ST437/537 – HW #05

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Due date: February 25, 2019

Instructions

Please follow the instructions below when you prepare and submit your assignment.

- **Include a cover-page** with your homework. It should contain

i. Full name,
ii. Course#: ST 437/537 and
iii. HW-#
iv. Submission date

- Assignments should be submitted in class on the date specified (“due date”).
- Neatly typed or hand-written solution on standard letter-size papers (stapled on the top-left corner) should be submitted. **All R code/output should be well commented, with relevant outputs highlighted.**
- **Always staple (upper left corner) your homework before coming to class. Ten percent points will be deducted otherwise.**
- When you solve a particular problem, do not only give the final answer. Instead **show all your work** and the steps you used (with proper explanation) to arrive at your answer to get full credit.
- **DO NOT** give printouts of whole dataset or matrices. Present only the relevant output when answering a question.

Problems

Solve the following problems. You may use `R` for these problems unless I specifically instruct otherwise.

DO NOT give printouts of whole dataset or matrices. Present only the relevant output/graphs when answering a question.

Problem 1: (10 points) A researcher measured three indices (concerning severity of hreat attacks), X_1, X_2 and X_3, for each of $n = 40$ heart attack patients, and produced summary statistics:

$$\bar{x} = \begin{bmatrix} 46.1 \\ 57.3 \\ 50.4 \end{bmatrix} \qquad \boldsymbol{S} = \begin{bmatrix} 101.3 & 63.0 & 71.0 \\ 63.0 & 80.2 & 55.6 \\ 71.0 & 55.6 & 97.4 \end{bmatrix}.$$

Test for the equality of mean indices at $\alpha = 0.05$. [Hint: write a proper contrast matrix, and write H_0 first].

Problem 2: (20 points) Consider the anesthasia data discussed in class.

a. Write another contrast matrix corresponding to $H_0 : \mu_1 = \ldots = \mu_4$ different from the ones presented in class, that is, **a different contrast than the two matrices below** (do not just multiply a constant and call it different contrast):

$$\boldsymbol{C}_1 = \begin{bmatrix} 1 & -1 & 0 & 0 \\ 1 & 0 & -1 & 0 \\ 1 & 0 & 0 & -1 \end{bmatrix} \qquad \boldsymbol{C}_2 = \begin{bmatrix} 1 & -1 & 0 & 0 \\ 0 & 1 & -1 & 0 \\ 0 & 0 & 1 & -1 \end{bmatrix}$$

b. For your contrast matrix in part (a), test H_0 and compare the results to those in lecture notes.

c. Separately, test for interaction effect, the main effect of halothane, and the main efffect of CO2, and interprete the results.

d. Suppose we want to test whether `CO2 effect (High - Low) when Halothane is present` is twice `CO2 effect (High - Low) when Halothane is absent`. Write the null hypothesis and the corresponding contrast matrix. Test this hypothesis and interprete the results.

Problem 3: (20 points) The dataset [here] (../data/T6-9.dat) gives measurements on the carapaces on 24 male and 24 female turtles.

```
dat <- read.table("../data/T6-9.dat", header = F)
colnames(dat) <- c("Length", "Width", "Height", "Gender")
head(dat)
```

```
##   Length Width Height Gender
## 1     98    81     38 female
## 2    103    84     38 female
## 3    103    86     42 female
## 4    105    86     42 female
## 5    109    88     44 female
## 6    123    92     50 female
```

```
tail(dat)
```

```
##    Length Width Height Gender
## 43    121    95     42   male
## 44    125    93     45   male
## 45    127    96     45   male
## 46    128    95     45   male
## 47    131    95     46   male
## 48    135   106     47   male
```

a. Test for equality of mean measurements between the two genders.

b. Create Bonferroni intervals for each component of the difference of the mean vector.

Problem 4: (20 points) Consider the `Pottery` data in the `car` library; see the help page for `Pottery` for details.

```
library(car)
```

```
## Loading required package: carData
```

```
head(Pottery)
```

```
##        Site   Al   Fe   Mg   Ca   Na
## 1 Llanedyrn 14.4 7.00 4.30 0.15 0.51
## 2 Llanedyrn 13.8 7.08 3.43 0.12 0.17
## 3 Llanedyrn 14.6 7.09 3.88 0.13 0.20
## 4 Llanedyrn 11.5 6.37 5.64 0.16 0.14
## 5 Llanedyrn 13.8 7.06 5.34 0.20 0.20
## 6 Llanedyrn 10.9 6.26 3.47 0.17 0.22
```

```
dat <- as.matrix(Pottery[,-1])
site <- Pottery[,1]
```

The first column defined the groups.

a. Estimate mean vector of each site (group), and the overall mean vector.
b. Perform a MANOVA to determine wheather the group means are equal or not. Give the sum of squares and cross product matrices (B and E) as defined in class.
c. If you reject the hypothesis of equality of means in part (a) [hint: you results in part (a) should reject H_0], investigate which components are different using pair-wise comparisons.
d. What assumptions on the population/sample are you making in this situation?

Problem 5: (20 points) The dataset [here] (../data/T6-17.dat) gives measurements on `Yield` (X_1), `Sound mature kernels` (X_2) and `Seed size` (X_3) on peanuts from different `Location` and `Variety` (two factors).

```
dat <- read.table("../data/T6-17.dat", header = F)
colnames(dat) <- c("Location", "Variety", "Yield", "SdMatKer", "Size")
dat
```

```
##    Location Variety Yield SdMatKer Size
## 1         1       5 195.3    153.1 51.4
## 2         1       5 194.3    167.7 53.7
## 3         2       5 189.7    139.5 55.5
## 4         2       5 180.4    121.1 44.4
## 5         1       6 203.0    156.8 49.8
## 6         1       6 195.9    166.0 45.8
## 7         2       6 202.7    166.1 60.4
## 8         2       6 197.6    161.8 54.1
## 9         1       8 193.5    164.5 57.8
## 10        1       8 187.0    165.1 58.6
## 11        2       8 201.5    166.8 65.0
## 12        2       8 200.0    173.8 67.2
```

a. Perform a MANOVA on this dataset. Test for a location-variety interaction effect, location effect and variety effect.

b. Using results in part (a), can we conclude that the effects of `Location` and `Variety` are additive?

c. Investigate whether location-variety interaction show up for some variables but not others by running three univariate ANOVA models. [Hint: don’t worry about multiple comparison here.]

d. Explain in words (in the context of the problem) what the location-variety interaction effect means.