
##
##  A
## A
##  160w  180w  200w  220w
## 551.2 587.4 625.4 707.0
```

```
### 隨機集區 & 二因子 ANOVA 分析 ### 無交互作用
```

接下來，我們將使 Montgomery 實驗設計書中的人造血管資料當作運算範例。人造血管是由聚四氟乙烯 (polytetrafluoroethylene) 合成樹脂經過擠壓而成的管狀物。在製造過程中，機器擠壓的壓力 (單位：PSI) 可能會造成人造血管上不同程度的污跡現象。另外，生產廠商也懷疑上游原料供應商所提供的不同貨批的樹脂原料也可能有影響。

擠壓壓力	集區 (樹脂貨批)					
	1	2	3	4	5	6
8500	90.3	89.2	98.2	93.9	87.4	97.9
8700	92.5	89.5	90.6	94.7	87.0	95.8
8900	85.5	89.5	85.6	87.4	78.9	90.7
9100	82.5	89.5	85.6	87.4	78.9	90.7

```
#way 1#
Blocks <- rep(paste("B",1:6,sep=""), each = 4)
Extrusion <- rep(c(8500,8700,8900,9100), times = 6)
way1 <- data.frame(Blocks, Extrusion); way1
```

```
##    Blocks Extrusion
## 1      B1      8500
## 2      B1      8700
## 3      B1      8900
## 4      B1      9100
## 5      B2      8500
## 6      B2      8700
## 7      B2      8900
## 8      B2      9100
## 9      B3      8500
## 10     B3      8700
## 11     B3      8900
## 12     B3      9100
## 13     B4      8500
## 14     B4      8700
## 15     B4      8900
## 16     B4      9100
## 17     B5      8500
## 18     B5      8700
## 19     B5      8900
## 20     B5      9100
## 21     B6      8500
## 22     B6      8700
## 23     B6      8900
## 24     B6      9100
```

```
#way 2#
way2 <- expand.grid(Blocks=paste("B",1:6,sep=""),
                    Extrusion=c(8500,8700,8900,9100))
way2
```

```
##    Blocks Extrusion
## 1      B1      8500
## 2      B2      8500
## 3      B3      8500
## 4      B4      8500
## 5      B5      8500
## 6      B6      8500
## 7      B1      8700
## 8      B2      8700
## 9      B3      8700
## 10     B4      8700
## 11     B5      8700
## 12     B6      8700
## 13     B1      8900
## 14     B2      8900
## 15     B3      8900
## 16     B4      8900
## 17     B5      8900
## 18     B6      8900
## 19     B1      9100
## 20     B2      9100
## 21     B3      9100
## 22     B4      9100
## 23     B5      9100
## 24     B6      9100
```

```
###
# 壓力
Y1 <- c(90.3,89.2,98.2,93.9,87.4,97.9)
Y2 <- c(92.5,89.5,90.6,94.7,87.0,95.8)
Y3 <- c(85.5,89.5,85.6,87.4,78.9,90.7)
Y4 <- c(82.5,89.5,85.6,87.4,78.9,90.7)
Y <- c(Y1,Y2,Y3,Y4); Y
```

```
##  [1] 90.3 89.2 98.2 93.9 87.4 97.9 92.5 89.5 90.6 94.7 87.0 95.8 85.
5 89.5 85.6
## [16] 87.4 78.9 90.7 82.5 89.5 85.6 87.4 78.9 90.7
```

```
way2$Extrusion <- as.factor(way2$Extrusion)
way2$Blocks <- as.factor(way2$Blocks)
way2$Y <- Y

# 基本資訊
tapply(way2$Y,list(way2$Extrusion),mean)
```

```
##     8500     8700     8900     9100
## 92.81667 91.68333 86.26667 85.76667
```

```
tapply(way2$Y,list(way2$Extrusion),sd)
```

```
##     8500     8700     8900     9100
## 4.577081 3.304189 4.163972 4.445072

tapply(way2$Y,list(way2$Blocks),mean)

##     B1     B2     B3     B4     B5     B6
## 87.700 89.425 90.000 90.850 83.050 93.775

tapply(way2$Y,list(way2$Blocks),sd)

