TECHNIUM

Romanian Journal of Applied Sciences and Technology

ISSN: 2668-778X

vol. 16 / 2023

The 7th International Conference on Science Technology

organized by
Faculty of Social Science and
Law Universitas Negeri Manado and
Consortium of International Conference
on Science and Technology

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Technium: Romanian Journal of Applied Sciences and Technology
Vol. 16, 280-285, October, 2023
ISSN: 2668-778X
www.techniumscience.com

Implementation of A*(Star) Algorithm in Robots Object Movement

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Abstract. Today the development of robots has increased a lot. Over time the robot can used as a medium of learning and education. The maze mapping system can be used as educational media in robotics. In this study, the idea was obtained to design a robot moving objects that can move on a flat striped plane like a line tracer robot. Robot it adopts a maze mapping system to find the fastest path in moving objects. These objects are in the form of mini objects that have been given a color consisting of red, yellow, green, and blue. The four colors are used as a reference for the robot to detect objects based on the color that will be moved from the object detection start point to the available finish point. The method to be used on the robot is A*. The A* algorithm can find the fastest route on the path traversed by the robot, by adding up the actual distance with the estimated distance, thus making it optimal in the search for the route. The microcontroller used on This robot is an Arduino Due which functions to enter data from the results of sensor readings is on the robots. The sensors consist of an infrared module that functions as a detector line and a TCS34725 color sensor to detect the object to be moved. This wheeled robot uses a DC motor with a voltage of 12V to drive the two wheels. Then 10 times experiment to determine the fastest path with 1 type of color, obtained success with 70%. The results of this study can be used as a comparison material for the A* method with the A* method, another fastest path search.

Keywords. maze, mapping, A* method, sensor, microcontroller.

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Vol. 16, 280-285, October, 2023
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1 Introduction

Mobile robots are one-of-a-kind robots that have experienced a lot of development in terms of technology, usability, and even mechanical design. Mobile robots are a construction of a robot whose trademark has an actuator in the form of a wheel to move the whole robot body, so the robot can change positions from one point to another [1]–[5]. The development of mobile robots can also be applied to find the fastest path or maze, there are two types of mazes in the field of robotics, namely wall maze and line maze. A wall maze is a labyrinth that is built from roofless walls. Meanwhile, a line maze is a labyrinth built from lines [6]–[10]. There are various kinds of algorithms that can be integrated with robot maze, one of which is the A* algorithm. Use of the A* algorithm is often implemented in the robot wall maze, while the line maze robot is sufficiently rarely used. This is the basis of conducted research on implementing the A* algorithm on the robot line maze.

So, an idea or idea is obtained to design a path-finding robot the fastest moving in the field of line maze. In the research to be carried out later, the robot is a mobile robot object mover integrated with the A* method as a pathfinding algorithm fastest. The working system of this robot is capable of moving like a line-follower robot. The robot's path is a black line which is detected using an infrared module. infrared module can be interpreted as a sense of sight for the robot. This sensor functions to find out the black line on the track so that the robot can know when it turns right, left, forward, or stops. In addition, the robot will adopt a maze mapping system to find the fastest way to move objects, and the robot will work autonomously. The robot moves from the initial start to perform left and right trace mapping while detecting object color and finish color using the TCS34725 color sensor. If the color has been stored, the robot moves through the line trajectory to the object detection point and moves to the finish of placing the object that matches the color. Then the robot can also move wherever the robot is placed. Therefore, so that this robot can move stably in the process of finding the fastest path, the A* method can be used.as an algorithm on the robot.

The A* algorithm can be used to find the fastest path for the robot. The A* algorithm can find the fastest route on the path traversed by the robot, namely by adding the actual distance to the distance estimates to make it optimal in finding the fastest route on the robot. The A* or A-star algorithm is a search algorithm that analyzes input, evaluates several possible paths, and produces a solution. In addition, the A* algorithm is a computer algorithm that is widely used in graph traversal and path discovery, and path planning processes that can be passed efficiently around points called nodes [11]–[17]. The A* algorithm uses the path with the lowest cost to the node, making it the best first search algorithm.

2 Methods

A* (Star) Algorithm

The A-star algorithm (A*) is one of the algorithms that is included in the category of search methods that have information (informed search method). This algorithm is very good as a solution to the path-finding process. This algorithm looks for the fastest route distance that will be taken by a starting point to the destination object [21]–[24].

