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The Intelligent Fire Fighting Tank Robot

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Abstract: Nowadays technology contribution in our life is more than as we expected, especially robotic. Technology development in robotic can be known from its type, shape, and applications. Robot can be used for a high risk task such as fire fighting. Fire fighting robot should be able to search certain area, to find and extinguish the flame. To complete these tasks, robot must be equipped with a proper controller. Because of this issue, we build the tank robot which is equipped with ultrasonic sensor, compass sensor, flame detector, thermal array sensor, white detector, and micro switch sensor. The tank robot is controlled by Microcontroller AVR ATMega16. The simulation area is designed in miniature. The miniature is equipped with furniture, sound damper, and uneven floor. Algorithms for tank robot are described in this paper.

Keywords: intelligent fire-fighting tank robot, microcontroller AVR ATMega16, algorithm

Abstrak: *Saat ini teknologi sangat berperan dalam kehidupan, terutama robot. Perkembangan teknologi dalam robot dapat diketahui dari jenis, bentuk, dan aplikasi robot. Robot dapat digunakan untuk tugas berisiko tinggi seperti pemadam kebakaran. Robot pemadam kebakaran harus dapat mencari daerah tertentu, menemukan, dan memadamkan api. Untuk melengkapi kemampuan robot ini, robot harus dilengkapi dengan pengontrol yang tepat. Pada penelitian ini direalisasikan robot tank yang dilengkapi dengan sensor ultrasonik, sensor kompas, detektor api, sensor array termal, detektor putih, dan sensor mikro switch. Robot tank dikendalikan oleh mikrokontroler AVR ATMega16. Arena simulasi dirancang dalam miniatur. Miniatur ini dilengkapi dengan penghalang, peredam suara, dan lantai yang tidak rata. Algoritma untuk robot tank dijelaskan dalam makalah ini.*

Kata kunci: *robot tank cerdas pemadam api, mikrokontroler AVR ATMega16, algoritma*

I. INTRODUCTION

Robot is a mechanic device that usually used for high risk task such as fire fighting.[1]. As a fire fighter, robot should be able to search certain area, find and extinguish the flame. Robot is equipped with ultrasonic sensor and compass sensor to navigate and maneuver in certain area. To find and extinguish the flame, robot is equipped with a flame detector to detect the flame and a thermal array sensor to know the position of the flame. In process to detect the flame, it is possible that robot cannot enter the room because of various door locations and stuck in any

place. Algorithm has a main role to solve that problem. Besides equipped with sensors that have different functions and specifications, algorithm for robot navigation is also needed. This paper will show how the importance of algorithm for robot navigation.[2]

II. Specification Robot Design

Tank robot dimension is 25 cm x 21 cm x 20 cm, made from combination of acrylic, plastic, aluminum, and iron. Robot components are two servo motors for each wheel, two DC motors to rotate two fans to extinguish the flame, ultrasonic sensor (SRF04), compass sensor (CMPS03), flame detector (UVTRON R2868), thermal array sensor (TPA81), white detector (IR & Phototransistor), and micro switch sensor. The tank robot is activated with sound, so it is equipped with a sound activation circuit. The sound activation circuit consists of a DTMF (Dual Tone Multi Frequency) transmitter and receiver.

Design of tank robot is shown in Figure 1 for the front side view, Figure 2 for the right side view, Figure 3 for the top side view, and Figure 4 for the bottom side view. Positions of ultrasonic sensors are in front, right side and left side as shown in Figure 1 and Figure 2. Compass sensor and flame detector sensor are located in centre top as shown in Figure 3. Thermal array sensor is located at centre front as shown in Figure 1. White detector is located at bottom as shown in Figure 4. Micro switch sensors are located in four corners of the tank robot and front side as shown in Figure 3. Sound activation circuit is located at backside of the robot as shown in Figure 3.

