STAT 46700/ CS 59000 Topics in Data Science Spring 2025
Homework 2

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Instruction: Please submit your R code along with a brief write-up of the solutions (do not submit raw output). Some of the questions below can be answered with very little or no programming. However, write code that outputs the final answer and does not require any additional paper calculations. For example, suppose I ask for how many numbers are greater than 5 in the vector, x=c(1,9,2,8,10,12,15). Do not simply count the number of by hand, instead let the R count the numbers by using appropriate code.

Q.N. 1) Consider points **A** (1,1,7), **B** (2,9,5), **C** (9,6,3), **D**(3,5,7) in a three-dimensional space. Using R
a) Calculate the Euclidean distance matrix
b) Calculate the Manhattan distance matrix.

```
> #### Q1
>
> # a -- Eucledian
> A = c(1,1,7)
> B = c(2,9,5)
> C = c(9,6,3)
> D = c(3,5,7)
> Q1 <- rbind(A,B,C,D)
> Q1
  [,1] [,2] [,3]
A    1    1    7
B    2    9    5
C    9    6    3
D    3    5    7
>
>
> cat("Euclidean Distances between the points are given by:")
Euclidean Distances between the points are given by:
> eucl_distance = dist(Q1, method = "euclidean")
> # or
> # install.packages("philentropy")
> # library(philentropy)
> # eucl_distance = distance(Q1, method = 'euclidean')
> eucl_distance
          A         B         C
B  8.306624
C 10.246951  7.874008
D  4.472136  4.582576  7.280110
> #
> # Euclidean Distance between A and B is 8.306624 units
> # Euclidean Distance between A and C is 10.246951 units
> # Euclidean Distance between A and D is 4.472136 units
> # Euclidean Distance between B and C is 7.874008 units
> # Euclidean Distance between B and D is 4.582576 units
> # Euclidean Distance between C and D is 7.280110 units
>
>
> # b -- Manhattan
> cat("Manhattan Distances between the points are given by:")
Manhattan Distances between the points are given by:
> manhattan_distance = dist(Q1, method = "manhattan")
> # or
> # manhattan_distance = distance(Q1, method = "manhattan")
```

```
> manhattan_distance
   A  B  C
B 11
C 17 12
D  6  7 11
> #
> # Manhattan Distance between A and B is 11 units
> # Manhattan Distance between A and C is 17 units
> # Manhattan Distance between A and D is 6 units
> # Manhattan Distance between B and C is 12 units
> # Manhattan Distance between B and D is 7 units
> # Manhattan Distance between C and D is 11 units
```

