RESEARCH TRACK 2

STATISTICAL ANALYSIS

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ABSTRACT

Statistical analysis is a fundamental part of a project aimed at improve the performance of a previous release.
In the course ”Research Track 2” of the University of Genoa, these aspects have been analyzed; for this reason, an assignment has been assigned to the student to test their knowledge about this topic.
In this report are reported all the steps that have been followed to compare the performances of a new robot with a given solution in a virtual environment.
The program that manage the robot is a python script.

Contents

1 Assignment

The assignment consists to perform a statistical analysis on the first assignment, considering two different implementations (the developed one, and a given solution) and testing which one performs better in the circuit given, when silver tokens are randomly placed in the environment.
As performance evaluators may possibly consider:

- the percentage of crashes / collisions with the walls / robot going in the wrong direction;
- the average time required to finish the circuit;
- the distance from the obstacles.

In this experiment the second one has been chosen.

2 Hypothesis Testing

2.1 Null Hypothesis

The Null Hypothesis H_0 occurs when the original assumption results not satisfied by the made tests. In this case it occurs if the new developed robot reports an average time to finish the circuit greater or equals than the given solution.

2.2 Alternative Hypothesis

The Alternative Hypothesis H_a occurs when the original assumption results satisfied by the made tests.
In this case it occurs if the new developed robot reports an average time to finish the circuit less than the given solution.

2.3 Level of Significance

The level of significance is the upper bound probability that a result occurs if the Null Hypothesis H_0 is true. If this happen, that result is rejected.
In this case it is set to 5%.

2.4 Distribution

Since the data are few, the whole set is considered; then, the normal distribution is adopted.

3 Data

3.1 New robot

In the Table 1 are reported the data collected about the new robot and the Figure 1 is shown the normal distribution of them.

Token density	Time (s)	Normal distribution
One token	75.84	0.0130167069
	77.91	0.0141626046
	78.10	0.0142655009
	78.45	0.0144537939
	79.62	0.0150698970
Half tokens	85.14	0.0175700307
	86.32	0.0179880316
	86.47	0.0180376411
	86.75	0.0181280442
	88.22	0.0185539131
Full tokens	97.18	0.0191495578
	98.50	0.0189342379
	98.94	0.0188458278
	99.20	0.0187897563
	99.78	0.0186545795
Double tokens	117.09	0.0104469512
	117.36	0.0102952538
	119.36	0.0091888671
	119.55	0.0090857076
	165.68	0.0000474524
Mean/Average	94.20	
Standard deviation	20.62	

Table 1: New robot data.

3.2 Given solution

In the Table 2 are reported the data collected about the given solution and the Figure 2 is shown the normal distribution of them.

