Mid Semester Examination

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Question 1

1. The R and D manager of an automobile company wishes to study the effect of "tyre brand" on the tread loss (in millimetre) of tyres. Four tyres from each of four different brands (A,B,C and D) are fitted to four different cars using the CRD.

(a) Write the corresponding model.

(b) Check whether the tyre brand has effect on the tread loss.

(c) Perform post hoc analysis.

Aim

(a) Write the corresponding model.

(b) Check whether the tyre brand has effect on the tread loss.

(c) Perform post hoc analysis.

Procedure

1. Model

$$y = u + ai + e$$

u : overall mean

ai : effect of the i treatment level

e : error

2. Hypothesis testing

Test used: One Way Anova

Alpha = 0.05

H0: There is no significant effect of the tyre brand on the tread loss.

H1: There is a significant effect of the tyre brand on the tread loss.

```r
library(readxl)
```

```
## Warning: package 'readxl' was built under R version 3.6.1
```

```r
datafile = read_excel("C:/Users/lebon/Desktop/q1.xlsx")
attach(datafile)
View(datafile)

model = aov(Treatment~Brand,data=datafile)
summary(model)
```

```
##             Df Sum Sq Mean Sq F value Pr(>F)
## Brand        3   67.5  22.500   5.806 0.0109 *
## Residuals   12   46.5   3.875
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

3. Post-hoc test

```r
library(agricolae)
```

```
## Warning: package 'agricolae' was built under R version 3.6.1
```

```r
result = LSD.test(model,"Brand",p.adj="bonferroni",alpha=0.01)
result
```

```
## $statistics
##   MSerror Df Mean       CV  t.value      MSD
##     3.875 12    5 39.37004 4.030845 5.610698
##
## $parameters
##         test  p.ajusted name.t ntr alpha
##   Fisher-LSD bonferroni  Brand   4  0.01
##
## $means
##   Treatment      std r        LCL       UCL Min Max  Q25 Q50  Q75
## A      8.00 1.825742 4  4.9935664 11.006434   6  10 6.75 8.0 9.25
## B      3.50 1.732051 4  0.4935664  6.506434   2   6 2.75 3.0 3.75
## C      5.75 2.629956 4  2.7435664  8.756434   2   8 5.00 6.5 7.25
## D      2.75 1.500000 4 -0.2564336  5.756434   1   4 1.75 3.0 4.00
##
## $comparison
## NULL
##
## $groups
##   Treatment groups
## A      8.00      a
## C      5.75      a
## B      3.50      a
## D      2.75      a
```

```
##
## attr(,"class")
## [1] "group"
```

Conclusion

From the above performed analysis, it can be seen that the p-value (0.0109) is less than 0.05. Hence, the null hypothesis is rejected. So, it can be concluded that that there is a significant effect of the tyre brand on the tread loss.

On performing post-hoc test, it is observed that all the four brands differ significantly from each other. Either brand can be used for the experiment.

Question 2

Three different group of floor laying workers (factor) and three different types of floor laying (marble, granite and tiles) are considered. The quality indices of the floor on 1-10 scale for different combinations of factor and block are shown below.

Aim

(a) Write the model of the randomized complete block design.

(b) Check whether each component of the model has effect on the quality index at a

significance level of 5%.

Procedure

1. Model

$$y = u + ai + Bj + e$$

u : overall mean

ai : effect of the i treatment level

Bj : effect of the jth treatment level

e : error

2. Hypothesis testing

Test used: Two Way Anova without interaction

Alpha = 0.05

Factor 1: Type

H0: There is no significant effect of the type on the quality index.

H1: There is a significant effect of the type on the quality index.

Factor 2: Group

H0: There is no significant effect of the groups on the quality index.

H1: There is a significant effect of the groups on the quality index.