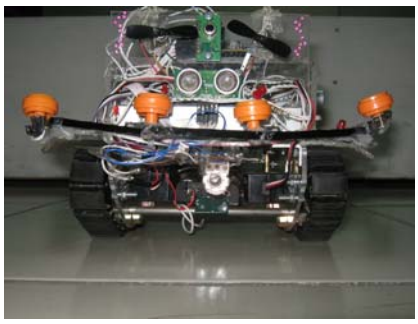


Figure 1. Front Side View

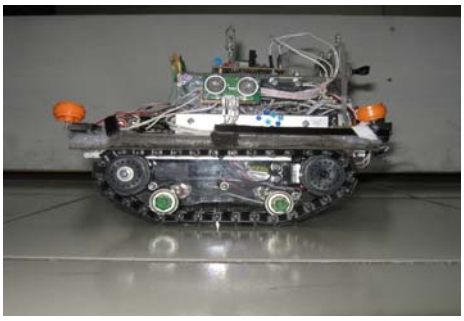


Figure 2. Right Side View

Figure 3. Top Side View

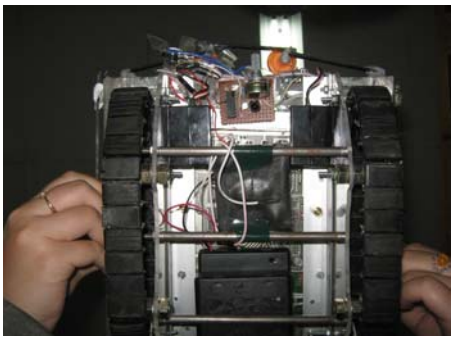


Figure 4. Bottom Side View

Block diagram of the tank robot is shown in Figure 5. Figure 5 shows that microcontroller AVR ATMega16 receive input from sound activation circuit, Infrared and Photodiode circuit as

white detector, micro switch sensor as furniture detector, UVTRON and TPA81 as flame detector and thermal detector, CMPS03 as navigation detector, SRF04 as ultrasonic sensors. Microcontroller processes signal inputs and gives signal outputs to servo motor (GWS S03 4.8V) in front-left wheel and front-right wheel, and DC motor to rotate the fan to extinguish the flame.

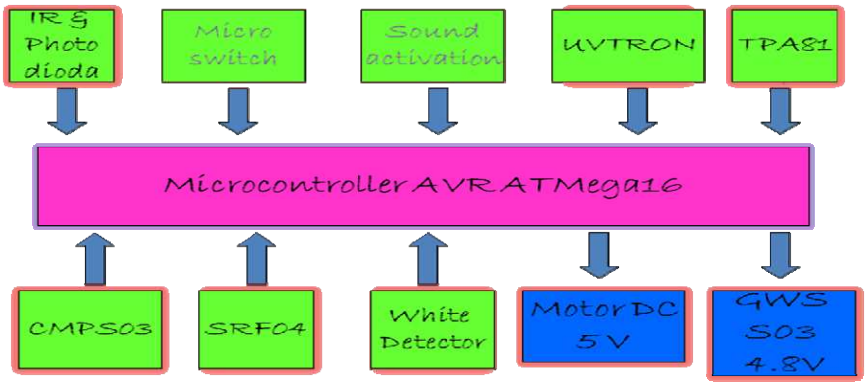


Figure 5. Block Diagram of the Tank Robot

The control block of tank robot is shown in Figure 6. Sensors play a role in feedback the signals from the actual value and then it compared with the reference value. The difference give the error signal for the ON/OFF controller and then give control signal to the mechanics and electronics of tank robot, such as control signal for the servo motors and DC motors.

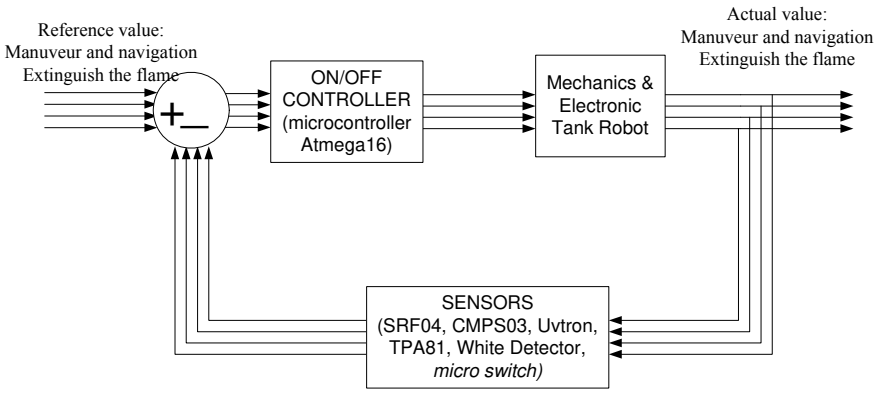


Figure 6. Control Block of Tank Robot

III. CONSTRAINTS

In this research the simulation area are shown in Figure 7, Figure 8, Figure 9, and Figure 10. Room 2 (R2) and Room 3 (R3) has a fixed door location, but the door Room 1 (R1) and Room 4 (R4) can be adjusted as described location in figures below. Room 1 (R1) has two possible variations of door, R1a and R1b. Room 4 (R4) has two possible variations of door, R4a and R4b. So there are four area configurations available in this research.