Q. N. 2) The "mtcars" data set, readily available in R, provides information about 32 different car models, including details like miles per gallon (mpg), number of cylinders (cyl), displacement (disp), horsepower (hp), weight (wt), and other performance metrics. Select the variable *mpg* from the dataset and rescale the values using z-score and minmax (0,1) method.

```
> #### Q2
>
> # a
> data(mtcars)
> head(mtcars)
                   mpg cyl disp  hp drat    wt  qsec vs am gear carb
Mazda RX4         21.0   6  160 110 3.90 2.620 16.46  0  1    4    4
Mazda RX4 Wag     21.0   6  160 110 3.90 2.875 17.02  0  1    4    4
Datsun 710        22.8   4  108  93 3.85 2.320 18.61  1  1    4    1
Hornet 4 Drive    21.4   6  258 110 3.08 3.215 19.44  1  0    3    1
Hornet Sportabout 18.7   8  360 175 3.15 3.440 17.02  0  0    3    2
Valiant           18.1   6  225 105 2.76 3.460 20.22  1  0    3    1
> names(mtcars)
 [1] "mpg"  "cyl"  "disp" "hp"   "drat" "wt"   "qsec" "vs"   "am"   "gear" "carb"
> dim(mtcars)
[1] 32 11
> Q2 <- mtcars[,1]
> Q2
 [1] 21.0 21.0 22.8 21.4 18.7 18.1 14.3 24.4 22.8 19.2 17.8 16.4 17.3 15.2 10.4 10.4 14.7
[18] 32.4 30.4 33.9 21.5 15.5 15.2 13.3 19.2 27.3 26.0 30.4 15.8 19.7 15.0 21.4
> length(Q2)
[1] 32
>
> cat("Zscore Distances of the mpg's are given by:")
Zscore Distances of the mpg's are given by:
> zscore <- scale(Q2)
> zscore
             [,1]
 [1,]  0.15088482
 [2,]  0.15088482
 [3,]  0.44954345
 [4,]  0.21725341
 [5,] -0.23073453
 [6,] -0.33028740
 [7,] -0.96078893
 [8,]  0.71501778
 [9,]  0.44954345
[10,] -0.14777380
[11,] -0.38006384
[12,] -0.61235388
[13,] -0.46302456
[14,] -0.81145962
[15,] -1.60788262
[16,] -1.60788262
[17,] -0.89442035
[18,]  2.04238943
[19,]  1.71054652
[20,]  2.29127162
```

```
[21,]  0.23384555
[22,] -0.76168319
[23,] -0.81145962
[24,] -1.12671039
[25,] -0.14777380
[26,]  1.19619000
[27,]  0.98049211
[28,]  1.71054652
[29,] -0.71190675
[30,] -0.06481307
[31,] -0.84464392
[32,]  0.21725341
attr(,"scaled:center")
[1] 20.09062
attr(,"scaled:scale")
[1] 6.02694
>
>
> # b
> cat("Min-Max(0,1) Distances of the mpg's are given by:")
Min-Max(0,1) Distances of the mpg's are given by:
> install.packages("scales")
> library(scales)
> min_max_score <- rescale(Q2)
> # or
> # min_max_score <- scale(Q2, center = min(Q2), scale = max(Q2) - min(Q2))
> min_max_score
 [1] 0.4510638 0.4510638 0.5276596 0.4680851 0.3531915 0.3276596 0.1659574 0.5957447
 [9] 0.5276596 0.3744681 0.3148936 0.2553191 0.2936170 0.2042553 0.0000000 0.0000000
[17] 0.1829787 0.9361702 0.8510638 1.0000000 0.4723404 0.2170213 0.2042553 0.1234043
[25] 0.3744681 0.7191489 0.6638298 0.8510638 0.2297872 0.3957447 0.1957447 0.4680851
```

Q. N. 3) An article entitled "Investigating the Effect of Task Complexities on the Response Time of Human Operators to Perform Emergency Tasks of Nuclear Power Plants" by J. Park and S. Cho was published in *Annals of Nuclear Energy in 2010*. Times for NPP workers to complete 35 emergency tacks of varying complexity (measured by TACOM score) are recorded. Tasks were completed by US and non-US workers. The data are provided in the link below:

http://users.stat.ufl.edu/~winner/data/nuclear_time.dat

The variables included in the data are: Task, Nationality (1= US, 0= non-US), Time to complete the task and TACOM complexity score.

a) Import the data in R and print first 5 observations.
b) Display the completion time of the task based on nationality.
c) Is there a significance difference in the completion time between US and non-US workers?

