# Redirection Concept of Autonomous Mobile Robot HY-SRF05 Sensor to Reduce The Number of Sensors

Nuryanto[1)], Andi Widiyanto[2)], Auliya Burhanuddin[3)]
[1,2,3)] Engineering Faculty
Universitas Muhammadiyah Magelang
Jawa Tengah, Indonesia
[1)] nuryanto@ummgl.ac.id [2)]andi.widiyanto@ummgl.ac.id [3)]auliya.burhanuddin@gmail.com

***Abstract*— The autonomous mobile robot can move around and avoid obstacles in front by itself. The data generated by the sensors is processed using an algorithm and specific methods to determine the movement of the robot. Ultrasonic sensor installed on the Mobile robot with a straight forward position. Ultrasonic sensor can detect the obstacle 30 degrees in front, which creates the blank area of the sensor between two ultrasonic sensors. Ultrasonic sensors installed at many points to reduce that blank area. This paper offers the concept of two ultrasonic sensor redirection by mounting it tilted so when it is drawn will form a right triangle that the concept of trigonometry applied. The results of the approximate distance between the obstacle sensor becomes the hypotenuse, while the distance between the two sensors already obtained so that the distance between the mobile robot with the real obstacle can be calculated. The mechanism of mobile robot movement mimics the movement of agricultural tractors. The test results showed that the optimum angle between the two ultrasonic sensors is 35 to 55 degree. Redirection ultrasonic sensors will reduce approximately 42% of the number of sensors that are installed straight ahead.**

***Keywords*— *Autonomous; Mobile robot; Ultrasonic; Trigonometry; Redirection***

## I. INTRODUCTION

The autonomous mobile robot is a robot that can move on its own and is able to avoid obstacles. The proximity sensor is used to estimate the distance so that the robot can avoid the obstacle in front of him. Sensors are commonly used infrared sensors or ultrasonic sensors.

HY-SRF05 is an ultrasonic sensor brands available and easily obtained. ultrasonic sensors detect the obstacle with coverage area $30^0$ center of the receiver and transmitter [1]. Installation of ultrasonic sensors mounted straight ahead (Fig.1). installation of these models indicate areas that are not detected by the ultrasonic sensor.

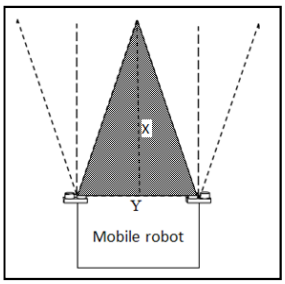


Fig. 1. Ultrasonic sensor installed straight forward

To be more accurate in detecting the obstacle in front of the installation of ultrasonic sensor on a mobile robot with such large quantities such as 3 pieces [2], 8 pieces [3], 9 units [4] and some have installed 24 [5]. Other researchers combine 8 ultrasonic sensors with IR sensor [6].

With the number of sensors that many microcontroller programming algorithms is also more complicated. The cost required in the assembly of the mobile robot is also more expensive. The fewer number of sensors will facilitate the preparation of robot programming algorithm and cheaper costs.

Ultrasonic sensors mounted oblique position with hitch if portrayed will form a right-angled triangle, so that the Pythagorean theorem applies (fig. 2). Estimated distance generated by the sensor becomes the hypotenuse with a certain angle. With ultrasonic sensor mounting models with exact degrees, then the sensor detection area is becoming more widespread and can reduce the number of sensors to be installed.

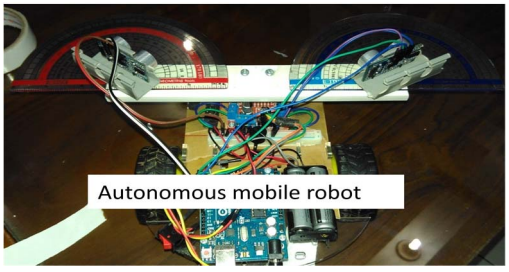


Fig. 2. Redirection ultrasonic sensor



978-1-5386-0549-3/17/$31.00 ©2017 IEEE

## II. Related Works

### A. Deployments of Sensors to Detect Objects

Installation 2 ultrasonic sensors are mounted straight ahead so that the mobile robot moving along the wall (wall-following). The right sensor detects the obstacle on the right and the left detects an obstruction to the left as shown in Fig 3 [2].