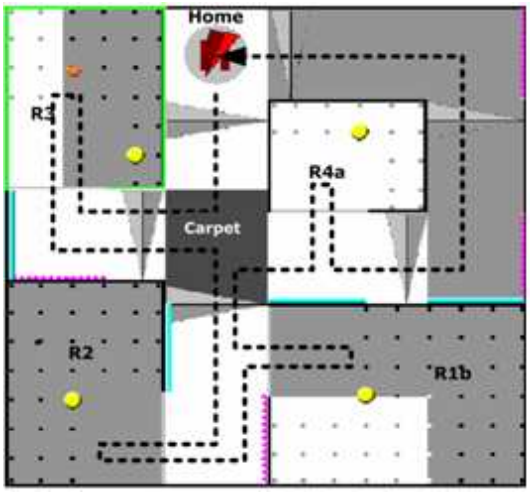


Figure 7. First Area Configuration

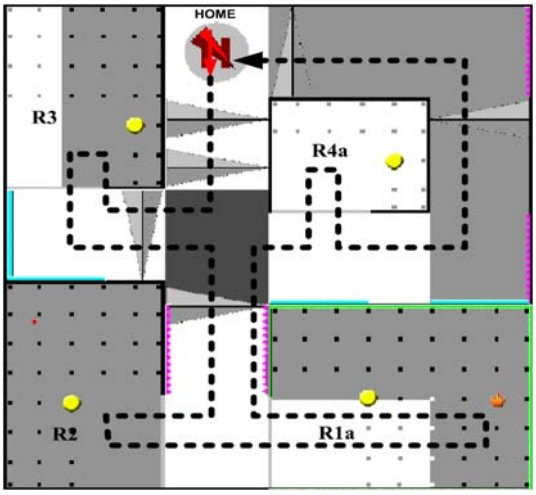


Figure 8. Second Area Configuration

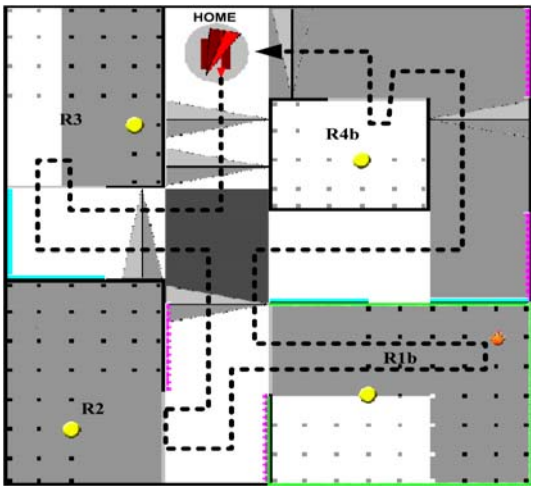


Figure 9. Third Area Configuration

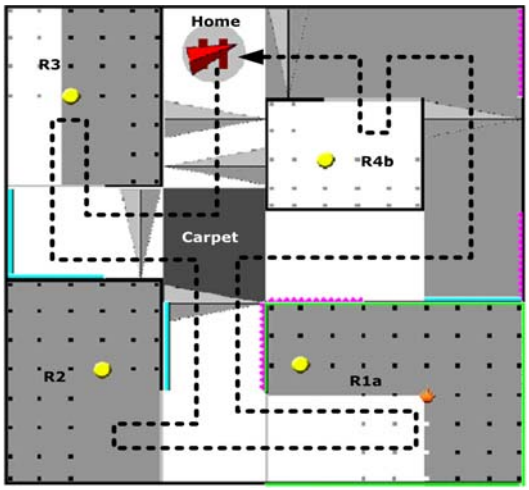


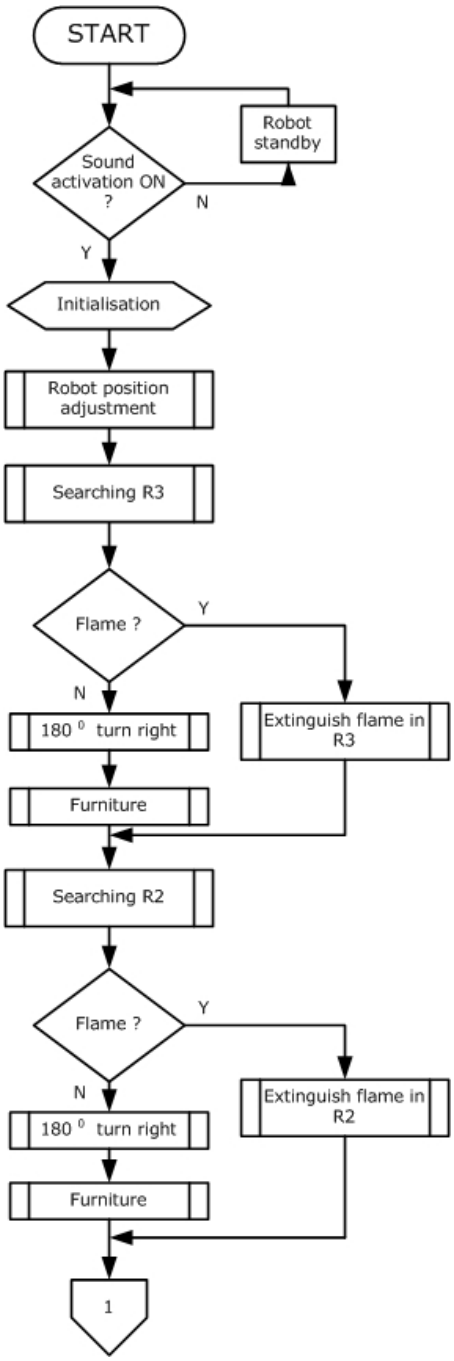
Figure 10. Fourth Area Configuration

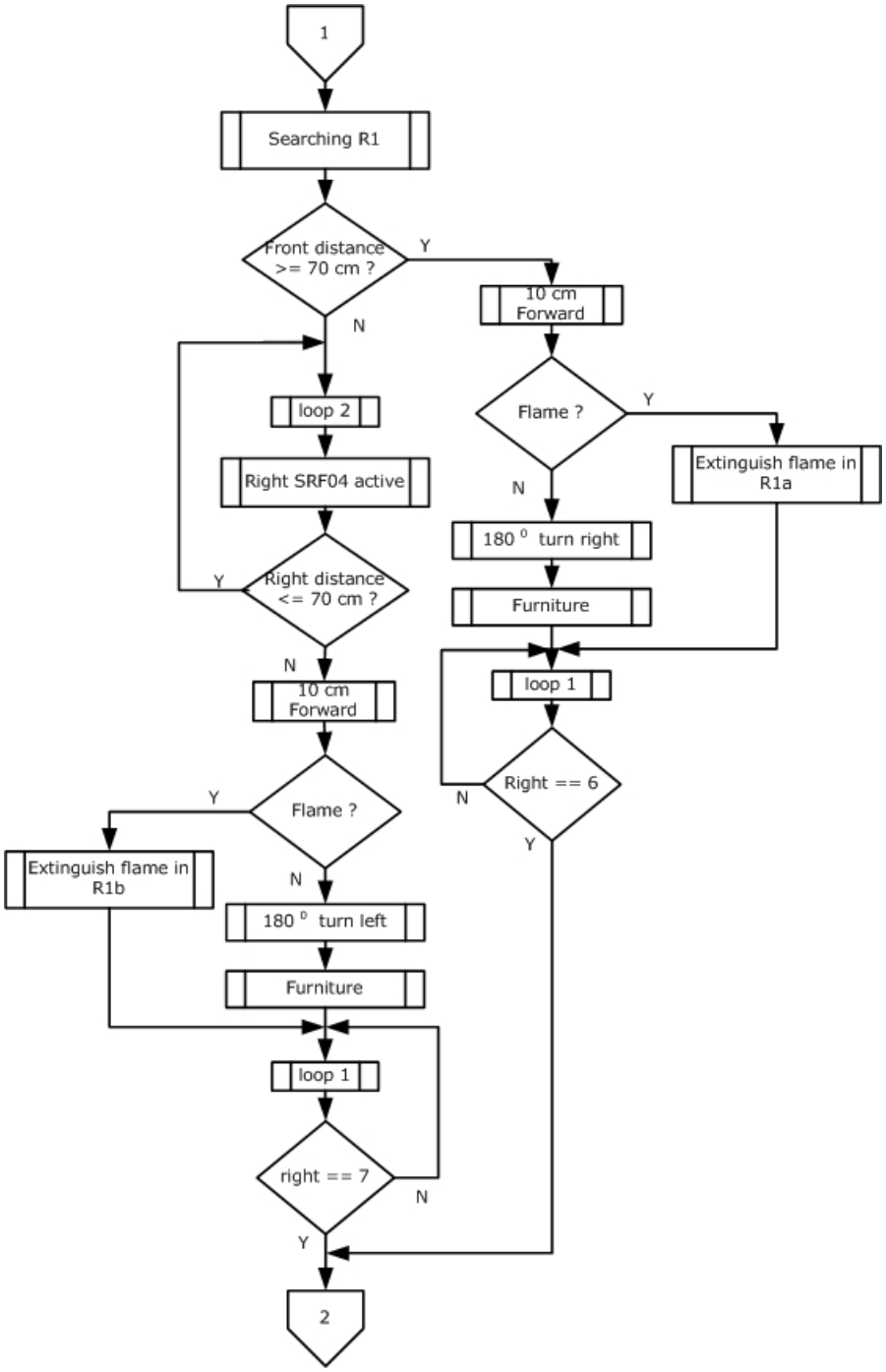
IV. ALGORITHMS

The objectives of the tank robot are to find and extinguish the flame as fast as possible then return to the Home position. The flow chart can be seen in Figure 11. The algorithms steps for tank robot are:

1. Tank robot start from Home with a random direction
2. Adjustment tank robot parameters such as position and direction
