# Research Track II - StatisticalAnalysis

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# *Introduction:*

The task is to do a statistical analysis of first assignment of Research Track 1, making some parameter choices, and comparing my result to Professor's solution.

## *Tools*

MATLAB 2022a served as my primary platform for coding up the data collection, processing, and visualization procedures required to conduct a thorough statistical analysis.

## *Environment*

I opted not to randomly assign locations, but rather to employ four distinct arena layouts with varying quantities of silver tokens. I have created the following four venues in particular:

- 7 Tokens (Standard Arena)
- 8 Tokens
- 9 Tokens
- 10 Tokens

The location of the tokens stays unchanging which is to say, the arrangement of tokens does not change when a new token is added.

## *Computerized Information*

Both my own research and my professor's research will benefit from the information gathered here. Below is a breakdown of the most crucial details:

- **Time to cover one Lap:** The first assignment of Research Track 1 requires measuring how long it takes the robot to complete a lap using a control loop code, which varies depending on the conditions of the track.
- **Distance measured:** Robot-to-wall distance measurements (golden tokens).

Each control cycle iterated while taking into consideration the lap number the robot was currently on, allowing for accurate distance measurements from the Golden Token. I was able to determine how long it takes for the robot to run a full lap (specifically, the time was initialized when the robot grabbed the first silver token and stopped when the robot grabbed the last one of the specific configurations). The robot will complete 5 full circuits. For every possible arena layout, we recorded the elapsed time and distance covered.

# *Results:*

## *Preface*

The hypothesis is often seen as the primary tool in scientific inquiry. Its primary role is to propose more research and observations. A hypothesis, in its simplest form, is a statement with an unproven prediction attached to it. The purpose of many experiments (in robotics and other domains) is specifically to test hypotheses, which may be thought of as a kind of informed guesswork. Tests of hypotheses are often used to see whether there is sufficient evidence in a sample to warrant extrapolating to the whole population. Probability claims regarding a population parameter may be made using hypothesis testing (s). Even if the theory can't be proven 100 percent, it's still OK to use in practice as long as it's held up to critical scrutiny.

## *Fundamental Concept*

There is a need for a primer on the fundamentals of hypothesis testing.

### *Null hypothesis and Alternative hypothesis:*

Null and alternative hypotheses are common topics of discussion in the realm of statistics. The null hypothesis is the default assumption when comparing two approaches for superiority, and it states that method A and method B are equivalent. If, on the other hand, we believe that Approach A is more effective than Approach B, we are proposing an alternate hypothesis. H0 is often used to represent the null hypothesis, whereas Ha represents the alternative. If the data from our study doesn't back up the null hypothesis, then we must draw a different conclusion. We call the conclusion reached after rejecting the null hypothesis an alternative hypothesis. The alternative hypothesis, then, refers to the list of potential explanations that may exist if the null hypothesis is incorrect. By accepting H0, we are also rejecting Ha, and by rejecting H0, we are also accepting Ha.

## *Mean Distance*

After collecting all of the distance information, we calculated the means for each arena layout. I decided to make a bar graph contrasting the average distances from the walls for each arrangement.

