# University of Genoa
# Robotics Engineering

## RESEARCH TRACK 2

Report of assignment 3
(Statistical analysis)

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# ABSTRACT

We developed two programs for the Research Track 1 course's first assignment, and this paper aims to demonstrate how to do a statistical analysis based on their performance. The programs under examination were written by my colleague Peyman Peyvandipour and me. The golden tokens were constructed concentrically and set outside the silver tokens, and these algorithms are designed to tell the robot to match all of the silver tokens in the arena with those golden tokens. The experiment we must do will enable us to evaluate the performance by altering the amount of tokens and the radius at which the tokens are generated.

# Introduction

In a scenario where the location and quantity of tokens on a map fluctuate, this study compares the success rates of two algorithms, Algorithm A and Algorithm B. The number of silver-gold token pairs divided by the overall number of tokens in the environment is the success rate. We are looking into whether there are any appreciable differences in the success rates of the two algorithms.

# Hypotheses

For our research, we define the following null and alternative hypotheses:
**- Null Hypothesis (H0):** Success rates for Algorithms A and B are not significantly different from one another.
**- Alternative Hypothesis (Ha):** Algorithm A and Algorithm B have significantly different success rates.

# Experimental Design

We use a paired t-test to assess our hypothesis because both algorithms are used in the same situation. We can contrast the effectiveness of Algorithm A with Algorithm B under the identical circumstances by using a paired t-test. In numerous trials, we track each algorithm's success rate..

# Significance Level

The cutoff point for disproving the null hypothesis is set at a significance level of 5% ( = 0.05). This level of significance is adequate given the anticipated

range of success rates between 0% and 100%, and we do not expect major deviations.

# Data Analysis

We employ the central limit theorem for the paired t-test to guarantee that the sampling distribution closely resembles a t-distribution. When the sample size is bigger than 30, this presumption is true. We run a total of 72 tests with each algorithm to ensure that it satisfies this requirement.

The data are listed below:

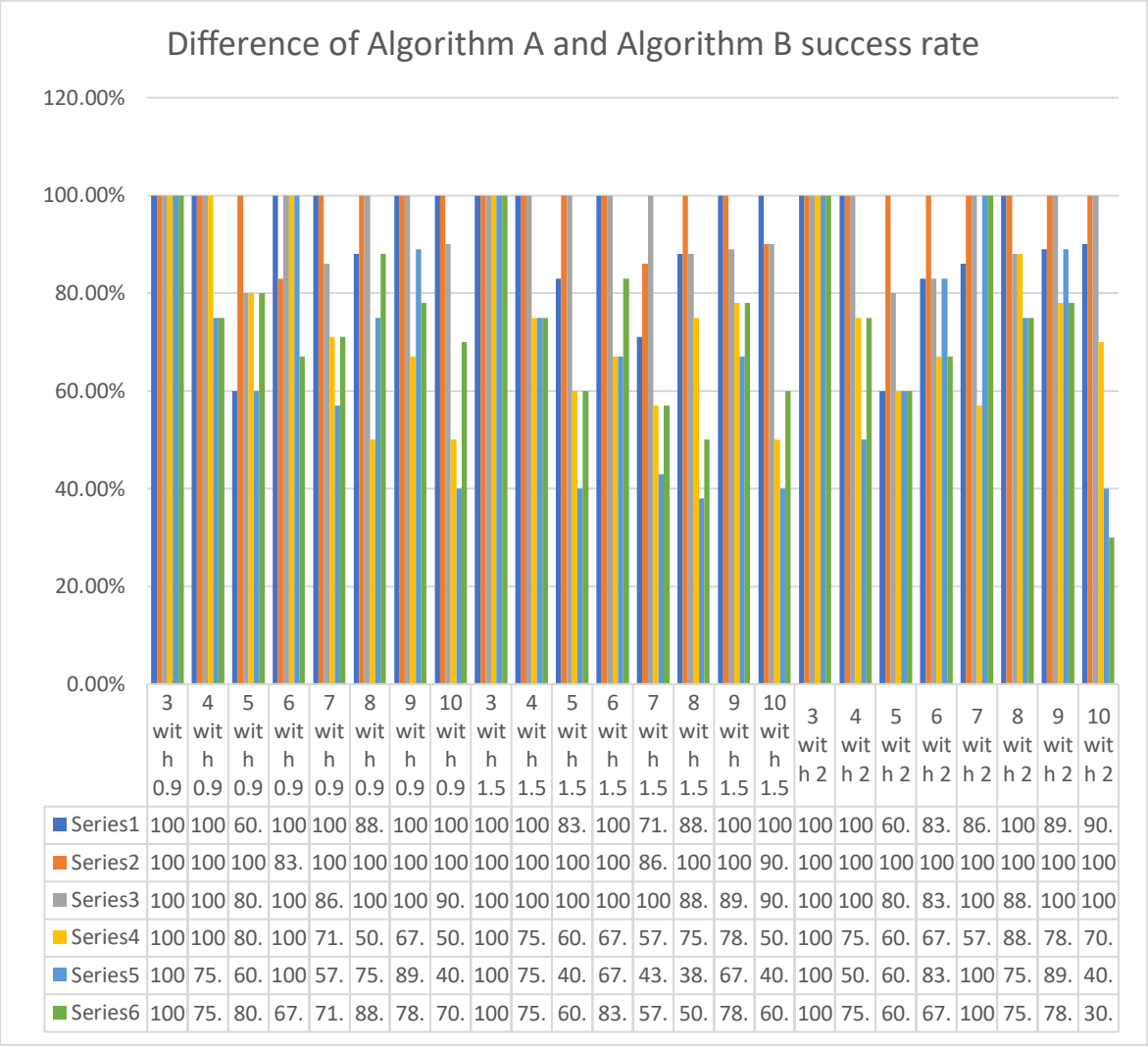
| Number of tokens with circle radius | Algorithm A sucsses in different attempt | | | Algorithm B sucsses in different attempt | | |
|---|---|---|---|---|---|---|
| **3 with 0.9** | 100.00% | 100.00% | 100.00% | 100.00% | 100.00% | 100.00% |
| **4 with 0.9** | 100.00% | 100.00% | 100.00% | 100.00% | 75.00% | 75.00% |
| **5 with 0.9** | 60.00% | 100.00% | 80.00% | 80.00% | 60.00% | 80.00% |
| **6 with 0.9** | 100.00% | 83.00% | 100.00% | 100.00% | 100.00% | 67.00% |
| **7 with 0.9** | 100.00% | 100.00% | 86.00% | 71.00% | 57.00% | 71.00% |
| **8 with 0.9** | 88.00% | 100.00% | 100.00% | 50.00% | 75.00% | 88.00% |
| **9 with 0.9** | 100.00% | 100.00% | 100.00% | 67.00% | 89.00% | 78.00% |
| **10 with 0.9** | 100.00% | 100.00% | 90.00% | 50.00% | 40.00% | 70.00% |
| **3 with 1.5** | 100.00% | 100.00% | 100.00% | 100.00% | 100.00% | 100.00% |
| **4 with 1.5** | 100.00% | 100.00% | 100.00% | 75.00% | 75.00% | 75.00% |
| **5 with 1.5** | 83.00% | 100.00% | 100.00% | 60.00% | 40.00% | 60.00% |
| **6 with 1.5** | 100.00% | 100.00% | 100.00% | 67.00% | 67.00% | 83.00% |
| **7 with 1.5** | 71.00% | 86.00% | 100.00% | 57.00% | 43.00% | 57.00% |
| **8 with 1.5** | 88.00% | 100.00% | 88.00% | 75.00% | 38.00% | 50.00% |
| **9 with 1.5** | 100.00% | 100.00% | 89.00% | 78.00% | 67.00% | 78.00% |
| **10 with 1.5** | 100.00% | 90.00% | 90.00% | 50.00% | 40.00% | 60.00% |
| **3 with 2** | 100.00% | 100.00% | 100.00% | 100.00% | 100.00% | 100.00% |
| **4 with 2** | 100.00% | 100.00% | 100.00% | 75.00% | 50.00% | 75.00% |
| **5 with 2** | 60.00% | 100.00% | 80.00% | 60.00% | 60.00% | 60.00% |
| **6 with 2** | 83.00% | 100.00% | 83.00% | 67.00% | 83.00% | 67.00% |
| **7 with 2** | 86.00% | 100.00% | 100.00% | 57.00% | 100.00% | 100.00% |
| **8 with 2** | 100.00% | 100.00% | 88.00% | 88.00% | 75.00% | 75.00% |
| **9 with 2** | 89.00% | 100.00% | 100.00% | 78.00% | 89.00% | 78.00% |
| **10 with 2** | 90.00% | 100.00% | 100.00% | 70.00% | 40.00% | 30.00% |

