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Controlling Mobile Robot With Ultrasonic Sensor Using Artificial Neural Networks And Sliding Mode Control

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Controlling Mobile Robot With Ultrasonic Sensor Using Artificial Neural Networks And Sliding Mode Control

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Abstract— **Ultrasonic sensor is a tool that can provide information about environmental conditions. That way, ultrasonic sensors are often used in detecting objects by measuring the distance so that they can get closer to or away from the object. Ultrasonic SRF 05 mode 2 is used in this design where the data receiver and sender lines are on one pin. Therefore, a robotic arm was designed with the ability to detect objects using ultrasonic sensors. Detection of objects not only requires results that can measure distance only. However, detection also requires accuracy in measuring and measurable in providing detection results. Artificial neural network and shear mode control are used in this study to control ultrasonic SRF 05 mode 2 to improve more accurate and measurable results in object detection. The results of this study can be concluded that the ANN method and the sliding mode control with the SRF 05 mode 2 sensor model in moving the robot arm to take the object in front of it, get a detection accuracy level with objects of 48.5 cm and the accuracy of the detection distance to objects of 50 cm. That way, the ultrasonic sensor can be more reliable and precise by using this method..**

Index Terms— **Artificial neural network, Sliding Mode Control, Ultrasonic Sensor**

I. Introduction

The development of robotic technology in the industry is growing faster by using control and sensor techniques that can effectively speed up the production process so well. The use of ultrasonic sensor is expected to help the production process accurately and increase its creativity and activities by using more efficient tools.

The Presence of ultrasonic that is applied to the robot is currently needed in a more accurate production process in the industry. One of them is the SRF 05 ultrasonic sensor that is developed in the production process. One of the advantages of the SRF 05 Ultrasonic sensor is able to detect objects very accurately and effectively.

Another advantage of the SRF 05 ultrasonic sensor is its Artificial Neural Network and Sliding Mode Control that are better at saving time and energy. Moreover, with SR 05 ultrasonic sensor applied inside, mobile robot can scan the objects in the dark and foggy situation.

II. Model

Mobile robot that equipped with Ultrasonic sensor with Artificial Neural Network method and Sliding Mode Control is an intelligent robot designed based on its capabilities and characteristics to meet the needs in technological development. Mobile robot can move according to the rules have been determined before

A. *Mechanical System*

Mechanical system describes how the robot's hand shape will be used.

1. Mechanical Design

Mechanical design is a principle that determines the skills /dexterity of an arm robot.

2. Motion Classification

Footnotes: 8-point Times New Roman font;

Manuscript received July 1, 2012; revised August 1, 2012; accepted September 1, 2012.

According to the its direction, motion can be divided into two kinds: Translation Motion/ Linear Motion and rotational Motion

3. Motion transmission

Motion transmission is divided into 2 types is motion transmition of rotational motion to rotation

Things that should be considered are Ideal Gear, Ideal gear means the gears are really full round, spinning at its midpoint, and also without inertia (inertialess). Friction does not occur between the gears, so that it does not cause power losses.

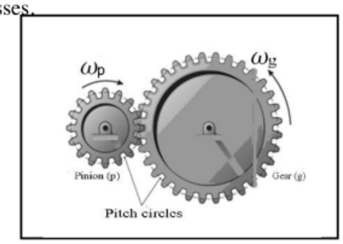

Figure 1. Ideal Gear

B. Ultarsonic Sensor

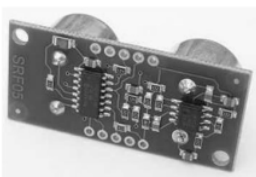

Figure 2. Ultrasonic Sensor SRF 05

Sensing component of a robot is usually called as sensor. Like humans, a robot will be able to find out the surrounding environmental conditions with the help of sensor. The robot will be able to avoid the barrier in front of it with the help of proximity sensor. A robot can extinguish the fire by blowing it, if it is installed with a flame detection sensor so that it is able to detect the source of fire around it. A robot may be able to approach an object and then take it because the robot is able to see with the help of a vision sensor in the form of a camera. A robot will be able to walk along the line or follow the light in front of it if it is assisted by a line or light detection sensor.