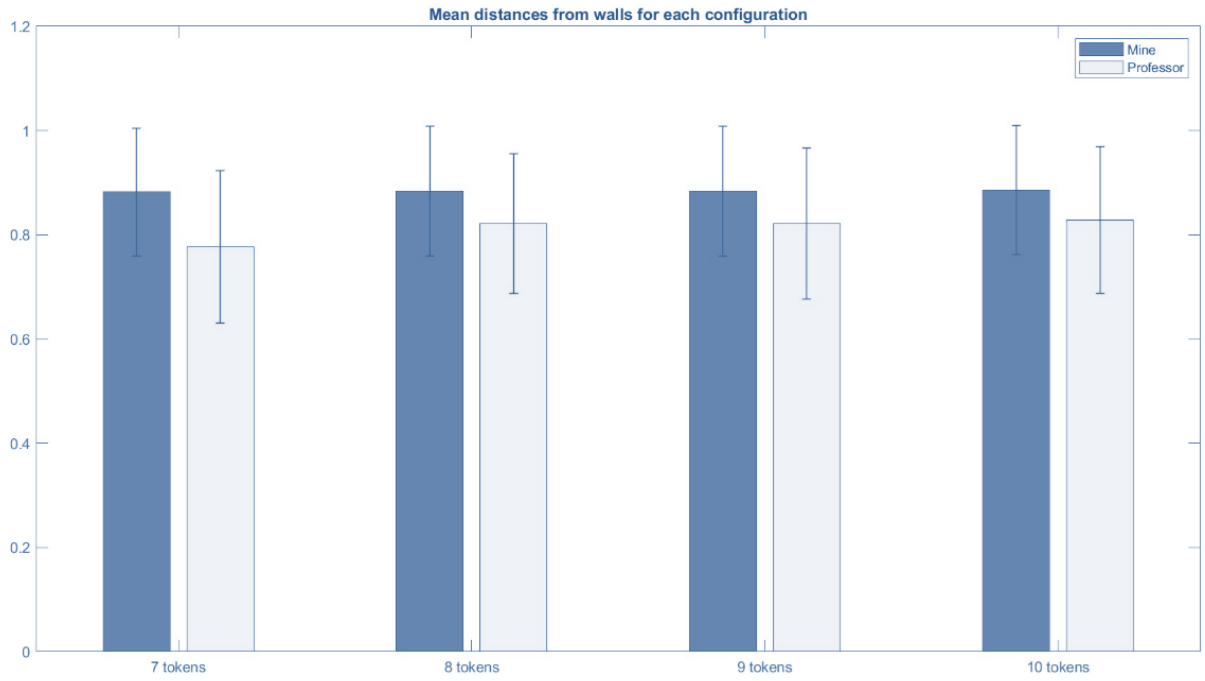


*Figure 1: Comparison between the robot's professor and my robot about mean distances*

It's obvious that compared to the Professor's robot, the gap between my robot and the walls is always rather great in any arrangement. In other words, in comparison to the Professor's robot, mine is quite a distance from the wall. This is likely attributable to the fact that I used a somewhat different strategy while designing the silver token, focusing on certain factors (threshold, etc.).

## *Mean Time*

After gathering all of the data, determine how long it takes, on average, to run all five laps of each arena layout. This time, a bar graph shows how my average compares to that of the Professor.

