

# Performance sensor analysis of HC-SR04 proximity sensor on distance measuring device with fuzzy logic method

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## ABSTRACT

The HC-Sr04 ultrasonic sensor (proximity sensor) is a widely used ultrasonic sensor, in addition to its affordable price also because of its easy use and easy installation. Ultrasonic sensors are electronic devices whose ability can convert from electrical energy into mechanical energy in the form of ultrasonic sound waves. HC-SR04 sensor is one of the ultrasonic sensors that is often used to monitor the distance of objects (objects) with sensors. This sensor consists of a series of ultrasonic transmitters called transmitters and ultrasonic receivers called receivers. The distance that can be handled ranges from 2 cm to 400 cm, with a precision level of 0.3 cm. The detection angle that can be handled is no more than 15°. The required current is not more than 2mA and the required voltage is +5V. The number of pins is 4. In this study, the authors used the fuzzy logic method to help classify the level of distance received by the sensor. Fuzzy logic is used because this method is able to determine the classification results of the received values, according to what is needed by the distance measuring device with this ultrasonic sensor.

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## 1. Introduction

In this modern era, we are found with many new technologies that are increasingly sophisticated and cover human shortcomings, especially in carelessness[1][2]. One of them is the ability of humans to think or determine something simple but can be fatal if it occurs at the wrong time[3]. For example, when you want to park the car, the position in the car makes it impossible for us to be able to look back and forth at once, especially if the object behind is not always visible from the rear windshield of the car, because this requires a sensor to detect the distance between the car and the object behind it to make it easier to park it.

Classifying distances is something that everyone needs to do every day[4][5]. Because determining the proximity of something is a common thing that might be fatal if wrong in its determination[6]. For example, when you park the vehicle but cannot determine whether the distance to the back is still far or close, so the vehicle reverses at irregular speed and hits the wall or other objects behind. This is certainly a loss on every side, both those who hit and those who are hit. Therefore, distance classification is needed to help us determine decisions related to daily distance[7].

The ultrasonic sensor used in this research is HC-SR04[8]. This sensor consists of a series of ultrasonic transmitters called transmitters and ultrasonic receivers called receivers[9][10][11]. The distance that can be handled ranges from 2 cm to 400 cm, with a precision level of 0.3 cm. the detection angle that can be handled is no more than 15°. The current required is no more than 2mA and the voltage required is +5V. The number of pins is 4 [12].

Ultrasonic proximity sensors are proximity sensors that utilize ultrasonic sound waves to detect objects in front of them[13][14]. The way ultrasonic proximity sensors work is the same as the way bats detect objects in front of them[15]. The way it works is that the ultrasonic wave transmitter (transmitter) will emit ultrasonic sound waves, then the ultrasonic waves will be reflected by the object and received ultrasonic reflected waves by the receiver (receiver) on the ultrasonic sensor[16][17]. However, in reality, the object or target does not have the same shape [18].

HCSR04 sensor is an ultrasonic wave-based distance measuring sensor[19][20][21]. The advantage of this sensor is the detection range of about 2 cm to the range of 400-500 cm with a resolution of 1 cm [22][23]. This tool has 4 pins, namely vcc, gnd, trigger, and echo. The vcc pin functions as a 5v power supply and gnd as ground[24][25]. The trigger pin functions to emit a signal from the sensor, and the echo pin is to capture reflections from the trigger [26][27].

This research uses the Fuzzy Logic method. Where fuzzy logic is a problem-solving control system methodology, which is suitable for implementation on the system[28][29][30]. Fuzzy logic is used to estimate things, make decisions, and as mechanical control[28]. In fuzzy sets are known degrees of membership that have a range of values from 0 to 1[31][32]. In contrast to the crisp set with a membership value there are only two possibilities, namely 1 and 0[33][34]. Fuzzy theory provides a mechanism for presenting the size of linguistic variables such as "near", "medium", "far" and so on [35][36].

By providing an in-depth exploration of the innovations and challenges of Deep Learning in agriculture, this research aims to contribute to the ongoing efforts to ensure global food security[37]. By understanding and overcoming the hurdles, we can harness the full potential of Deep Learning in revolutionizing agricultural practices, making them more sustainable, efficient, and resilient to future challenges[38][39][40]. Through this study, we hope to shed light on the transformative power of Deep Learning in securing the food supply and promoting sustainable development for generations to come.

## 2. State of the Art

### Arduino Uno

Arduino Uno is a board that uses an ATmega328 microcontroller. The Arduino Uno has 14 digital pins (6 pins can be used as PWM outputs), 6 analog inputs, a 16 MHz oscillator crystal, a USB connection, a voltage source connector, an ICSP header, and a reset button. Arduino Uno contains everything needed to support a microcontroller[41].