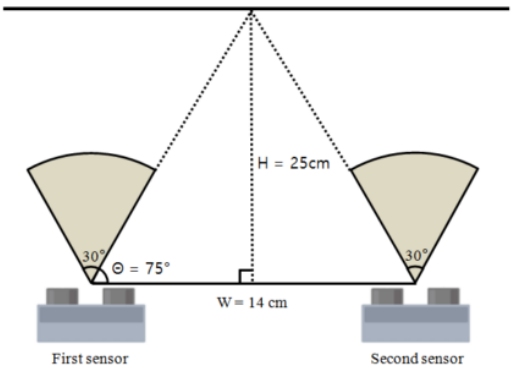


Fig. 3. Two ultrasonic sensors Installed straight forward for wall-following method

The distance between two sensors 14 cm with the constant distance of 25 cm from the wall. Based on the equation 1:

$$W = 2 \times \frac{H}{\tan \emptyset} \quad (1)$$

Means any multiple of 14 cm require additional ultrasonic sensors. Wider the mobile robot, it needs more sensors. This study uses the same concept but crosswise direction sensor, the right sensor detects left side and the left sensor detects the right side.

### B. Navigations of Mobile Robots

The autonomous mobile robot can move automatically to avoid obstacles by using several methods such as wall-following [2], the RFID system [6], vision-based navigation method [7], the fuzzy-based algorithm [8] [9] and etc. How if the mobile robot is in the wide open area without walls, GPS, RFID System to guide the movement of the robot?

This study for the mobile robot that moves freely in any direction. Mobile robot has two wheels driven 2 motors and movement mimics the movement of agricultural tractors. The mobile robot moves forward if there is no obstacle. The right sensor will be compared with the left sensor, to determine the direction of the turn [10]. The mechanism turns by adjusting the motor rotation speed of the right and left motor rests on the freewheel (fig. 4).

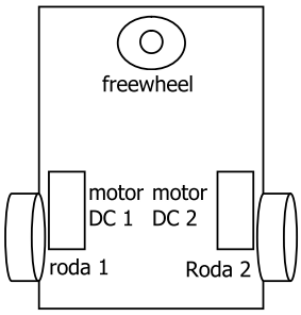


Fig. 4. The mobile robot with two wheels and a freewheel

## III. Implementation Details

### A. Hardware Design of the Mobile Robot

Mobile robots use two DC motors with L298N driver module that is controlled by an Arduino microcontroller series such as Uno, Mega 2560, Nano, Promini and so on. Ultrasonic sensors (HY-SRF05) mounted front right and left side of the chassis of the robot.

Arduino microcontroller will drive a DC motor via L298N driver module with a certain speed. DC motor speed difference with the right and left resting on freewheel mobile robot will make a sharp turn to the right or to the left or turn to a particular angle. DC motor speed logic with the turn as shown in Table 1 [10]:

$$\alpha + \beta = \chi. \quad (1) \quad (1)$$

TABLE I. MOTORDC SPEED SETTING - ROBOT DIRECTION

| Motor DC Right Speed | Motor DC Left Speed | Direction |
|---|---|---|
| 100 | 100 | Forward |
| 100<br>50 | 50<br>100 | Right ($45^0$)<br>Left ($45^0$) |
| 100<br>0 | 0<br>100 | Right ($90^0$)<br>Left ($90^0$) |
| -100 (exchanged pole) | -100 (exchanged pole) | Backward |

### B. Sensor-Deployment Strategies

HY-SRF05 front mounted mobile robot on the right and left. Right side sensor detects obstacles that are in front and to the left, while the right side to detect otherwise. Results HY-SRF05 approximate distance to the left than to the right to determine the direction of the turn to the right or to the left. The design of the redirection sensor in the form of angle α and β with calculations based on estimates of the distance sensor (C1 and C2) as Fig.5.

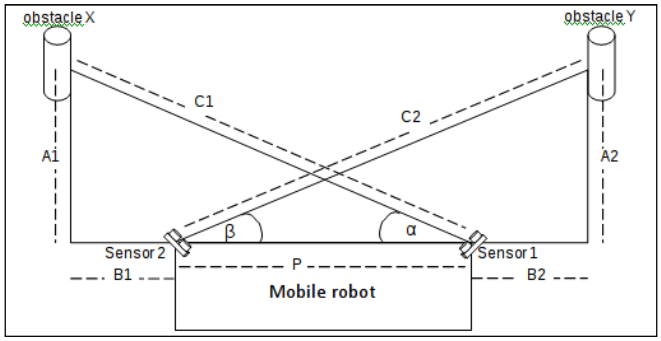

Fig. 5. Redirection ultrasonic concept

At the time of the mobile robot to move, if there is a barrier, then the ultrasonic sensors will estimate the distance from the sensor to the barrier. X barrier will be detected by the sensor 1, the approximate distance from the sensor to the hypotenuse (C1), to find the length of the high side (A1) using trigonometric functions Sine. The length is the distance between the sensor pad with a line drawn perpendicular from the barrier (P + B1) so as to form a right triangle with applicable law and the Pythagorean theorem.