3. Search R3 with right wall follower method
4. In R3, tank robot tries to find flame. If the flame is detected then the robot extinguishes the flame by using two fans, and then goes out from R3. If there is no flame is detected then the robot go out from R3 directly.
5. Search R2 with right wall follower method
6. In R2, tank robot tries to find flame. If the flame is detected then the robot extinguishes the flame by using two fans, and then goes out from R2. If there is no flame is detected then the robot go out from R2 directly.
7. Search R1 with right wall follower method

8. In R1, tank robot tries to find flame. If the flame is detected then the robot extinguishes the flame by using two fans, and then goes out from R1. If there is no flame is detected then the robot go out from R1 directly.
9. After the robot pass the carpet, then the robot search R4 with left wall follower method
10. In R4, tank robot tries to find flame. If the flame is detected then the robot extinguishes the flame by using two fans, and then goes out from R4. If there is no flame is detected then the robot go out from R4 directly.
11. Then the robot return to Home position with left wall follower method




1
Searching R1
Front distance >= 70 cm ?
Y
N
10 cm Forward
loop 2
Flame ?
Y
Extinguish flame in R1a
Right SRF04 active
N
180 0 turn right
Right distance <= 70 cm ?
Y
Furniture
N
loop 1
10 cm Forward
Right == 6
N
Y
Flame ?
Y
Extinguish flame in R1b
N
180 0 turn left
Furniture
loop 1
right == 7
N
Y
2