##       B1       B2       B3       B4       B5       B6
## 4.534314 0.150000 5.953150 3.997082 4.794789 3.652739

#
a2 <- aov(Y ~ Extrusion + Blocks, data = way2)
summary(a2)

##             Df Sum Sq Mean Sq F value   Pr(>F)
## Extrusion    3 237.73   79.24  13.621 0.000148 ***
## Blocks       5 257.56   51.51   8.854 0.000445 ***
## Residuals   15  87.26    5.82
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

tab2 <- tidy(a2) #製成表格

#### 有交互作用 ####
```

下表的資料，是六種不同的殺蟲劑與六種不同農作物土壤，經過噴灑殺蟲劑數天之後，蚊蟲的幼蟲 (cranefly larvae) 從土壤中爬出地面的數目。每塊土地採樣兩次，每次取樣面積為 1 平方碼 (一碼約 1 公尺)。

作物種類	殺蟲劑種類					
	A1	A2	A3	A4	A5	A6
B1	33	30	8	12	6	17
	59	36	11	17	10	8
B2	36	23	15	6	4	3
	24	23	20	4	7	2
B3	19	42	10	12	4	6
	27	39	7	10	12	3
B4	71	39	17	5	5	1
	49	20	26	8	5	1
B5	22	42	14	12	2	2
	27	22	11	12	6	5
B6	84	23	22	16	17	6
	50	37	30	4	11	5

```
M <- read.table("twoway-2.txt")
M <- as.matrix(M)
```

```r
# way 1 #
N <- 6*12
Y <- numeric(N)
FactorA <- character(N)
FactorB <- character(N)

k <- 1
for (i in 1:12)
{
  i2 <- ceiling(i/2) #factor B 每兩列 (row) 為一類
  for (j in 1:6)
  {
    Y[k] <- M[i,j]
    FactorA[k] <- switch(j,"A1","A2","A3","A4","A5","A6")
    FactorB[k] <- switch(i2,"B1","B2","B3","B4","B5","B6")
    k <- k+1
  }
}

data <- data.frame(Y, FactorA, FactorB)
data
```

```
##     Y FactorA FactorB
## 1  33      A1      B1
## 2  30      A2      B1
## 3   8      A3      B1
## 4  12      A4      B1
## 5   6      A5      B1
## 6  17      A6      B1
## 7  59      A1      B1
## 8  36      A2      B1
## 9  11      A3      B1
## 10 17      A4      B1
## 11 10      A5      B1
## 12  8      A6      B1
## 13 36      A1      B2
## 14 23      A2      B2
## 15 15      A3      B2
## 16  6      A4      B2
## 17  4      A5      B2
## 18  3      A6      B2
## 19 24      A1      B2
## 20 23      A2      B2
## 21 20      A3      B2
## 22  4      A4      B2
## 23  7      A5      B2
## 24  2      A6      B2
## 25 19      A1      B3
## 26 42      A2      B3
```

```
## 27 10      A3      B3
## 28 12      A4      B3
## 29  4      A5      B3
## 30  6      A6      B3
## 31 27      A1      B3
## 32 39      A2      B3
## 33  7      A3      B3
## 34 10      A4      B3
## 35 12      A5      B3
## 36  3      A6      B3
## 37 71      A1      B4
## 38 39      A2      B4
## 39 17      A3      B4
## 40  5      A4      B4
## 41  5      A5      B4
## 42  1      A6      B4
## 43 49      A1      B4
## 44 20      A2      B4
## 45 26      A3      B4
## 46  8      A4      B4
## 47  5      A5      B4
## 48  1      A6      B4
## 49 22      A1      B5
## 50 42      A2      B5
## 51 14      A3      B5
## 52 12      A4      B5
## 53  2      A5      B5
## 54  2      A6      B5
## 55 27      A1      B5
## 56 22      A2      B5
## 57 11      A3      B5
## 58 12      A4      B5
## 59  6      A5      B5
## 60  5      A6      B5
## 61 84      A1      B6
## 62 23      A2      B6
## 63 22      A3      B6
## 64 16      A4      B6
## 65 17      A5      B6
## 66  6      A6      B6
## 67 50      A1      B6
## 68 37      A2      B6
## 69 30      A3      B6
## 70  4      A4      B6
## 71 11      A5      B6
## 72  5      A6      B6
```

