Research Track 2

Assignment 1 statistics report

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Introduction

For the first assignment of the Research Track 2 course we were asked to perform a statistical analysis on the first assignment of the Research Track 1 course, considering two different implementations (our implementation and the teacher's implementation) and testing which one performs better in the given circuit, when silver tokens are randomly placed in the environment.
Let's consider my implementation as **Algorithm A** and the teacher's implementation as **Algorithm B**.

As performance evaluator I chose to consider the average time required to finish the circuit, so given μ_1 the mean of the samples of Algorithm A and μ_2 the mean of the samples of Algorithm B, my starting data were the following:

- null hypothesis H_0: both implementations take the same average time to finish the circuit, so $\mu_1 = \mu_2$;
- alternative hypothesis H_a: Algorithm A takes less time to finish the circuit with respect to Algorithm B, so $\mu_1 < \mu_2$;
- 5% level of significance, thus $\alpha = 0.05$.

To perform the statistical analysis I decided to use a one-tailed paired t-test, which needs the samples to be normally distributed. Given the Central Limit Theorem, which states that for $n > 3$ the shape of the sampling distribution will become more and more like a normal distribution, this test could be used.

Implementation

To test my hypothesis I ran both implementations 30 times, each time changing the position of each silver token.
This was the step that took more time, given that I decided to change manually each time the position of the tokens to grab, so that I could be sure that the number of silver tokens inside the circuit would not change for both implementations (I did not want the tokens to be placed on the other side of the golden tokens walls, so I had to be careful with the position of the silver tokens).

To get different data, for the first 10 laps around the circuit I changed the position of 7 silver tokens, for the following 10 laps I added one silver token, changing the position of the 8 silver tokens each time, and finally, for the last 10 laps, I added another silver token, thus changing the position of 9 silver tokens each time.
In the following tables the reader can find the data acquired to perform the statistical analysis.

	obs1	obs2	obs3	obs4	obs5	obs6	obs7	obs8	obs9	obs10
A	1.59	2.02	2	1.49	2.06	1.52	1.57	2.02	2.03	1.59
B	2.47	2.49	2.59	2.48	2.58	2.57	2.51	2.54	2.54	2.54

Table 1: Time (in minutes) to complete a lap around the circuit with 7 silver tokens for algorithm A and for algorithm B.

	obs11	obs12	obs13	obs14	obs15	obs16	obs17	obs18	obs19	obs20
A	2.1	2.1	2.14	2.09	2.08	2.09	2.1	2.12	2.06	2.09
B	2.58	2.57	2.59	2.51	3.01	3.02	2.52	3.03	2.24	3

Table 2: Time (in minutes) to complete a lap around the circuit with 8 silver tokens for algorithm A and for algorithm B.

	obs21	obs22	obs23	obs24	obs25	obs26	obs27	obs28	obs29	obs30
A	2.18	2.22	2.2	2.17	2.16	2.18	2.24	2.17	2.19	2.19
B	3.06	3.04	3.12	3.09	3.06	2.57	3.04	3.11	3.02	3.07

Table 3: Time (in minutes) to complete a lap around the circuit with 9 silver tokens for algorithm A and for algorithm B.

Results & Conclusions

To perform the statistical analysis I decided to implement a Python script using the *SciPy* library; in particular I used the *ttest_rel* function from the scipy.stats package.
This function returns two values, t-value and p-value, of a two-tailed t-test. Given that we want a one-tailed t-test, we must divide the p-value by 2.
The results are:

- **t-value** $= -16.51051232660805$
- **p-value** $= 0.0$

Interpreting the result, we have that $\frac{\textbf{p-value}}{2} < \alpha$, so we must reject the null hypothesis H_0; moreover, the **t-value** is negative, so we accept the alternative hypothesis H_a. We can conclude that Algorithm A is better than Algorithm B in terms of time to complete a lap around the circuit.