In navigating, the robot uses PING)), which was produced by Parralax Inc., as the proximity sensor. This sensor works by sending ultrasonic waves (above the threshold of human hearing) and provides output pulses related to the time needed when the reflection wave is received back by the sensor. By measuring the time lag between sending pulses to received pulses, the measured distance can be calculated. PING)) Parallax has precision measurements without any contact with measuring points from 3 cm to 3 m. The following is the explanation of several things related to ultrasonic sensor.

C. Ultrasonic Sensor Model

1. SRF 04 compatible - Separate Trigger and Echo

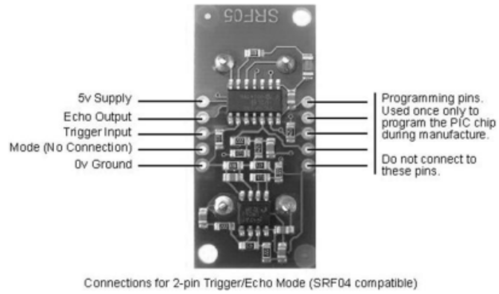

Figure 3. Compatible ultrasonic type

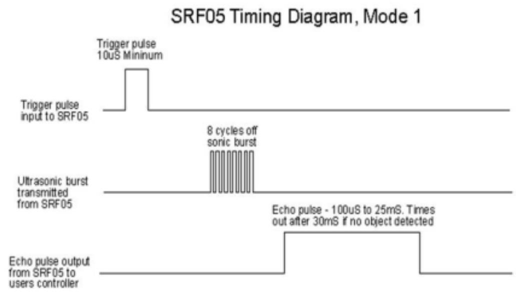

Figure 4. Mode 1 timing diagram

2. Single pin for both Trigger and Echo

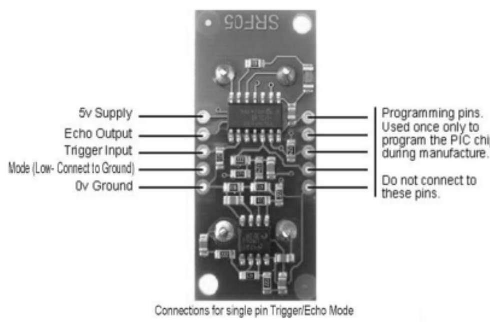

Figure 5. Single-pin SRF ultrasonic

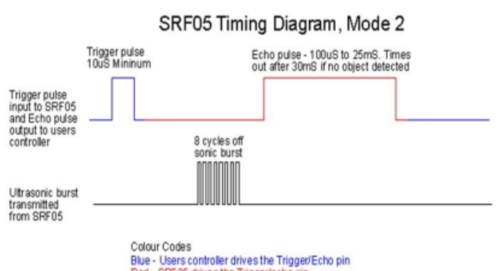

Figure 6. Timing Diagram, Mode 2

D. *Artificial Neural Network Model (ANN)*

The design of artificial neural networks is not linear and linear in the form of equipment analysis process which resulted in no basic relationship to the equipment analysis process. The design of basic building blocks in Artificial Neural Networks includes;

1. Design of Artificial Neural Networks
2. Determine the appropriate weight
3. Activation function

The arrangement of neurons into layers and the pattern of connection within and in between layer are generally called as the architecture of the net. There are various type of network architectures:

1. Open Loop
2. Closed Loop
3. Networks that are connected to each other
4. Reverse network

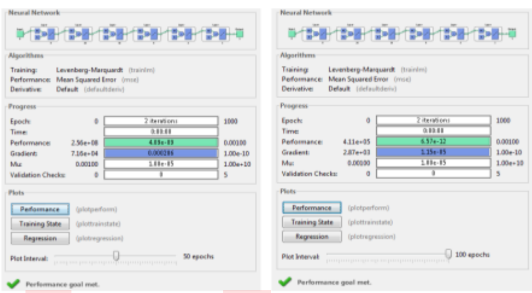

Figure 7, Analyze Artificial Neural Networks with 50 epochs and 100 epochs

Feed forward network works in one layer capacity, where the input is directly connected to the output or multiple layers with the position that is arranged in the removed group. Artificial neural network works using removed groups to make the real value appears in the input position. This application of Artificial Neural Network works quickly and in control on Ultrasonic sensor when an emergency in the area is detected. Block diagram is generally intended to detect objects with Ultrasonic sensor using Artificial Neural Networks and sliding modes.[1] It is shown in Figure 8.

Ultrasonic sensor requires Sliding Mode Control and Artificial Neural Network to demonstrate the reliability of Ultrasonic sensor under optimal working conditions. Sliding mode setting of Artificial Neural Networks is fully empowered to optimal performance with variations in parameters and changes in detected objects [2].

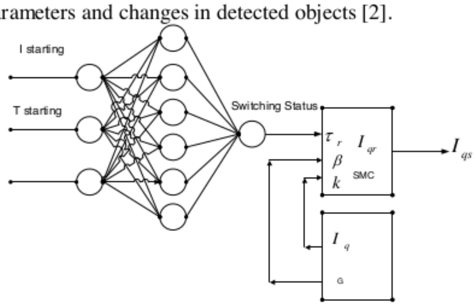

Figure 8. Model diagram of Artificial Neural Network with

Sliding Mode Control

E. *Sliding Mode Control*

Ultrasonic sensor uses Sliding Mode Control to show the reliability of the sliding mode control that works well even in interference conditions. This form of sliding mode control is very strong even though it is interfering with parameter variations and changes in load signals. Figure 9 shows how the block diagram works, Ultrasonic sensor general equation as follows [3] :

$$J\frac{d\omega_m}{dt} + B\omega_m + \tau_1 = \tau_g \quad (1)$$

It is Where J and B are constant and efficient sending and receiving signals on Ultrasonic sensor. Tl is the load distance and ω_m is the angle of load position. Te is sensitivity level of Ultrasonic sensor with equation -5 [4]:

$$\tau_g = 1.5 * \frac{p}{2}(\lambda_{ds} * i_{qs} - \lambda_{qs} * i_{ds} \quad (2)$$

Ultrasonic sensor equations can be transformed on [5]

$$\omega_m + \frac{b}{j} * \omega_m + \frac{\tau_1}{j} = \frac{1}{j} * \tau_g \quad (3)$$

$$\text{where } a = \frac{b}{j}; b = \frac{1}{j}; d = \frac{\tau_1}{j}$$

If the equation Ultrasonic sensor distance is known, then to change the equation if the position of the error equation becomes [6]:

$$\omega_m = -(a + \Delta a) * \omega_m - (d + \Delta d) + (b + \Delta b) * \tau_g \quad (4)$$

$\Delta a, \Delta b$ *and* Δc is fixed in the parameters a, b and c like the parameter arrangement J and B. To determine the equation of the Ultrasonic sensor error, the formula [7] is used:

$$e(t) = \tau_m(t) - \tau_m^*(t) \quad (5)$$

With τ_m^*(t) as sensor reference. If the equation is correct, then the equation becomes the following equation [8]:

$$e(t) = \tau_m(t) - \tau_m^*(t) = -ae(t) + f(t) + x(t) \quad (6)$$

With passive working components of f (t) and x (t) which are indicated by the following equation [9]:

$$f(t) = b\tau_g(t) - a\omega_m^* - d(t) - \omega_m^* \quad (7)$$

X (t) is a change in the working component and is shown in equation-11 [10]:

$$f(t) = b\tau_g(t) - \Delta a\omega_m^* - \Delta d(t) - \Delta b\tau_m^* \quad (8)$$