The A* algorithm requires two model queues: open and closed. Modifying the heuristic function of the A* algorithm can make predictions on each node created. this step is done to simplify the algorithm to determine the expected next steps. This method can be denoted by the function f(n), as an approximation to the function f(n), where function f(n) is the true evaluation function to nodes (n). The formulation of the A* formula for The mathematical function can be written as equation 1.

$$F(n) = G(n) + H(n) \quad (1)$$

Information:
$F(n)$: node value
$G(n)$: distance between nodes (n)
$H(n)$: estimated time required to objective.
Meanwhile, to obtain the fastest path on the robot is determined based on the rotation of the wheel embedded in the encoder. The value of this encoder is then added up so that the smallest value is obtained from the sum. If the encoder rotation is not known, the reading of the node value can be obtained from equation 2.

$$node = \frac{heuristic\ value}{speed} \quad (2)$$

The following is an example of the application of the A* method shown in Figure 1 based on the mathematical formula.

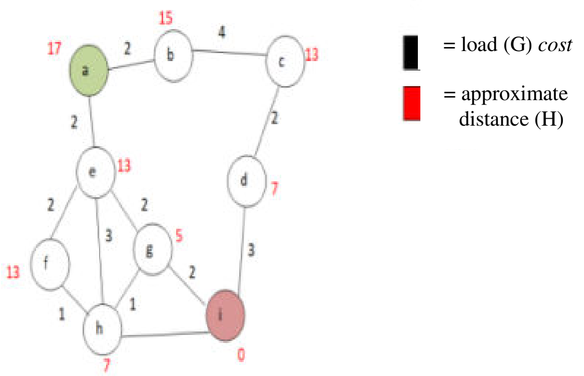

Fig. 1. *Example Case A**

In the case example A* shown in Figure 1, a simple calculation from A* with the aim of going from point a to i, has an estimated heuristic distance of 17. To reach the value of i by determining the fastest path, a comparison is obtained, including:

1. Obtained path comparison between (a) through (b) and (a) through (e), then calculate:

a. (a) passing (b) with a cost value is:
costs = 2 + 15 = 17

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b. (a) passing through (e) at a cost value is:
costs = 2 + 13 = 15

Then the results are obtained, path (a) passes (e) is the shortest path than path (a) passes (b).

2. After finding the fastest path (a)-(e), then determine the fastest path from (e) to the finish (i). 3 comparison paths are obtained, namely:

a. (e) passing (g) with a cost value is:
cost = 2 + 2 + 5 = 9

b. (e) passing through (f) with a cost value is:
costs = 2 + 2 + 13 = 17

c. (e) passing (h) with a cost value is:
costs = 2 + 3 + 7 = 12

So that the results with the least amount of cost are obtained, namely (e) passing (g). So the total fastest route with the lowest cost is (a) passing (e) passing (g) and reaching the finish (i).

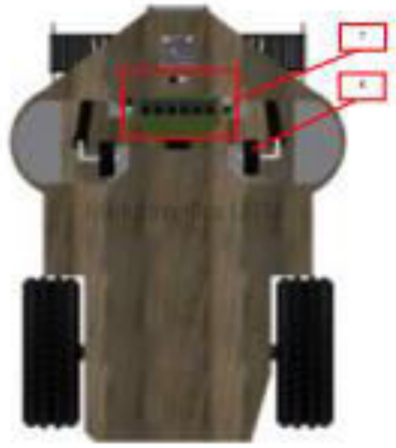

Fig 4. Object Moving Robot Design View Below

Making Robot Design

The following is a design plan for the robot's dimensions shown in Figure 2. The robot has a chassis length of 35 cm and a width of 20 cm, which the overall design of the robot is shown in Figure 3 and Figure 4.