### Ultrasonic Sensor

Ultrasonic sensor is a sensor that functions to convert physical quantities (sound) into electrical quantities and vice versa. Ultrasonic waves are sound waves that have a frequency of 20,000 Hz. Ultrasonic sound cannot be heard by the human ear. Ultrasonic sound can propagate through solids, liquids and gases.

Ultrasonic waves are generated through piezoelectricity with a certain frequency. Piezoelectricity will generate ultrasonic waves (generally 40kHz frequency) when an oscillator is applied to the object. In general, this tool will shoot ultrasonic waves towards an area or a target, after the wave touches the target surface, the wave is reflected back [42].

Hybrid Approaches: The integration of multiple techniques, as proposed in this research, is a promising direction[43]. Researchers have begun to explore hybrid approaches combining fuzzy logic with other methodologies like genetic algorithms or neural networks, showing potential for improving decision-making and adaptability in SCM.

### Ultrasonic Sensor HC-SR04

The HC-SR04 ultrasonic sensor is an ultrasonic sensor that uses a frequency of 40Hz[44]. The HC-SR04 ultrasonic sensor is a sensor that can be used to measure the distance between objects with the HC-SR04 sensor[8]. The ultrasonic sensor HC-SR04 consists of 4 pins, namely Vcc, Trigger, Echo and Ground. The following are the specifications of the HC-SR04 ultrasonic sensor, namely the sensor works at a DC voltage of 5V with a working current of 15mA, working frequency of 40Hz, maximum measurement distance of 4 meters and minimum measurement distance of 2cm, angle measurement of 15 degrees, trigger input signal of 10s TTL pulse [18]. The image of the HC-SR04 Ultrasonic Sensor can be seen in the following figure 1:

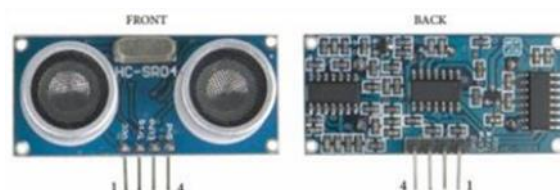


Figure 1. Ultrasonic Sensor HC-SR04[45]

The HC-SR04 ultrasonic sensor emits ultrasonic waves at a frequency of 40 000 Hz that propagate through the air and if there is an object or obstruction in the range of the wave emission, the ultrasonic waves will bounce back to the module. The following is an explanation regarding the calculation of distance between sensors and objects

- The Ping sensor detects the distance of an object by emitting ultrasonic waves
- Ping emits a high output pulse on the SIG pin after emitting ultrasonic waves
- Ping will make the output low on the SIG pin. If reflected waves are detected
- High pulse width (tIN) will correspond to the travel time of the ultrasonic wave for 2x the measuring distance to the object. Then the distance is measured. [27]

### 3. Method

The first step in processing Fuzzy logic contains so-called domain transformations fuzzification[46][47]. The crisp input is transformed into input Fuzzy. To change it, Membership functions must first be determined for each input[48]. Digital logic usually only recognize two clear conditions (crisp), namely: yes or no, 0 or 1 and ON or OFF[49][50]. In contrast to ordinary digital logic, fuzzy logic imitates the method Human thinking uses the concept of the similarity of values[51]. By using fuzzy logic, the values are no longer just 0 or 1, but all then between 0 and 1 [52].

The first step in processing Fuzzy logic contains so-called domain transformations fuzzification[47]. The crisp input is transformed into input Fuzzy[53]. To change it, Membership functions must first be determined for each input [54].

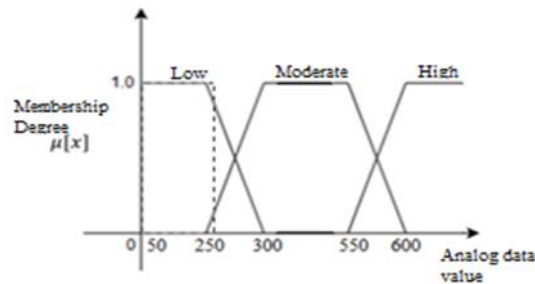


Figure 2. Analog Data Membership

As seen in figure 11, an analog data value of 251 falls into the set of low (descending curve) and medium (ascending curve). The value of the degree of membership can be written as follows:

Low set (descending curve).