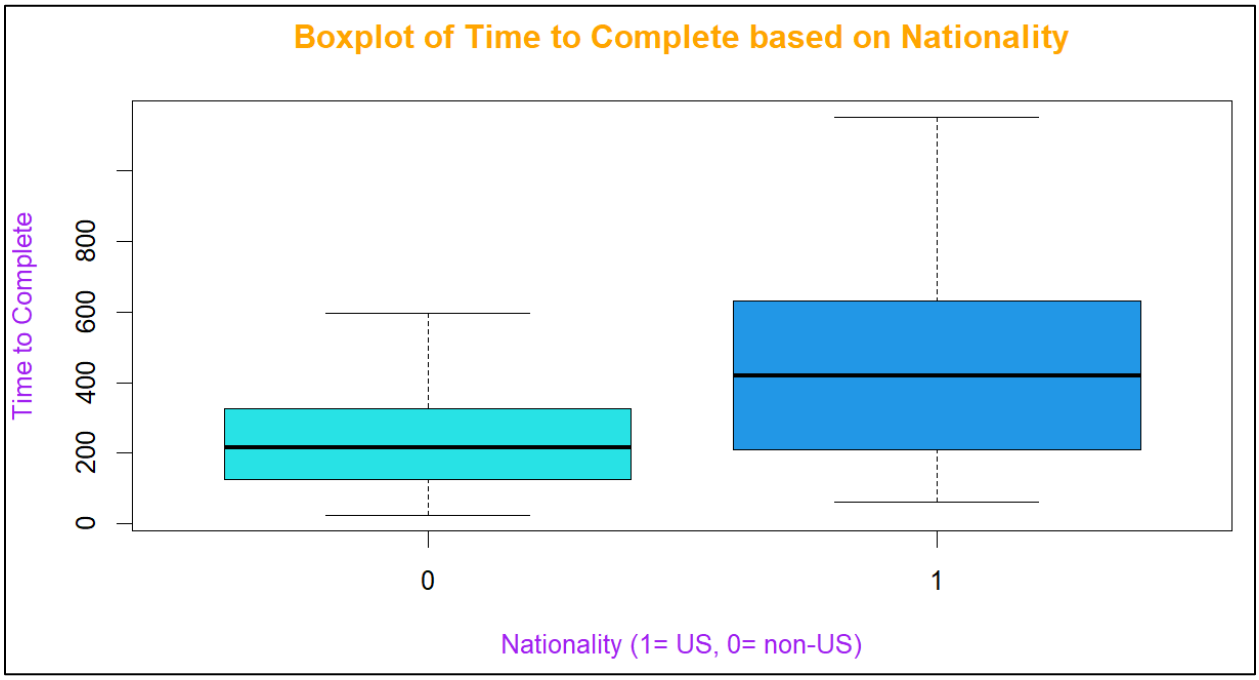
```
> #### Q3
>
> # a
> Q3 <- read.table("https://users.stat.ufl.edu/~winner/data/nuclear_time.dat")
> head(Q3,5)
  V1 V2  V3    V4
1  1  1  60 3.788
2  2  1 336 6.108
3  3  1 432 6.283
4  4  1 516 6.373
5  5  1 624 6.459
> names(Q3) = c("Task","Nationality","Time_to_Complete","TACOM_Complexity_Score")
> head(Q3,5)
```

```
  Task Nationality Time_to_Complete TACOM_Complexity_Score
1    1           1               60                  3.788
2    2           1              336                  6.108
3    3           1              432                  6.283
4    4           1              516                  6.373
5    5           1              624                  6.459
> attach(Q3)
>
>
> # b
> boxplot(Time_to_Complete~Nationality, main = "Boxplot of Time to Complete based on Nationality",
xlab = "Nationality (1= US, 0= non-US)", ylab = "Time to Complete", col = c(5,12), col.main = "oran
ge", col.lab = "purple")
>
>
> # c
> t.test(Time_to_Complete~Nationality)

        Welch Two Sample t-test

data:  Time_to_Complete by Nationality
t = -3.8266, df = 52.494, p-value = 0.0003475
alternative hypothesis: true difference in means between group 0 and group 1 is not equal to 0
95 percent confidence interval:
 -311.99847  -97.37296
sample estimates:
mean in group 0 mean in group 1
       235.2000        439.8857

> cat("Here, the pvalue = 0.0003475, which is less than 0.05. Thus, we reject the null hypothesis a
nd conclude that there is a significant difference in the time to complete the task between the US
and the non-US individuals.")
Here, the pvalue = 0.0003475, which is less than 0.05. Thus, we reject the null hypothesis and conc
lude that there is a significant difference in the time to complete the task between the US and the
non-US individuals.
```