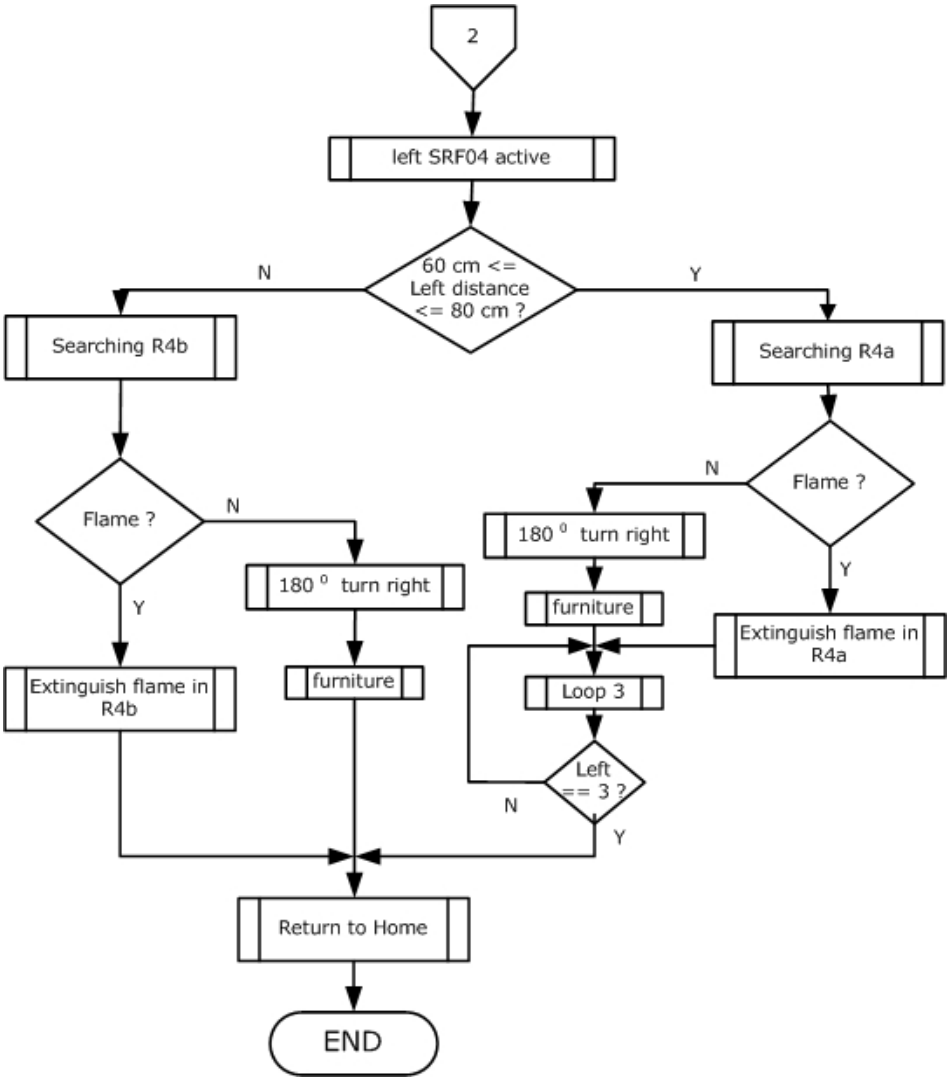


Figure 11. The Flowchart of the Tank Robot

V. RESULT

Table 1 presented experiment results for this research. The objective is to search certain area, find and extinguish the flame for different flame positions, room configuration with the disturbance such as the furniture in the room, uneven floor, mirror, and sound damper in corridor. The results are:

1. The tank robot can be activated with the DTMF transmitter and receiver
2. Although the position adjustment of tank robot does not work, but the tank robot can still find the rooms with the role of the three sensor SRF04
3. If the robot could not find the fourth room (R4) then the robot cannot return to home
4. The tank robot can move on an uneven floor with caterpillar structure of wheels
5. If the tank robot cannot detect the flame then the robot cannot extinguish the flame
6. If the tank robot detect the flame but cannot determine flame position then the robot cannot extinguish the flame

TABLE 1. EXPERIMENT RESULTS

No	Tasks	Configuration I			Configuration II			Configuration III			Configuration IV		
		1	2	3	1	2	3	1	2	3	1	2	3
1	Sound activation	√	√	√	√	√	√	√	√	√	√	√	√
2	Position adjustment	√	√	√	√	X	√	√	√	√	√	√	√
3	Search R1	X	√	√	√	√	√	√	√	√	X	X	√
4	Search R2	X	√	√	√	√	√	√	√	√	X	√	√
5	Search R3	√	√	√	√	√	√	√	√	√	X	√	√
6	Search R4	X	√	X	√	√	√	√	√	X	X	X	√
7	Flame detection	√	√	√	√	√	√	√	√	√	X	X	√
8	Determine flame position	√	√	√	√	X	√	√	√	√	X	X	√
9	Extinguish the flame	X	√	√	√	X	√	√	√	√	X	X	√
10	Move through on uneven floor	√	√	√	√	√	√	√	√	√	√	√	√
11	Avoid the furniture	√	√	√	√	√	√	√	√	√	X	√	√
12	Pass on hanging objects (mirror & sound damper)	√	√	√	√	√	√	√	√	√	√	√	√
13	Return to Home	X	√	X	X	X	√	√	X	X	X	X	√
success		8	13	11	12	9	13	13	12	10	4	7	13
Total per configuration				32			34			35			24
Total (%) per configuration				82.05%			87.18%			89.74%			61.54%
Total (%)													80.13%

Note: √ = succeed
X = failed

VI. CONCLUSIONS

The algorithms are success applied in the tank robot. The percentages of success are:

1. In average 82.05 % of success in searching and extinguish the flame for configuration I
2. In average 87.18 % of success in searching and extinguish the flame for configuration II
3. In average 89.74 % of success in searching and extinguish the flame for configuration III
4. In average 61.54 % of success in searching and extinguish the flame for configuration IV

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