Homework 1

Applied Mutlivariate Analysis

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1 Workspace

1.1 Packages

```
library(car)
library(knitr)
library(kableExtra)
library(plyr)
library(tidyverse)

## -- Attaching packages ---------------------------------------------------------------------------
tidyverse 1.2.1 --
##  ggplot2 2.2.1     purrr  0.2.4
##  tibble  1.4.2     dplyr  0.7.5
##  tidyr  0.8.0     stringr 1.3.0
##  readr  1.1.1     forcats 0.3.0
## -- Conflicts ------------------------------------------------------------------------------------
tidyverse_conflicts() --
## x dplyr::arrange()  masks plyr::arrange()
## x purrr::compact()  masks plyr::compact()
## x dplyr::count()    masks plyr::count()
## x dplyr::failwith()  masks plyr::failwith()
## x dplyr::filter()    masks stats::filter()
## x dplyr::id()        masks plyr::id()
## x dplyr::lag()      masks stats::lag()
## x dplyr::mutate()    masks plyr::mutate()
## x dplyr::recode()    masks car::recode()
## x dplyr::rename()    masks plyr::rename()
## x purrr::some()      masks car::some()
## x dplyr::summarise() masks plyr::summarise()
## x dplyr::summarize() masks plyr::summarize()
```

1.2 data

```
dat <- tribble(
  ~Group, ~V1, ~V2, ~V3, ~V4,
  1, 4, 9, 3, 8,
  2, 6, 7, 2, 1,
  3, 1, 6, 6, 2,
```

```
  4, 3, 8, 7, 4
)
X <- dat %>% select(-Group) %>% as.matrix
```

```
dat %>%
  kable(., "latex", escape = F) %>%
  column_spec(1, bold = T)
```

Group	V1	V2	V3	V4
1	4	9	3	8
2	6	7	2	1
3	1	6	6	2
4	3	8	7	4

The general matrix equation, LXM, describes how to create linear combinations of the groups (the L matrix) and variables (the M matrix) to test different hypotheses.

2 Part 1

In words, describe what each of the following L vectors is trying to accomplish:

```
L1 <- c(1, 1, 1, 1)
L2 <- c(1, 0, 0,-1)
L3 <- c(1, 0, 0, 0)
L4 <- c(1, 1,-2, 0)
L5 <- c(1, 1,-1,-1)
```

2.1 Question 1

[1 1 1 1] = L1
The grand mean across groups.

2.2 Question 2

[1 0 0 -1] = L2
The difference in means between the first and fourth groups.

2.3 Question 3

[1 0 0 0] = L3
The mean of the first group.

2.4 Question 4

[1 1 -2 0] = L4
The differnce in means between groups 1+2 and 3.

2.5 Question 5

5. [1 1 -1 -1] = L5
The difference in means between groups 1+2 and 3+4.

3 Part 2

Assume that you want to answer the following "variable" questions. Give the appropriate M vector or matrix.

3.1 Question 6

6. The linear combination given by L should be performed separately on each of the variables (= M1).

```
(M1 <- diag(1, 4, 4))
```

```
##      [,1] [,2] [,3] [,4]
## [1,]    1    0    0    0
## [2,]    0    1    0    0
## [3,]    0    0    1    0
## [4,]    0    0    0    1
```

3.2 Question 7

7. Variable 3 is the only variable of interest (= M2).

```
(M2 <- c(0,0,1,0))
```

```
## [1] 0 0 1 0
```

3.3 Question 8

8. The difference between Variables 1 and 4 is of interest (=M3).

```
(M3 <- c(1, 0, -1, 0))
```

```
## [1]  1  0 -1  0
```

3.4 Question 9

9. The sum of all variables is of interest (= M4).

```
(M4 <- rep(1,4))
```

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

3.5 Question 10

10.The difference between the first two variables and the difference between the second two variables is to be compared (= M5).

```
(M5 <- c(1, -1, -1, 1))
```

```
## [1]  1 -1 -1  1
```

4 Part 3

Carry out the following matrix multiplications, in R.

4.1 Question 11

$$L1XM2 = \begin{bmatrix} 1 \\ 1 \\ 1 \\ 1 \end{bmatrix} \begin{bmatrix} 4 & 9 & 3 & 8 \\ 6 & 7 & 2 & 1 \\ 1 & 6 & 6 & 2 \\ 3 & 8 & 7 & 4 \end{bmatrix} \begin{bmatrix} 0 & 0 & 10 \end{bmatrix}$$

```
L1 %*% X %*% M2
```

```
##      [,1]
## [1,]   18
```

4.2 Question 12

$$L2XM5 = \begin{bmatrix} 1 \\ 0 \\ 0 \\ -1 \end{bmatrix} \begin{bmatrix} 4 & 9 & 3 & 8 \\ 6 & 7 & 2 & 1 \\ 1 & 6 & 6 & 2 \\ 3 & 8 & 7 & 4 \end{bmatrix} \begin{bmatrix} 1 & -1 & -11 \end{bmatrix}$$

```
L2 %*% X %*% M5
```

```
##      [,1]
## [1,]    8
```

4.3 Question 13

$$L3XM3 = \begin{bmatrix} 1 \\ 0 \\ 0 \\ 0 \end{bmatrix} \begin{bmatrix} 4 & 9 & 3 & 8 \\ 6 & 7 & 2 & 1 \\ 1 & 6 & 6 & 2 \\ 3 & 8 & 7 & 4 \end{bmatrix} \begin{bmatrix} 1 & 0 & -10 \end{bmatrix}$$

```
L3 %*% X %*% M3
```

```
##      [,1]
## [1,]    1
```

4.4 Question 14

$$L4XM4 = \begin{bmatrix} 1 \\ 1 \\ -2 \\ 0 \end{bmatrix} \begin{bmatrix} 4 & 9 & 3 & 8 \\ 6 & 7 & 2 & 1 \\ 1 & 6 & 6 & 2 \\ 3 & 8 & 7 & 4 \end{bmatrix} \begin{bmatrix} 1 & 1 & 1 & 1 \end{bmatrix}$$

```
L4 %*% X %*% M4
```

```
##      [,1]
## [1,]   10
```

4.5 Question 15

$$L5XM1 = \begin{bmatrix} 1 \\ 1 \\ -1 \\ -1 \end{bmatrix} \begin{bmatrix} 4 & 9 & 3 & 8 \\ 6 & 7 & 2 & 1 \\ 1 & 6 & 6 & 2 \\ 3 & 8 & 7 & 4 \end{bmatrix} \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

```
L5 %*% X %*% M1

##      [,1] [,2] [,3] [,4]
## [1,]    6    2   -8    3
```