Licenciatura em Engenharia Informática – DEI/ISEP

Análise de Dados em Informática 2023/2024

Theoretical-Practical Sheet 3

Nonparametric Hypothesis Tests

Objectives:

- Becoming familiar with the R tool in addressing nonparametric hypothesis tests;
- Analysis and results discussion.

Exercises

1. The result of a test on reaction under pressure shows that 45% of the adult population has a score higher than 50 points. A group of 25 army officers took the same test and 13 officers scored higher than 50 points.
Is it possible to deduce, with a significance level of 5%, that army officers react better when under pressure than the general population?

NOTE: Establish the test hypothesis and its statistic and compute the p-value.

2. The aim is to investigate whether the children show preference for a particular colour. Therefore, 19 children were randomly selected. In this group, each child had to choose between a red bucket and a blue bucket. Taking into consideration that 15 children chose the red bucket, can we deduce, with a significance level of $\alpha = 0.05$, that children prefer the red colour over the blue one?

3. The aim is to investigate whether the political party P will obtain a percentage higher than 30% in the upcoming elections. Therefore, a random sample of 2000 voters, representing the voting population, was taking into consideration. In the survey 700 voters expressed their intention to vote for the party P. Based on this survey can we conclude with $\alpha = 0.05$ that the party P will receive a percentage higher than 30%?

4. An IT company developed a new product (product A) and the marketing department intends to determine whether this product will be as successful as the favourite existing product (product B), use $\alpha = 5\%$. For this purpose, 150 participants were selected to experience both products. Each participant tried both products randomly and indicated their favourite one. The file **`Ex4.csv`** contains the result of this test.

participante	produto
1	B
2	B
3	A
4	A
5	A
6	B

5. A die with 6 numbered faces from 1 to 6 was rolled 60 times and the number of the face-up side was consecutively recorded. The file **`Ex5.csv`**. contains these results.

Can we declare, with a significance level of 5%, that the die is biased? Use the Chi-square goodness of fit test.

6. A computer engineer estimates that the running time of a particular algorithm exceeds 25 seconds. Therefore, eight computers were randomly selected and the algorithm running times were recorded in seconds:

25,36 24,64 25,17 24,56 24,56 24,80 25,21 25,38 24,55

Verify the validity of the engineer's estimation (use $\alpha = 0.05$).

7. A computer engineer installed a new device in 6 randomly selected computers and recorded the boot times, in seconds, before and after the device installation. The results are shown in the table below

	Computer					
	1	**2**	**3**	**4**	**5**	**6**
Boot time before the device(s) installation	14	9,0	12,5	13	9,5	12,1
Boot time after the device(s) installation	13,8	8,9	12,6	12,8	9,2	14,2

Considering a significance level of 5% verify whether the installation of the new device reduces the computer boot. If possible. use:

a) the Signal Test;
b) the Wilcoxon signed-rank Test;
c) a suitable parametric test.

8. The harvest (bushels per acre) of 5 different varieties (Var) of barley in 6 locations (Loc) in 1931 (Y1) and 1932 (Y2) was recorded. This data can be obtained in the file **`cevada.csv`** or by importing the data frame ***immer*** from the package **MASS**.

a) Test whether both harvests are identical (assume $\alpha = 0.05$).
b) Solve the previous clause assuming that the samples are small and not from a normal distribution.

9. In a usability test, two web pages were compared, ***webA*** and ***webB***. Twelve participants were divided into two groups and each group was asked to conduct a usability test to one of the web pages. In the global assessment, on a scale from 1 to 10, the following results were obtained:

webA	3	4	2	6	2	5
webB	9	7	5	10	6	8

With a significance level of 5%, use a suitable nonparametric test to analyse whether the web page ***webB*** is more suited to the users demands.

10. The file **`Processadores.txt`** contains a set of measurements (properly controlled) of the speed (GHz) of two processors with the same features but from different brands. Use an appropriate method to determine the differences between the speeds of the two processors (use a significance level of 5%).

11. A hospital administered three types of vaccines to 18 people and measured the presence of antibodies (μ/ml) in the bloodstream. The results can be found in the file ***`dados_vacinas.csv`***. Can we conclude, with a significance level of 5%, the existence of differences in the antibodies production of the three different vaccines?

12. A company that created a particular web page conducted a usability testing on a newly created page for a streaming service. Therefore, they selected a group of participants of various ages sorted in the following manner: from 15 to 30 years old, from 31 to 45 years old and from 46 to 60 years old. After resuming the tasks, they answered a survey that intended to analyse the level of difficulty in changing user profile data. The following table shows the collected results based on a Likert scale with 5 levels.