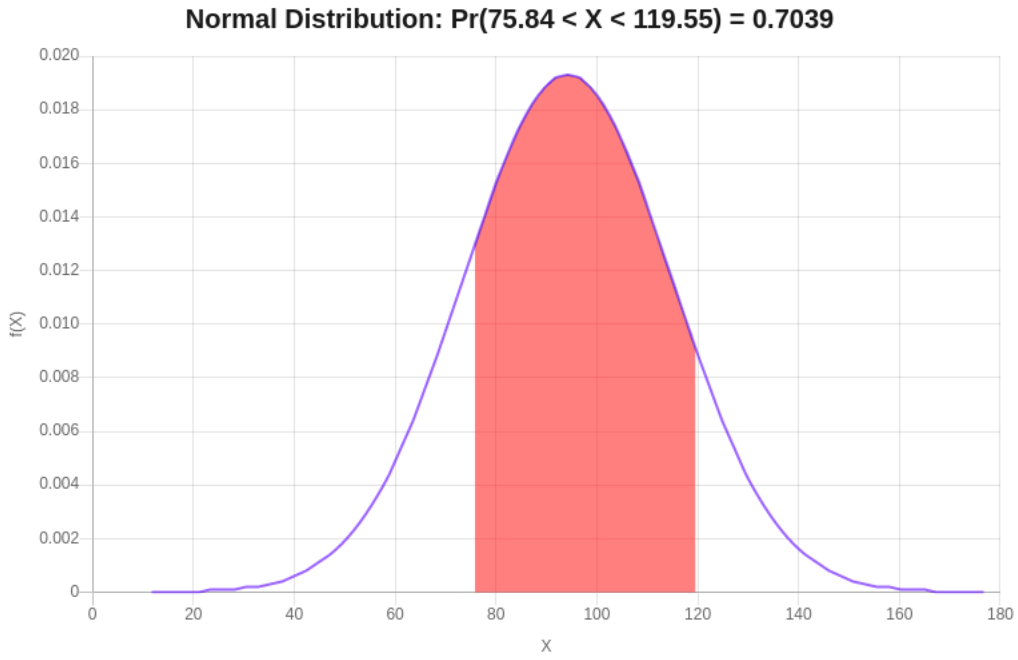

Figure 1: Normal distribution of the new robot data.

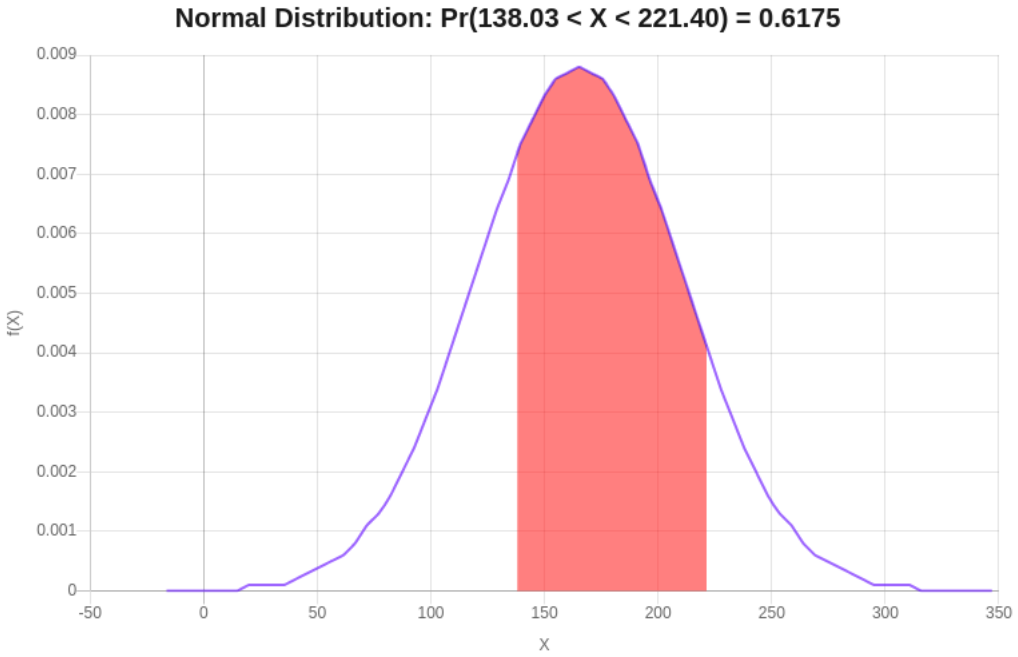

Figure 2: Normal distribution of the given solution data.

Token density	Time (s)	Normal distribution
One token	138.03	0.0073391585
	139.50	0.0073391585
	140.03	0.0075283107
	142.15	0.0077177745
	142.17	0.0077195043
Half tokens	144.90	0.0079448211
	149.92	0.0082977962
	150.83	0.0083525045
	152.03	0.0084200280
	154.81	0.0085555777
Full tokens	161.48	0.0087549286
	164.21	0.0087830329
	165.91	0.0087845231
	166.36	0.0087828569
	166.73	0.0087808412
Double tokens	212.22	0.0051474411
	213.17	0.0050361838
	214.20	0.0049158414
	221.40	0.0040919824
	339.72	0.0000054804
Mean/Average	165.27	
Standard deviation	45.41	

Table 2: Given solution data.