## IV. Experimental Results

In fig. 5 ultrasonic sensors that tilt and hitch forming two right-angled triangles. C1 & C2 is the hypotenuse produced by HY-SRF05 sensor, the base is a second distance sensor (P) plus the distance to the obstacle sensor if drawn perpendicular (B1 & B2) so as following equation (2) and equation (3):

$$A1 = C1 * \sin \quad (2)$$

$$B1 = \left(\sqrt{C1^2 - A1^2}\right) - P \quad (3)$$

If the length between the two sensors (P) is 14 cm, angle (α and β) add by 5 degrees, the approximate distance (C1 and C2) is determined: 25 cm the final result as shown in Table 1:

TABLE II. Calculation Table Redirection Sensor

| α | β | C1 | C2 | A1 | A2 | B1 | B2 |
|---|---|---|---|---|---|---|---|
| 5 | 5 | 25 | 25 | 2,18 | 2,18 | 10,90 | 10,90 |
| 10 | 10 | 25 | 25 | 4,34 | 4,34 | 10,62 | 10,62 |
| 15 | 15 | 25 | 25 | 6,47 | 6,47 | 10,15 | 10,15 |
| 20 | 20 | 25 | 25 | 8,55 | 8,55 | 9,49 | 9,49 |
| 25 | 25 | 25 | 25 | 10,57 | 10,57 | 8,66 | 8,66 |
| 30 | 30 | 25 | 25 | 12,50 | 12,50 | 7,65 | 7,65 |
| 35 | 35 | 25 | 25 | 14,34 | 14,34 | 6,48 | 6,48 |
| 40 | 40 | 25 | 25 | 16,07 | 16,07 | 5,15 | 5,15 |
| 45 | 45 | 25 | 25 | 17,68 | 17,68 | 3,68 | 3,68 |
| 50 | 50 | 25 | 25 | 19,15 | 19,15 | 2,07 | 2,07 |
| 55 | 55 | 25 | 25 | 20,48 | 20,48 | 0,34 | 0,34 |
| 60 | 60 | 25 | 25 | 21,65 | 21,65 | -1,50 | -1,50 |
| 65 | 65 | 25 | 25 | 22,66 | 22,66 | -3,43 | -3,43 |
| 70 | 70 | 25 | 25 | 23,49 | 23,49 | -5,45 | -5,45 |
| 75 | 75 | 25 | 25 | 24,15 | 24,15 | -7,53 | -7,53 |
| 80 | 80 | 25 | 25 | 24,62 | 24,62 | -9,66 | -9,66 |
| 85 | 85 | 25 | 25 | 24,90 | 24,90 | -11,82 | -11,82 |

If the value of B1 or B2 is zero or negative that means the barrier in front of the mobile robot, so it's going to collision. To turn requires a distance with a minimum obstruction equal to the distance between 2 sensors. If adjusted to the distance to the obstacle 25 cm [2] then the optimum angle is 35-55 degrees.

Grafik hasil perhitungan The distance of sensor-obstacle to ahead (A1), The distance of sensor-obstacle to ahead (A1) disajikan di Fig. 6.

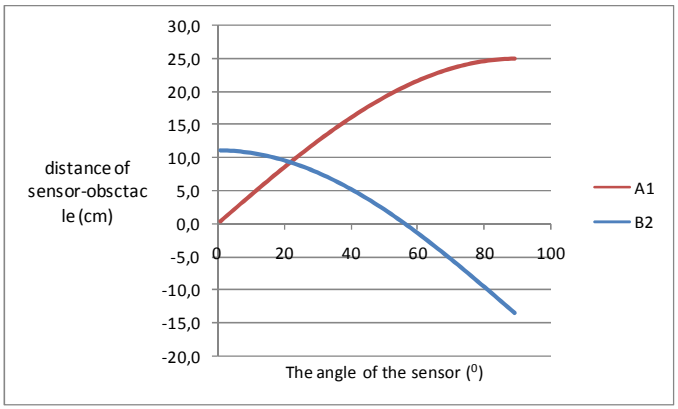


Fig. 6. Distance of 2 sensors with redirection angle

Using the equation (1) the approximate distance of the sensor and obstacle (H) = 25 cm and the angular variable α, the result of the distance of the two sensors (W) is presented as the following graph (Fig. 7):