The sliding mode setting that change frequently with the increasing component is explained in equation -12 [11]:

$$S(t) = e(t) - \int_0^{\tau}(h - a) * e(\tau)d\tau \quad (9)$$

Where h is fixed reinforcement. To determine the rotation flow, the assumption is used and follows the equation -12 [12]:

Assumption-1: The value of h is chosen with (h-0) positive and h > 0, shows the sliding material that is shown in equation -13 [13]:

$$S(t) = e(t) - \int_0^{\tau}(h - a) * e(\tau)d\tau = 0 \quad (10)$$

For switching control request that is directed to sliding mode, The setting of the Ultrasonic sensor distance in detecting objects is shown in equation -14 [14] :

$$f(t) = he(t) - \beta * sgn(S(t)) \quad (11)$$

B is a fixed amplifier switch. S (t) is a sliding variable that is determined by the equation and sgn (.) is a signal function that is defined as follows:

$$sgn(S(t)) = \begin{Bmatrix} +1 \; if \; S(t)>0 \\ -1 \; if \; S(t)<0 \end{Bmatrix} \quad (12)$$

Assumption 2: Amplifier β is also chosen if β ≥ x (t) for all conditions. When the sliding mode matches the sliding mode material, S (t) = S (t) = 0, and tracking error e (t) results in exponential convergence that is close to zero.

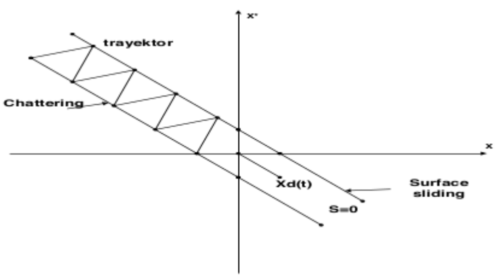

Figure 9. Sliding Mode Chart Diagram

Sliding Mode Control greatly matches the Ultrasonic sensor parameters in equation 4, when assumptions 1 and 2 correspond like the Ultrasonic sensor detection limit shown in equation 11. Sensor detection distance to object ƶm, also error detection sensor tracking e(t) = $ƶ_m$(t) - $ƶ_m^*$ heading towards zero point, Also towards certain conditions. Then resulted Lyapunov stability theory. The function of Lyapunov theory is as follows [15][16]:

$$V(t) = 0.5 * S(t) * S(t) \quad (13)$$
$$V(t) = S(t) * S(t) \quad (14)$$

By using equation 15, it produces the following:

V(t) = S(t)S(t) = S[(-ae + f + x) – (he – ae)]

$$= S[he - \beta sgn(S(t)) + x - he] \quad (15)$$
$$= S[x - \beta sgn(S(t))]$$

Then,

$$\beta sgn(S(t)) \le 0$$

Next, the optimization method with Artificial Neural Network method is used to determine the value of β and h. Artificial Neural Network is working by determining the value of β and h, also the error value toward the convergent value if several changes happen. Overall, Ultrasonic sensor have $ƶe^*$ reference which can determine the value of change by replacing equation 8 to equation 18 as follows [17][18][19]:

$$\tau_g^* = \frac{1}{n}[\![he(t) - \beta sgn(S(t)) + a\omega_m^* + \omega_m^* + d]\!] \quad (16)$$

F. ATMega 8535 Microcontroller

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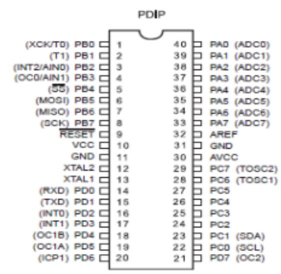
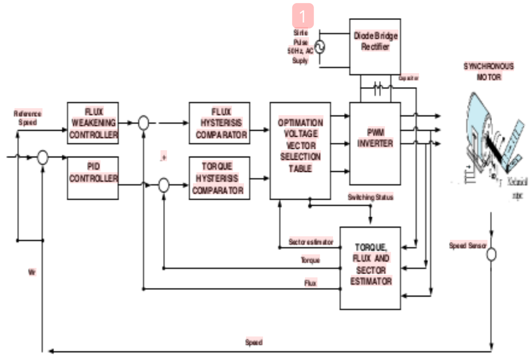