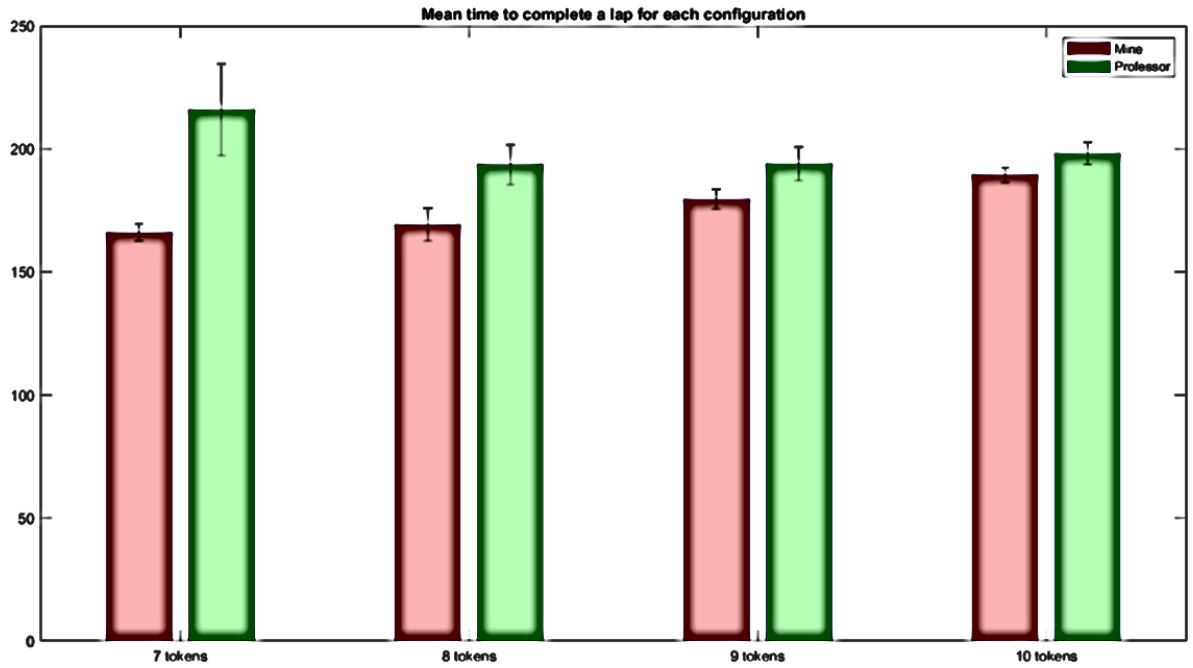


*Figure 2: comparison between the robot's professor and my robot about mean times*

This data helped me determine that, across the board, my robot configurations were marginally quicker than the Professor's. In addition, the Professor's robot takes about the same amount of time to complete a full lap (not including the scenario with 7 tokens), but my robot's elapsed time rises with the number of tokens.

**NB:** By increasing to 8 tokens, the average time drops significantly from the 7 tokens setup. This is most likely due to interferences that occurred during the 5 laps in the 7 tokens setup, which negatively affected the efficiency of the PC, etc.