3.3 Table description

As can be seen the tables are structured in the following way:

- the first column reports the ”Token density”, thus if the map is with just one of the default token, or half, full, double of them;
- the second column reports the ”Time” in seconds of each lap;
- the third column reports the ”Normal distribution” of each value, computed thanks to the ”Mean/Average” and the ”Standard deviation” values reported respectively in the penultimate and last row.

The red value in the last row of each table is a value given by a robot error during the simulation, like the inversion of direction.
Given the fact that this experiment aimed to test just the average time to complete a race, with different map configurations, errors like this one, given by an inefficient control robot sensor, are not be taken into account for the computation of the ”Mean/Average” and ”Standard deviation” values.

3.4 Z-Test

To compare the results they were taken the mean and the standard deviation of the new robot and it has computed the probability

$$Pr(138.03 <= T <= 221.40) = 0.0168 \quad (1)$$

where T is the average time took by the robot to perform a lap.
This means that the probability that the new robot version perform a lap with an average time greater than 138.03 seconds is very low.
The same result is shown in the Figure 3.

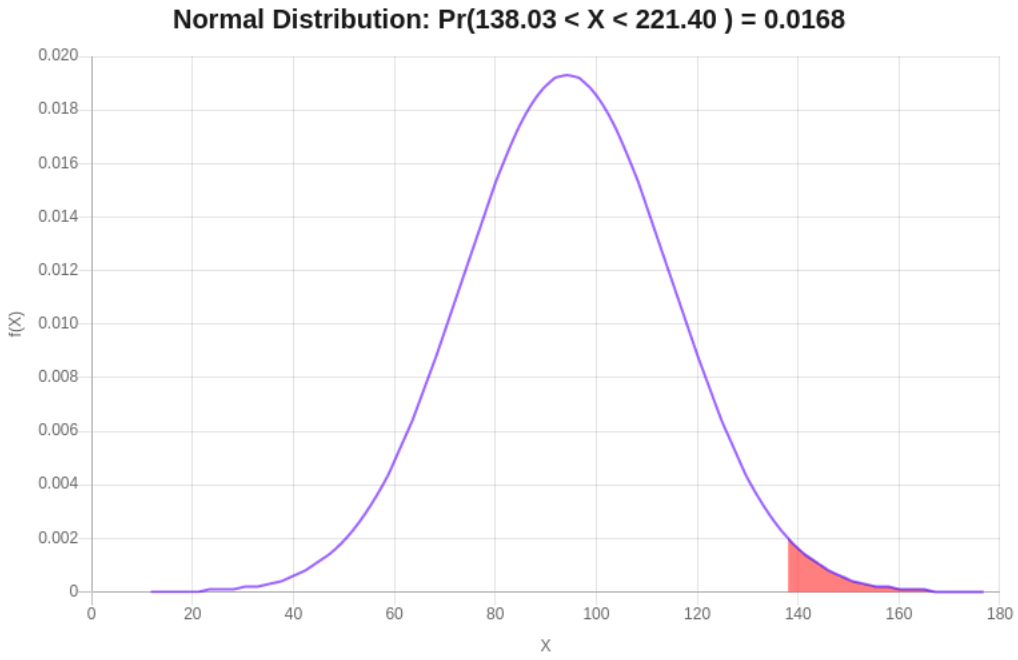

Figure 3: Z-Test.

4 Conclusion

By the Z-Test result and the data reported in the tables, it is possible to conclude that the new robot version has highlighted a better performance in terms of velocity to complete a lap of the map for all the configurations that have been used, with a difference of ”Mean/Average” value of 71.07 seconds.

References

[1] Prof. Carmine Tommaso Recchiuto (2022) *Fundaments of Statistics*.