```r
# way 2 #
y <- as.vector(t(M))
y1 <- c(M)
```

```r
#
FA <- rep(c("A1","A2","A3","A4","A5","A6"), times = 12)
FB <- rep(c("B1","B2","B3","B4","B5","B6"), each = 12)

D <- data.frame(y, FA, FB)

# 基本資訊
tapply(D$y,list(D$FA),mean)
```

```
##        A1        A2        A3        A4        A5        A6
## 41.750000 31.333333 15.916667  9.833333  7.416667  4.916667
```

```r
tapply(D$y,list(D$FA),sd)
```

```
##        A1        A2        A3        A4        A5        A6
## 20.946360  8.658504  7.292067  4.448357  4.273775  4.399552
```

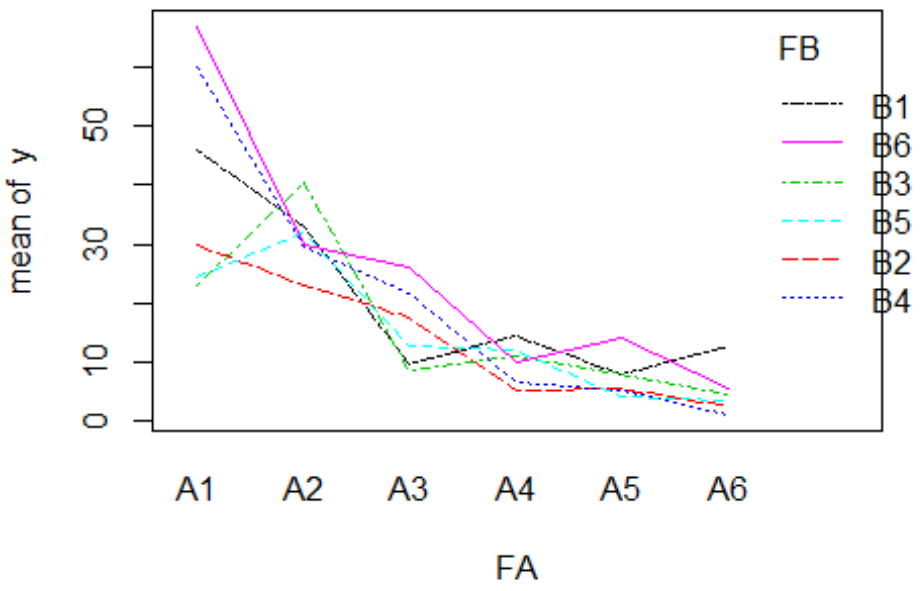
```r
tapply(D$y,list(D$FB),mean)
```

```
##       B1       B2       B3       B4       B5       B6
## 20.58333 13.91667 15.91667 20.58333 14.75000 25.41667
```