## *Lap Time*

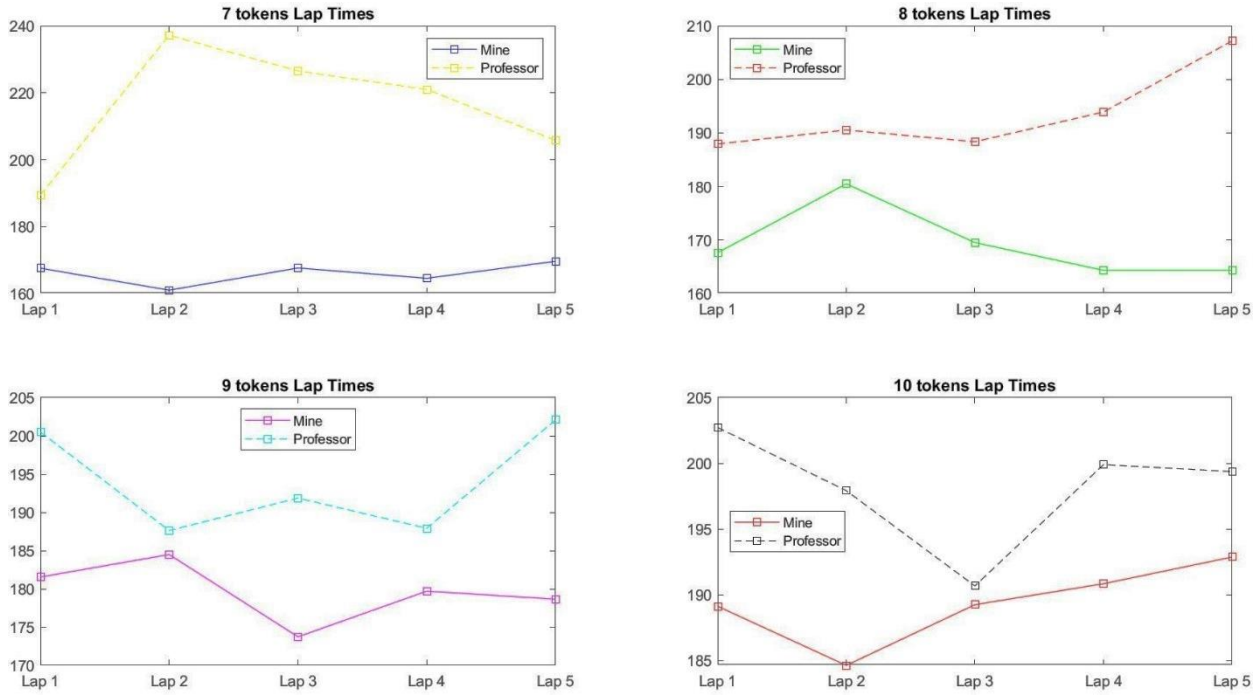


*Figure 3: lap time comparison considering the different configurations*

It's clear from the picture that my robot can outpace the professor's robot regardless of the number of tokens we throw at them. This, of course, is conditional on the specifics of the algorithm used to control the robot's position and motion in its surroundings. This is because the professor's and my approaches were both tested on the same hardware and software. As I said earlier, there is a sizable and continuous gap in lap timings between my robot and the professor's robot, with the exception of certain occasions in which the graphical lines seem to overlap, signifying a little discrepancy in the times for that lap under those conditions. Assuming the most common setup with 7 silver tokens, the main difference becomes more apparent.

## *T-Test*

A hypothesis test that may be used to compare the means of one or two populations is the t-test (or Student's t-test). A t-test is required to determine whether one group deviates from known values (1 sample t-test), if two groups are different from each other (2 independent sample t-tests), or, as in our instance, if there is a significant difference between the paired measurements (paired or dependent sample testing). Since we want to compare the same experiment with two distinct implementations, the paired sample test seems like the best option. Choose alpha as well. This is the

default; the significance level indicates how likely it is that the null hypothesis is false. If the significance threshold is set at 0.05, for instance, there is a 5% chance that a difference exists when none does.

The results may have suffered from a type I statistical error as a result. T-test results may be evaluated as follows: if H = 0, then the null hypothesis cannot be rejected at the given significance level, and if H = 1, then the null hypothesis is rejected at the given significance level. The t-test also produces a p-value, which indicates whether the discrepancy between the observed and the expected result can be attributed to the randomness provided by the sampling process or if it is statistically significant and hence impossible to explain by chance alone. Average times, average distances from walls, and average distances from walls in relation to individual laps were all tested using t-tests. For every possible arena layout, this was completed. Starting with four pieces, I compared the average distance from the golden token in each arena layout and for both implementations. This is the first t-test result:

| | Value |
|---|---|
| ***H*** | **1** |
| ***p*** | **0.00970** |

The second t-test was a comparison of two data sets with the average lap time for each arena layout, yielding a five-element data set. Because of this,

| | Value |
|---|---|
| ***H*** | **1** |
| ***p*** | **3.39e-05** |

Ultimately, I decided to do four t-tests based on the mean distances for each lap and each arena layout.

## *Outcome*

| | 7 tokens | 8 tokens | 9 tokens | 10 tokens |
|---|---|---|---|---|
| ***H*** | 1 | 1 | 1 | **1** |
| ***p*** | **3.93e-04** | **0.03591** | **0.00351** | **0.00788** |

## *Conclusions*

Finding specific discrepancies between my algorithm and the algorithm's professor that "guide" the robot within the environment is the primary goal of this statistical portion of the project. Knowing that results are non-deterministic, I have collected copious amounts of data while maintaining the same conditions throughout the collection process (a fully charged PC connected to an outlet) in an effort to minimize discrepancies brought about by the PCs prominences (even if there are). Ultimately, I discovered that the lap durations and lengths awarded by golden tokens vary considerably. In reality, my robot maintains a larger buffer zone between itself and the walls, which is crucial since many wall-crush accidents are preventable. And in the last lap, my robot is quicker than the professor's robot no matter how many silver tokens he gives me. The statistical tests I ran confirmed all of the early assumptions I made about the project.