15 – 30 years	4	5	3	2	5	4	4	5	
31 – 45 years	3	4	3	3	5	3	4	4	
46 – 60 years	2	3	4	2	3	5	4	3	2

For a significance level of 5%, can we observe differences in the perceived usability of the mentioned functionality based on the age of the participants?

13. In a computer performance evaluation, twelve advanced level users were randomly selected to evaluate three computers with similar features but from different brands (A, B e C). The aim of the research is to ascertain whether the brand of the computer has influence in the user evaluation. In the table below, we can observe the rating of each computer, according to each user, on a scale from 1 to 10. This data can be found in the file **`desempenho.csv`**. With a significance level of 5%, verify whether the brand of the computer has influence in the user evaluation.

14. A group of 6 foodies rated 4 restaurants (A, B, C e D) on a scale from 1 to 100. These data can be found in the file **`aval_restaurantes.csv`**. With a significance level of 5%, find evidence that determines that there is no agreement among the evaluators regarding the restaurant?

Consolidation Exercises

1. The table below shows the (approximate) distribution of the number of daily accesses during a week to a new mobile app (expected frequencies). The app managers suspect that there is a difference in the number of accesses during the vacation weeks. Therefore, data from a particular vacation week was recorded (observed frequencies).

	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
Observed Frequencies	35 000	24 000	27 000	32 000	25 000	36 000	31 000
Expected Frequencies	35 000	24 500	27 300	31 700	24 900	36 000	31 100

With a significance level of 5%, test the hypothesis of an unusual distribution of the number of app accesses during vacation weeks.

2. The running times, in seconds, of a certain algorithm on 20 randomly selected computers, were recorded.

10,9	10,2	14,9	9,4	9,9
11,8	8,9	8,8	11,1	11,7
9,2	13,3	9,8	7,5	9
6,4	9,5	12,4	12	9,1

a) Create a QQ-plot for the sample and analyse the possibility of it having a normal distribution.
b) Use the Kolmogorov-Smirnov test to verify whether the data comes from a population with a distribution of $N(10;2^2)$? (Use α=0,05).
c) This time use the Shapiro-Wilk test to evaluate the normal distribution of the data. Compare with the previous clause and discuss it.
d) Test the hypothesis that the average running time is 10 seconds.

3. Fifteen laptops from a particular brand were randomly selected and the following measurements of their thicknesses (in mm) were obtained:

30 30 30 30 31 32 32 32 32 33 33
34 34 34 35

Test the hypothesis H_0: $\mu = 32,5$ against H_1:$\mu \neq 32,5$ (assuming $\alpha = 0,05$).

4. In a company, the quality control department wants to perform some tests on the weight of a particular laptop model, whose weight according to the manufacturing specifications is 2,5 kg.

Aiming to verify whether the effective weight of each laptop exceeds the one mentioned in its specifications, 16 laptops of the referred model were randomly selected. The weights, in grams, are shown in the table below:

2550	2550	2450	2560	2520	2530	2530	2500
2490	2510	2520	2520	2530	2510	2550	2550

With a significance level of 5%, is it possible to conclude that the weight of each laptop mentioned in the manufacturing specifications is actually the correct weight?

5. A rice packaging machine was recently calibrated so that the weight of a pack of rice would be normally distributed with a mean of 1kg and a standard deviation of 5,1 grams. A random sample of 10 packs of rice, packed by the machine, were collected and the following results were obtained:

1007	990	997	1010,1	1001,5	999	1002,5	1007,1	1010	1010,5

Considering the obtained sample, is it possible to state that the standards are being met? (Use α=0.05).

6. A vet believes that brand B dog dry food leads to weight gain when compared to brand A. Therefore, 8 dogs of different breeds were randomly selected and fed with brand A for 6 months and with brand B for the next 6 months. Their weights, in kgs, were recorded at the end of each stage, as the following table shows:

Dog	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Weight measured after 6 months of feeding with **brand A** dog food (kg)	31,2	26,5	24,1	10,2	25,3	12,1	30,3	39,2
Weight measured after 6 months of feeding with **brand B** dog food (kg)	35,8	21,3	15,8	11,1	28,5	10,3	31,6	25,4

What can we conclude about the vet suspicions? Consider a significance level α = 0,05. If possible, use:

a) the Signal Test;
b) the Wilcoxon Test;
c) a suitable parametric test.