$$\alpha + \beta = \chi. \quad (1) \quad (1)$$

$$\alpha + \beta = \chi. \quad (1) \quad (1)$$

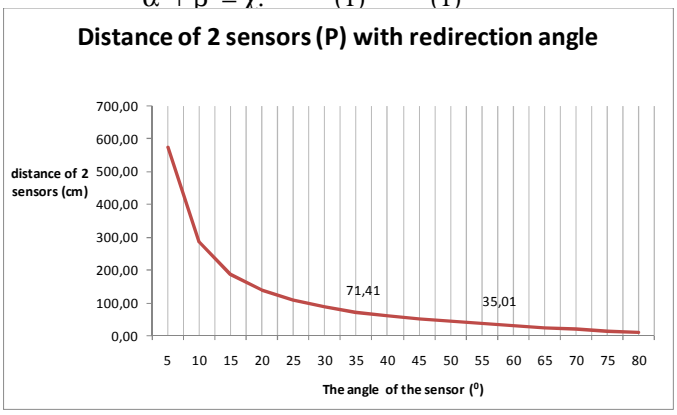


Fig. 7. Distance of 2 sensors with redirection angle

The optimum angle is 35-55 degrees so that the installation of redirection 2 ultrasonic sensors can be between 55.01 to 71.41 cm. Installation of a straight forward sensor requires 1 ultrasonic sensor every 14 cm, whereas with the redirection model only 2 sensors. Installation of ultrasonic sensors with redirection will reduce the number of ultrasonic sensors by an average of 42% compared to straight forward installation

## Conclusion

Ultrasonic sensors mounted askew to reduce blank areas generated by the two sensors is straightforward to implement the Pythagorean theorem and trigonometry functions. Redirection optimum angle is 35 -55 degrees. Redirection ultrasonic sensors will reduce approximately 42% of the number of sensors that are installed straight ahead.

## Acknowledgment

The authors would like to acknowledge LP3M Universitas Muhammadiyah Magelang for the funding support of the research project.

## *References*

[1] N. Nuryanto, A. Widiyanto, and A. Burhanudin, "Redirection HC-SR05 untuk Efisiensi Jumlah Sensor," Magelang, 2016.

[2] J. Lim, S. J. Lee, G. Tewolde, and J. Kwon, "Ultrasonic-sensor deployment strategies and use of smartphone sensors for mobile robot navigation in indoor environment," in *IEEE International Conference on Electro Information Technology*, 2014, pp. 593–598.

[3] Z. A. Nurmaini Siti, "Sistem Navigasi Non Holonomic Mobile Robot Menggunakan Aplikasi Sensor Ultrasonic," *J. Ilm. Generic*, vol. 4, no. 1, p. 11, 2009.

[4] B.-S. Choi, J.-W. Lee, J.-J. Lee, and K.-T. Park, "A Hierarchical Algorithm for Indoor Mobile Robot Localization Using RFID Sensor Fusion," *IEEE Trans. Ind. Electron.*, vol. 58, no. 6, pp. 2226–2235, 2011.

[5] J. L. Crowley, "World modeling and position estimation for a mobile robot using ultrasonic ranging," in *Proceedings, 1989 International Conference on Robotics and Automation*, 1989, vol. 3, no. February, pp. 674–680.

[6] K. Yelamarthi, S. Sherbrook, J. Beckwith, M. Williams, and R. Lefief, "An RFID based autonomous indoor tour guide robot," in *Midwest Symposium on Circuits and Systems*, pp. 562–565.

[7] A. Ohya, A. Kosaka, and A. Kak, "Vision-based navigation of mobile robot with obstacle avoidance by\nsingle camera vision and ultrasonic sensing," in *Proceedings of the 1997 IEEE/RSJ International Conference on Intelligent Robot and Systems. Innovative Robotics for Real-World Applications. IROS '97*, 1997, vol. 2, pp. 704–711.

[8] I. Sugiarto, L. L. Un Tung, and M. I. Rahman, "Implementation of Fuzzy Logic in FPGA for Maze Tracking of a Mobile Robot Based on Ultrasonic Distance Measurement," *J. Tek. Elektro*, vol. 8, no. 2, pp. 96–102, 2010.

[9] X. Ruan and W. Li, "Ultrasonic sensor based two-wheeled self-balancing robot obstacle avoidance control system," in *2014 IEEE International Conference on Mechatronics and Automation, IEEE ICMA 2014*, 2014, pp. 896–900.

[10] N. Nuryanto and A. Widiyanto, "Rancang Bangun Mobile Robot 2WD dengan 2 Sensor HC-SRF05 untuk Menentukan Arah Belokan," in *Semnasteknomedia*, 2016, p. 35.25-35.30.