Figure 10. Pin out ATMEGA 8535

Atmel is one of the vendors engaged in microelectronics, has developed AVR (Alf and Vegard's Risc Processor) in 1970. Unlike MCS51, AVR uses RISC (Reduction Instruction Set Computer) architecture which has 8 bits of data width. The difference can be seen from the working frequency. MCS51 has a super working frequency, twelve times the oscillator frequency while the AVR working frequency is the same as the oscillator frequency, AVR speed is twelve times faster than the speed of MCS51. AVR is divided into 4 classes: Attiny, AT90Sxx, ATMega and AT86RFxx. The difference lies only in the features offered, while in terms of architecture and instruction set used almost all the same.

III Block Diagram

In this research will be developed the most accurate and sensitive distance measurement of Ultrasonic sensor using a microcontroller simulated in a mathematical model with Sliding Mode and Artificial Neural Network using the Matlab GUI toolbox. Modeling of an ultrasonic sensor is placed in a mobile robot shown in Figure 10.



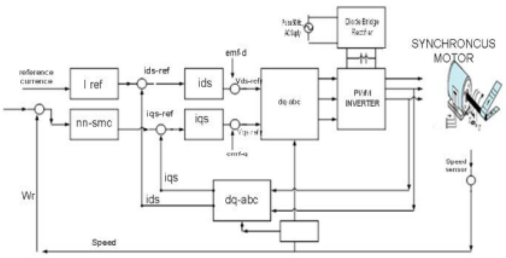


Figure 11. Block diagrams and control diagram models of mobile robots with ultrasonic sensor

IV. RESULT

In the design, the mobile robot that is used is a mobile robot that using the SRF 05 Mode 2 Ultrasonic sensor, where the input trigger and the echo input are located in one circuit. Here is the Ultrasonic timing diagram which has been simplified in its reading.

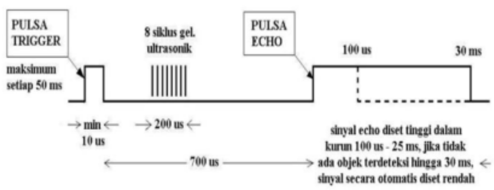


Figure 12, SRF 05 MODE 2 Timing Diagram

TABLE 1, TESTING WITHOUT ARTIFICIAL NEURO NETWORK (ANN) AND SLIDING MODE CONTROL (SMC)

Object Specifications	Distance between Sensor and object	Object detection that has been done
12 cm long, 4 cm wide, 1cm thick	50 cm	The sensor has found the object located in front.

TABLE 2, TESTING WITH ARTIFICIAL NEURO NETWORK (ANN) AND SLIDING MODE CONTROL (SMC)

Object Specifications	Distance between Sensor and object	Object detection that has been done
12 cm long, 4 cm wide, 1cm thick	48.5 cm	The sensor has found the object located in front.

V. CONCLUSION

From the results of the work and research that has been conducted in this final project, several conclusions can be obtained including:

1. The design of the Ultrasonic sensor on the mobile robot has been successfully done.

2. The method used was scanning objects with Ultrasonic Sensor. The accuracy of object detection distance has been obtained at 50 cm with SRF 05 Mode 2 sensor model

3. The accuracy of object detection distance has been obtained at 48.5 cm with the SRF 05 Mode 2 sensor model using JST and SMC

4. Sensor detection has successfully moved the arm to retrieve the object located in front of it.

VI. CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

VII. AUTHOR CONTRIBUTION

Mr. Otong saeful as the first author to conduct research on sensors, harliana as a research assistant in collecting and preparing research needs.

fitro and rudianto contributed in analyzing the data and writing the manuscript for publication. All authors contributed in writing the manuscript and had approved the final version

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Controlling Mobile Robot With Ultrasonic Sensor Using Artificial Neural Networks And Sliding Mode Control

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