Birkbeck

(University of London)

BSc EXAMINATION

Department of Computer Science and Information Systems

INTRODUCTION TO DATA ANALYTICS USING R (BUCI045H6)

CREDIT VALUE: 15 credits

Date of examination: THURSDAY 8 JUNE 2017
Duration of paper: 10.00 – 13.00

RUBRIC

1. This paper contains 8 questions for a total of 100 marks.
2. Students should attempt to answer **all** of them.
3. The use of non-programmable electronic calculators is permitted.
4. This paper is not prior-disclosed.
5. Time allowed: 3 hours.

1. . . . . (**15** marks)

(a) What are the four scales of measurement? Which scale of measurement does the military ranks data belong to? (**4** marks)

(b) What is overfitting? Why does a model have poor predictive performance if it has been overfit? (**6** marks)

(c) What does PCA stand for? How does one perform PCA? (**5** marks)

2. . . . . (**8** marks)

(a) Which R command can create the following matrix? There may be more than one way to create such a matrix. Write down one possible way. (**4** marks)

```
> A
     [,1] [,2] [,3] [,4]
[1,]    1    2    3    4
[2,]    5    6    7    8
[3,]    9   10   11   12
[4,]   13   14   15   16
```

(b) Based on the matrix A as above, use positive indices to derive the following matrix: (**2** marks)

```
     [,1] [,2] [,3] [,4]
[1,]    1    2    3    4
[2,]    9   10   11   12
```

(c) Based on the matrix A as above, use negative indices to derive the following matrix: (**2** marks)

```
     [,1] [,2] [,3]
[1,]    1    2    4
[2,]    9   10   12
```

3. . . . . (**11** marks)

A sample X consists of five observations: $\{2, 3, 6, 10, 4\}$. Another sample Y consists of five observations: $\{6, 4, 2, -3, 1\}$.

(a) What is the unbiased sample covariance coefficient between X and Y? (**3** marks)

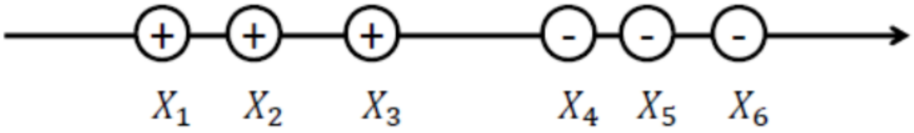
(b) The unbiased standard deviation of X is $\sqrt{10}$ and the unbiased standard deviation of Y is $\sqrt{11.5}$. What is the correlation coefficient of X and Y? (**2** marks)

(c) Comment on the correlation between X and Y. For instance, is it perfect positive correlation, or low negative correlation, or no correlation, etc? (**2** marks)

(d) Write down the commands in R that define X and Y, and calculate the unbiased sample covariance and correlation between X and Y. (**4** marks)

4. . . . . (**10** marks)

(a) Consider applying a support vector classifier (SVC) to the 1-dimensional data shown below. What will be the support vectors for the parameter cost $C = 0$ and $C = \infty$, respectively? (**4** marks)



(b) What impact will the following operation have on overfitting, increase, decrease or no impact? (**6** marks)

(i) Increase C for support vector machines

(ii) Increase the amount of training data for logistic regression

(iii) Remove non-support vector instances in the training set for SVM

5. . . . . (**15** marks)

(a) What is a good clustering? What is a cluster centroid? (**6** marks)

(b) How does random forest improve the results from decision trees? (**5** marks)

(c) What are the two properties of the least squares line in simple linear regression? (**4** marks)

6. . . . . (**11** marks)

The Swiss military carried out a study in order to analyze which soldiers are fit enough to join the special force team AAD10. In this regard, the dependent binary variable (y) reflects state of fitness of a soldier. $y = 1$ means that the soldier is fit enough for the special force team AAD10, whereas $y = 0$ indicates that the soldier is not fit enough. The following predictor variables were used for the analysis:

- x_1: The soldiers age (in years older than 18)
- x_2: The body mass index
- x_3: The average amount of sport/exercise per week (in hours)

(a) Look at the following R-Output. Write down the logistic regression model for this case. (**3** marks)

```
Coefficients:
               Estimate Std. Error z value  Pr(>|z|)
(Intercept)  -15.5543  7.2946     -2.132   0.0330
x1           -0.5859   0.3569       ???      ???
x2            0.5643   0.3317       ???      ???
x3            1.9639   0.8800       ???      ???
```

(b) Does the odds for fitness increase or decrease with soldier age? (**2** marks)

(c) Estimate the probability for $y = 1$ with $x_1 = 3$, $x_2 = 25$ and $x_3 = 2$. What would be your prediction for y in this case? (**3** marks)

(d) Suppose the dataset is called `SoldierFitness`. Write down the R command for this logistic regression model. (**3** marks)

7. . . . . (**10** marks)

Suppose we have 6 observations, for which we compute a dissimilarity (distance) matrix as follows:

	A	B	C	D	E	F
A	0					
B	0.24	0				
C	0.22	0.15	0			
D	0.37	0.20	0.15	0		
E	0.34	0.14	0.28	0.29	0	
F	0.23	0.25	0.11	0.22	0.39	0

On the basis of the matrix, sketch the dendrogram that results from hierarchically clustering these 6 observations using complete linkage.

8. . . . . (**20** marks)

One end A of an elastic string was attached to a horizontal bar and a mass m grams, was attached to the other end B. The mass was suspended freely and allowed to settle vertically below A. The length AB, $l$mm, was recorded, for various masses as follows:

m	100	200	300	400	500	600
l	228	236	256	278	285	301

Part of the output from fitting the simple linear regression for predicting the length `l` from mass `m` is shown below:

```
Coefficients:
             Estimate   Std. Error   t value   Pr(>|t|)
(Intercept)  210.60000    4.06706     51.78    8.32e-07 ***
m              0.15257    0.01044     14.61    0.000128 ***
---
Signif.  codes:  0 *** 0.001 ** 0.01 * 0.05 .  0.1   1

Residual standard error:  4.369 on 4 degrees of freedom
Multiple R-squared:  0.9816, Adjusted R-squared:  0.977
F-statistic:  213.4 on 1 and 4 DF, p-value:  0.0001277
```

(a) Write down the least squares line of regression of l on m. (**2** marks)

(b) What is the expected length AB for a mass of 290 grams? (**2** marks)

(c) Interpret the estimated slope of the fitted model. (**2** marks)

(d) Is there a significant linear relationship between length l and mass m? Provide a null hypothesis, a test statistic, p-value, and conclusion. (**4** marks)

(e) Suppose now you are given more observations and your dataset `ElasticString` has 200 observations in total. Write down your R code to (**10** marks)

i. build a linear regression model, and (**4** marks)

ii. estimate the testing mean squared error. (**6** marks)