```
datafile2 = read_excel("C:/Users/lebon/Desktop/q2.xlsx")
attach(datafile2)
View(datafile2)

Treatments<-as.factor(datafile2$Treatments)
Groups<-as.factor(datafile2$Group)
Type <- as.factor(datafile2$Type)
str(datafile2)

## Classes 'tbl_df', 'tbl' and 'data.frame':    9 obs. of  3 variables:
##  $ Type      : chr  "Marble" "Granite" "Tile" "Marble" ...
##  $ Group     : chr  "G1" "G1" "G1" "G2" ...
##  $ Treatments: num  8 9 6 9 6 7 5 10 8

m1 <- aov(datafile2$Treatments ~ datafile2$Type + datafile2$Group)
summary(m1)

##                 Df Sum Sq Mean Sq F value Pr(>F)
## datafile2$Type   2  2.889   1.444   0.302  0.755
## datafile2$Group  2  0.222   0.111   0.023  0.977
## Residuals        4 19.111   4.778

lm1 <- lm(datafile2$Treatments~datafile2$Type+datafile2$Group)
library(lsmeans)

## Warning: package 'lsmeans' was built under R version 3.6.1

## Loading required package: emmeans

## Warning: package 'emmeans' was built under R version 3.6.1

## The 'lsmeans' package is now basically a front end for 'emmeans'.
## Users are encouraged to switch the rest of the way.
## See help('transition') for more information, including how to
## convert old 'lsmeans' objects and scripts to work with 'emmeans'.
```

Factor 1: Type

```
lsm1 <- lsmeans(lm1,"Type")
pairs(lsm1)

##  contrast         estimate   SE df t.ratio p.value
##  Granite - Marble    1.000 1.78  4 0.560   0.8472
##  Granite - Tile      1.333 1.78  4 0.747   0.7514
##  Marble - Tile       0.333 1.78  4 0.187   0.9810
##
```

```
## Results are averaged over the levels of: Group
## P value adjustment: tukey method for comparing a family of 3 estimates
```

```
library(multcompView)
```

```
## Warning: package 'multcompView' was built under R version 3.6.1
```

```
CLD(lsm1,Letters = "abc")
```

```
## Warning: 'CLD' will be deprecated. Its use is discouraged.
## See '? CLD' for an explanation. Use 'pwpp' or 'multcomp::cld' instead.
```

```
##  Type    lsmean   SE df lower.CL upper.CL .group
##  Tile      7.00 1.26  4     3.50     10.5  a
##  Marble    7.33 1.26  4     3.83     10.8  a
##  Granite   8.33 1.26  4     4.83     11.8  a
##
## Results are averaged over the levels of: Group
## Confidence level used: 0.95
## P value adjustment: tukey method for comparing a family of 3 estimates
## significance level used: alpha = 0.05
```

Factor 2: Group

```
lsm2 = lsmeans(lm1, "Group")
lsm2
```

```
##  Group lsmean   SE df lower.CL upper.CL
##  G1      7.67 1.26  4     4.16     11.2
##  G2      7.33 1.26  4     3.83     10.8
##  G3      7.67 1.26  4     4.16     11.2
##
## Results are averaged over the levels of: Type
## Confidence level used: 0.95
```

```
pairs(lsm2)
```

```
##  contrast estimate   SE df t.ratio p.value
##  G1 - G2     0.333 1.78  4  0.187  0.9810
##  G1 - G3     0.000 1.78  4  0.000  1.0000
##  G2 - G3    -0.333 1.78  4 -0.187  0.9810
##
## Results are averaged over the levels of: Type
## P value adjustment: tukey method for comparing a family of 3 estimates
```

```
CLD(lsm2,Letters = "abcdef")
```

```
## Warning: 'CLD' will be deprecated. Its use is discouraged.
## See '? CLD' for an explanation. Use 'pwpp' or 'multcomp::cld' instead.
```

```
##  Group lsmean   SE df lower.CL upper.CL .group
##  G2      7.33 1.26  4     3.83     10.8  a
##  G1      7.67 1.26  4     4.16     11.2  a
```

```
##  G3      7.67 1.26  4     4.16     11.2  a
##
## Results are averaged over the levels of: Type
## Confidence level used: 0.95
## P value adjustment: tukey method for comparing a family of 3 estimates
## significance level used: alpha = 0.05
```

Conclusion

Factor 1:

From the above performed analysis, it can be seen that the p-value is greater than 0.05. Hence, the null hypothesis is accepted. So, it can be concluded that that there is no significant effect of the type on the quality index.

By using *lsmeans* package, it is found that the Marble-Tile pair is significantly better than all the other pairs.

Factor 2:

From the above performed analysis, it can be seen that the p-value is greater than 0.05. Hence, the null hypothesis is accepted. So, it can be concluded that that there is no significant effect of the groups on the quality index.

By using *lsmeans* package, it is found that the G1-G3 pair is significantly better than all the other pairs.