Fig. 2. Dimensions of The Robot Frame

Fig. 3. Top View of Object Moving Robot Design

The following is a description of Figure 3 of the top view of the robot design and Figure 4 of the bottom view of the robot design of the object moving robot:

1. There are 2 TCS34725 sensors consisting of the front to detect the color of the object and the bottom to detect the color of the finish point.
2. Servo, the amount used is 2 pieces, which are placed on the right and left and function as the clamp's actuator.
3. Object clamps, where the placement of the clamps is right and left.
4. The MPU 6050 sensor is a combination of gyro and accelerometer, where this sensor functions to stabilize the angle when the robot makes turns and to determine the initial coordinates of the robot at the start position.
5. The robot body has a length span of 35 cm and a width of 20 cm.
6. Motor wheels, namely using 2 motor wheels as a robot motion system.
7. The part marked with a red box is an infrared sensor, in which 9 sensors function to detect the trajectory of a black line.
8. The last part is the front wheel which is on the right and left side of the robot, which functions to help.

Object Moving Robot Block Diagram

In the block diagram of the object moving robot, two types of sensors are used in the object moving robot: the color sensor TCS34725 and infrared sensors. The TC34725 color sensor detects objects' color, where the color consists of four colors, including red, yellow, green, and blue. After the color is detected, the servo will clamp the existing object. Then the infrared sensor will detect the existing lines, and the results of reading these lines are processed by Arduino to move the actuator in the form of a DC motor. The following is a block diagram of the object-moving robot shown in Figure 5.

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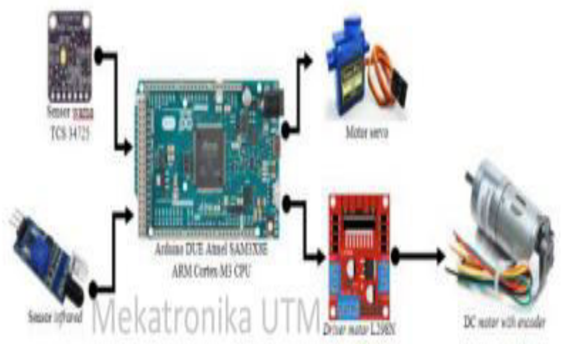