```r
tapply(D$y,list(D$FB),sd)
```

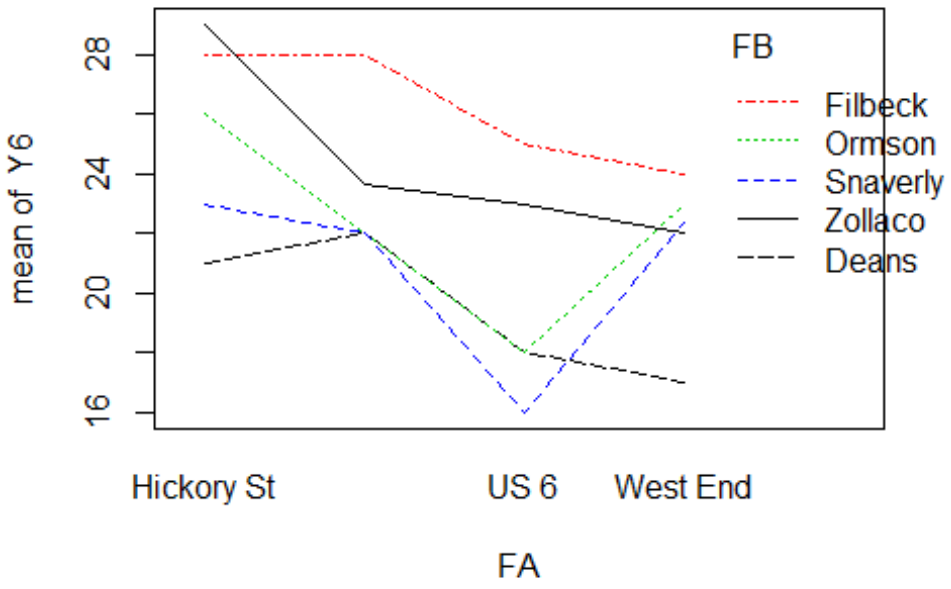
```
##       B1       B2       B3       B4       B5       B6
## 15.92287 11.12294 13.25593 22.12550 11.77150 23.01959
```

```r
# interaction.plot
interaction.plot(FA,FB,y,col=1:6)
```




```
#
aov.model <- aov(y ~ FA*FB, data = D)
summary(aov.model)

##             Df Sum Sq Mean Sq F value             Pr(>F)
## FA           5  13133  2626.5  45.285 0.0000000000000153 ***
## FB           5   1179   235.8   4.066            0.00499 **
## FA:FB       25   3600   144.0   2.483            0.00625 **
## Residuals   36   2088    58.0
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

tab3 <- tidy(aov.model)

### 課堂練習 ###
r1 <- c(18, 17, 21, 22)
r2 <- c(15, 14, 20, 19)
r3 <- c(21, 20, 22, 25)
r4 <- c(16, 23, 23, 22)
r5 <- c(19, 19, 24, 20)
r6 <- c(13, 25, 22, 24)
r7 <- c(21, 21, 26, 22)
r8 <- c(19, 23, 24, 24)
r9 <- c(14, 25, 28, 20)
r10 <- c(23, 22, 29, 25)
r11 <- c(21, 24, 30, 20)
r12 <- c(25, 20, 28, 26)
```

```
r13 <- c(25, 24, 28, 28)
r14 <- c(24, 25, 29, 30)
r15 <- c(26, 23, 27, 26)
Y6 <- c(r1, r2, r3, r4, r5, r6, r7, r8, r9, r10,
        r11, r12, r13, r14, r15)
#
FA <- rep(c("US 6","West End","Hickory St","Route 59"), times = 15)
FB <- rep(c("Deans","Snaverly","Ormson","Zollaco","Filbeck"), each = 1
2)

D2 <- data.frame(Y6, FA, FB)

# 基本資訊
tapply(D2$Y6,list(D2$FA),mean)

## Hickory St   Route 59       US 6   West End
##   25.40000   23.53333   20.00000   21.66667

tapply(D2$Y6,list(D2$FA),sd)

## Hickory St   Route 59       US 6   West End
##   3.290679   3.204164   4.191829   3.199702

tapply(D2$Y6,list(D2$FB),mean)

##    Deans  Filbeck   Ormson Snaverly  Zollaco
## 19.50000 26.25000 22.25000 20.83333 24.41667

tapply(D2$Y6,list(D2$FB),sd)

##    Deans  Filbeck   Ormson Snaverly  Zollaco
## 3.118858 2.179449 3.671141 3.588703 3.396745

# interaction.plot
interaction.plot(FA,FB,Y6,col=1:4)
```




```
#
aov.model <- aov(Y6 ~ FA*FB, data = D2)
summary(aov.model)

##             Df Sum Sq Mean Sq F value       Pr(>F)
## FA           3  245.0   81.66  15.908 0.0000005835 ***
## FB           4  353.6   88.39  17.219 0.0000000274 ***
## FA:FB       12  125.8   10.48   2.042       0.0456 *
## Residuals   40  205.3    5.13
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

tab3 <- tidy(aov.model)
```