# Paired T-test

The following steps are taken to test the null hypothesis that the true mean difference is zero:

1. Determine the difference between the two observations for each pair using the formula di = yi xi, being careful to distinguish between positive and negative differences.

We are left with the information in the chart below after calculating the differences:




| | 3 with 0.9 | 4 with 0.9 | 5 with 0.9 | 6 with 0.9 | 7 with 0.9 | 8 with 0.9 | 9 with 0.9 | 10 with 0.9 | 3 with 1.5 | 4 with 1.5 | 5 with 1.5 | 6 with 1.5 | 7 with 1.5 | 8 with 1.5 | 9 with 1.5 | 10 with 1.5 | 3 with 2 | 4 with 2 | 5 with 2 | 6 with 2 | 7 with 2 | 8 with 2 | 9 with 2 | 10 with 2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Series1 | 100 | 100 | 60. | 100 | 100 | 88. | 100 | 100 | 100 | 100 | 83. | 100 | 71. | 88. | 100 | 100 | 100 | 100 | 60. | 83. | 86. | 100 | 89. | 90. |
| Series2 | 100 | 100 | 100 | 83. | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 86. | 100 | 100 | 90. | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| Series3 | 100 | 100 | 80. | 100 | 86. | 100 | 100 | 90. | 100 | 100 | 100 | 100 | 100 | 88. | 89. | 90. | 100 | 100 | 80. | 83. | 100 | 88. | 100 | 100 |
| Series4 | 100 | 100 | 80. | 100 | 71. | 50. | 67. | 50. | 100 | 75. | 60. | 67. | 57. | 75. | 78. | 50. | 100 | 75. | 60. | 67. | 57. | 88. | 78. | 70. |
| Series5 | 100 | 75. | 60. | 100 | 57. | 75. | 89. | 40. | 100 | 75. | 40. | 67. | 43. | 38. | 67. | 40. | 100 | 50. | 60. | 83. | 100 | 75. | 89. | 40. |
| Series6 | 100 | 75. | 80. | 67. | 71. | 88. | 78. | 70. | 100 | 75. | 60. | 83. | 57. | 50. | 78. | 60. | 100 | 75. | 60. | 67. | 100 | 75. | 78. | 30. |

2. Determine the mean difference

d = 22.44% = 0.2244

3. Determine the differences' standard deviation, or sd, and use that information to determine the mean difference's standard error.

Sd = 0.193746523
Se = 0.022833247

4. Use the t-statistic, which is given by T=d/Se to calculate it.

T = 9.82972099

This statistic exhibits a t-distribution with n-1 (72-1=71) degrees of freedom under the null hypothesis.

5. To compare your value for T to the t n-1 distribution, use tables of the t-distribution. This will reveal the paired t-test's p-value.

# Results

The paired t-test was used in statistical analysis to evaluate the collected data. The calculated t-value, which is 9.82972099, shows that there is a significant difference between the matched data. A two-sided test with a significance threshold of 0.05 (5%), and a critical t-value of 1.995, were employed to assess the relevance of this finding. The total number of paired observations in this investigation, which was 72, was used to calculate the degrees of freedom for this test.

Degree of freedom = 72-1 = 71

As a result, we find that there is a significant difference between Algorithm A and Algorithm B in terms of total success rates and reject the null hypothesis.