Fig. 5. Object Moving Robot Block Diagram

System Flowcharts

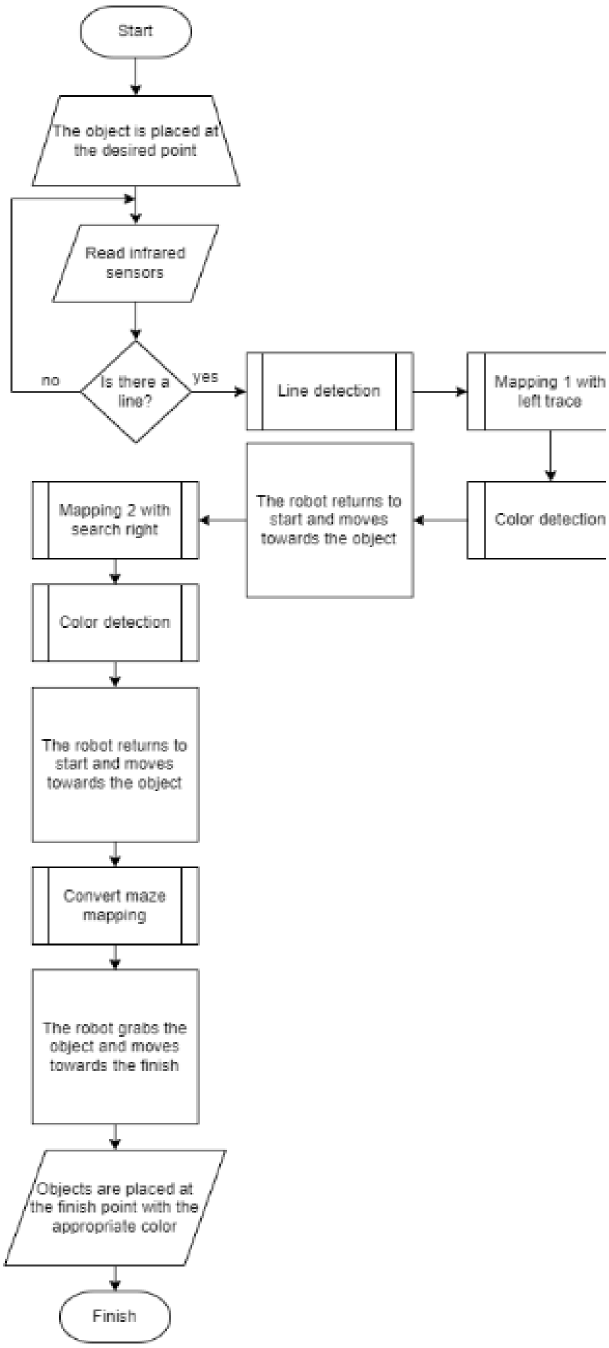

Fig. 6. System Flowcharts

In the system flowchart of the object-moving robot, the infrared sensor initializes the line. If the line is detected, the robot moves from the starting point to map 1 left path through all existing intersections. While the robot reads the color on the object and the color at the finish point, until finally, the robot returns to the initial starting point to map 2 traces to the right with the same process as traces to the left. The results of these two searches are converted into the fastest path, in which the robot eliminates unnecessary paths and moves with the fastest path to the object. Then the robot pinches the object toward the finish that matches the color object brought with the result of the fastest path. The following is a system flowchart shown in Figure 6.

3 Result and Discussion

Implementation and analysis of tool testing are carried out to ensure the system is working correctly or not. In this case, the analysis and testing procedure consists of several stages, namely infrared sensor testing, color sensor testing, distance testing, tracing tracking testing, maze-solving elimination system testing and fastest path testing.

Testing the Level of Success and Error on the Robot

The last stage of testing on object-moving robots is performed with a 10-time test system, with samples used on the test using a red object and finish. The robot is said to be successful if it meets the criteria; namely, it can take the fastest path according to the results of A* to the object and to the finish. Meanwhile, the robot is said to have failed the test if the robot only reaches the object and fails to move the object or the robot fails to detect the existing color, the Bluetooth connection is broken, and the robot fails the mapping process. From the trial the following tests are obtained:

Testing with red objects

In Figure 7 the path that will be passed by the robot has an overall distance of 502 cm. The robot moves from the start at node h, towards the object at node q with a distance of 319 cm which is marked with an orange path. Then the robot moves from the node q place the object is towards the finish at node m which is marked with a brown path with a distance of 183 cm. Then the trial results were processed in tabular form shown in Table 1.

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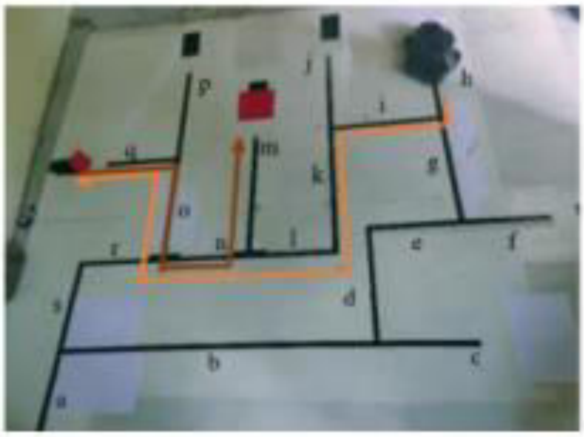

Fig. 7. Test The Success Rate With Red Objects

From the tests with red objects that have been carried out, 7 successes and 3 failures occurred in the 3rd trial due to a broken bluetooth connection, while the 5th and 6th trials of the robot make a less-than-perfect turn then go off the course. In this test, success was obtained with the percentage according to the following calculation:

$$persentase\ (\%) = \frac{7}{10} x100\%$$
$$persentase\ (\%) = 70\%$$

Tabel 1. The final stage of testing with red objects

Testing	The result of A* goes to the object	Result A* goes to the finish	Total distance	Trial results	
				Succeed	**Fail**
1	333 cm	228 cm	561 cm	√	
2	345 cm	221 cm	566 cm	√	
3	-	-	15 cm		√
4	345 cm	221 cm	569 cm	√	
5	-	-	275 cm		√
6	450 cm	-	450 cm		√
7	342 cm	225 cm	567 cm	√	
8	363 cm	202 cm	565 cm	√	
9	363 cm	229 cm	570 cm	√	
10	352 cm	208 cm	560 cm	√	

4 Conclusion

There are several conclusions obtained from the results of the design and trials on the robot:

1. The application of the A* method in this study is less accurate due to the slip system on the tires and the condition of the battery which is not stable, thus disrupting the stopping distance of the robot and giving distance results that are not in accordance with the actual distance.
2. The robot can only be used for approximately 4 times with an average test of 7 minutes, due to inadequate battery conditions with a capacity of 6500 mAh.

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