Q. N. 4) The dataset provided in the link below contains the prices of ladies' diamond rings and the carat size of their diamond stones. The rings are made with gold of 20 carats purity and are each mounted with a single diamond stone. The article associated with this dataset appears in the Journal of Statistics Education, Volume 4, Number 3 (1996).

http://jse.amstat.org/datasets/diamond.dat.txt

a) Import the data in R
b) The first column represent the size of the diamond in carats and second column is the Price of the ring (in Singapore dollars). Insert the variable names: Size and Price for column 1 and column 2 respectively.
c) Display the Size and Price of the rings using scatterplot.
d) Fit a simple linear regression model using Price as a response variable. State the equation of the linear regression model.
e) Test for significance of the size to determine the price of the ring.
f) Predict the price of a ring of size 0.24 carat. Construct a 95% confidence interval and prediction interval for the predicted price.

```
> #### Q4
>
> # a
> Q4 <- read.table("https://jse.amstat.org/datasets/diamond.dat.txt")
> head(Q4)
    V1  V2
1 0.17 355
2 0.16 328
3 0.17 350
4 0.18 325
5 0.25 642
6 0.16 342
>
> # b
> colnames(Q4) = c("Size","Price")
> head(Q4)
  Size Price
1 0.17   355
2 0.16   328
3 0.17   350
4 0.18   325
5 0.25   642
6 0.16   342
> attach(Q4)
>
> # c
> plot(Size, Price, main = "Prize against Size", pch = 17, col = 2, cex = 1.5, xlab = "Size(in cara
ts)", ylab = "Prize(in Singapore Dollar)", col.lab = "orange", col.main = "maroon",ylim = c(100, 12
50))
>
> # d
> model = lm(Price~Size)
> model
Call:
lm(formula = Price ~ Size)

Coefficients:
(Intercept)         Size
     -259.6       3721.0

> abline(model, lwd = 2, col = "green")
> cat("Fitted Model:
+ Price = -259.6 + 3721*Size")
```

```
Fitted Model:
Price = -259.6 + 3721*Size
>
> # e
> summary(model)
Call:
lm(formula = Price ~ Size)

Residuals:
    Min      1Q  Median      3Q     Max
-85.159 -21.448  -0.869  18.972  79.370

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept)  -259.63      17.32  -14.99   <2e-16 ***
Size         3721.02      81.79   45.50   <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 31.84 on 46 degrees of freedom
Multiple R-squared:  0.9783,  Adjusted R-squared:  0.9778
F-statistic:  2070 on 1 and 46 DF,  p-value: < 2.2e-16

> cat("Here, the pvalue = 2.2e-16, which is less than 0.05. Thus we reject the null hypothesis, and
conclude that the size of the diamond (in carats) has a significant positive relationship with its
price.")
Here, the pvalue = 2.2e-16, which is less than 0.05. Thus we reject the null hypothesis, and conclu
de that the size of the diamond (in carats) has a significant positive relationship with its price.
>
> # f
> predict(model, data.frame(Size = 0.24))
       1
633.4201
> cat("For 0.24 carat, the predicted Price is 633.4201 Singaporean Dollar")
For 0.24 carat, the predicted Price is 633.4201 Singaporean Dollar
> predict(model, data.frame(Size = 0.24), interval = "confidence", level = 0.95)
       fit      lwr      upr
1 633.4201 622.4484 644.3917
> cat("95% Confidence Interval: for 0.24 carat, the predicted price lies in [622.4484, 644.3917]")
95% Confidence Interval: for 0.24 carat, the predicted price lies in [622.4484, 644.3917]
> predict(model, data.frame(Size = 0.24), interval = "prediction", level = 0.95)
       fit      lwr     upr
1 633.4201 568.3961 698.444
> cat("95% Prediction Interval: for 0.24 carat, the predicted price lies in [568.3961, 698.444]")
95% Prediction Interval: for 0.24 carat, the predicted price lies in [568.3961, 698.444]
```