$$\mu [x] = 0; x \leq a \text{ or } x \geq d$$

$$(x-a) / (b-a); a < x \leq b$$

$$1; b < x \leq c$$

$$(d-x) / (d-c); c < x < d$$

$$\begin{aligned} \mu [x] &= (d-x) / (d-c); c < x < d \\ &= (300-251) / (300-250); \\ &= 49 / 50 \\ &= 0,98 \end{aligned}$$

Medium set (rising curve)

$$\mu [x] = 0; x \leq a \text{ or } x \geq d$$

$$(x-a) / (b-a); a < x \leq b$$

$$1; b < x \leq c$$

$$(d-x) / (d-c); c < x < d$$

$$\begin{aligned} \mu [x] &= (x-a) / (b-a); a < x \leq b \\ &= (251-250) / (300-250); \\ &= 1 / 50 \\ &= 0,02 \end{aligned}$$

So the set of  $\mu$  analog data values in can be (0.98, 0.02, 0) or low  $\mu [251] = 0.98$ , medium  $\mu [251] = 0.02$ .

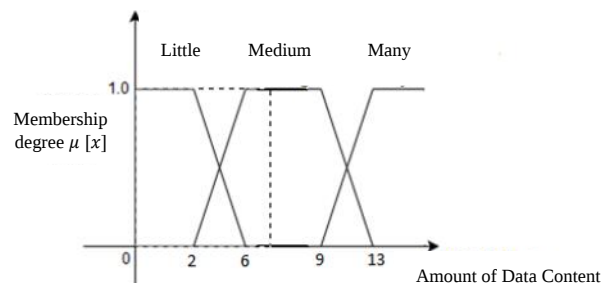


Figure 2. Membership Fill in Data

It can be seen in figure 2 that the value of 7 is on the medium curve (peak), so the degree value can be written as follows:

$$\mu [y] = 0; x \leq a \text{ or } x \geq d$$

$$(x-a) / (b-a); a < x \leq b$$

$1; b < x \leq c$   
 $(d-x) / (d-c); c < x < d$   
 smaller than  $c$  so that the value of  $y$  is 1.

$$\mu [x] = 1 ; b < x \leq c$$

$$\mu [x] = 1$$

Dikarenakan nilai 7 berada pada titik puncak himpunan sedang, maka rumus yang berlaku adalah  $x$  smaller than  $B$  and  $X$  smaller equal to  $C$  so the value of  $y$  is 1.

$$\mu [x] = 1 ; b < x \leq c$$

$$\mu [x] = 1.$$

So the set of  $\mu$  the sum of the data contents in can be  $(0,1,0)$ . After  $\mu$  from the two inputs are obtained, the next stage is to enter the rule evaluation with the minimum comparison method. The minimum comparison is obtained as follows:

$$\begin{aligned} \mu (x \cap y) (1) &= \min [\mu x [\text{Low}] \cap \mu y [\text{Moderate}]] \\ &= \min (0,98 ; 1) \\ &= 0,98 (\text{Very Low}) \end{aligned}$$

$$\begin{aligned} \mu (x \cap y) (2) &= \min [\mu x [\text{Moderate}] \cap \mu y [\text{Moderate}]] \\ &= \min (0,02 ; 1) \\ &= 0,02 (\text{Very Low}) \end{aligned}$$

In this study the author will make so that the results released by the ultrasonic sensor HC-SR04 can be classified into 5 types, namely very close, near, medium, far and very far. To classify the following 5 types of distances using the fuzzy logic method. Because the fuzzy logic method is very suitable to be used in this study as a decision maker of the classification to be divided. In this study, the fuzzy logic method was used as a decision support system to divide the classification of the magnitude of the distance received by the ultrasonic sensor HC-SR04. The following is the process flow carried out in this study:

- Analyze the data value received by the ultrasonic sensor HC-SR04
- Using fuzzy logic methods connected to sensors to classify data.
- Analyze the data received by the sensor and then classify the received data using the fuzzy logic method.

#### 4. Results and Discussion

After the minimum comparative implications have been obtained, the final step is defuzification with the centre of single-ton method.

Table 1. Fuzzy Rule Evaluation.

| Number<br>of Data<br>Data<br>Value |               |               |               |
|------------------------------------|---------------|---------------|---------------|
|                                    | Min<br>(0)    | Medium<br>(1) | Max<br>(0)    |
| Min<br>(0,98)                      | Medium<br>(0) | Max<br>(0,98) | Max<br>(0)    |
| Medium<br>(0,02)                   | min<br>(0)    | Min<br>(0,02) | Max<br>(0)    |
| Max<br>(0)                         | Min<br>(0)    | Min<br>(0)    | Medium<br>(0) |

$$\begin{aligned} \text{decision index} &= (0.98 \times 8) + (0.02 \times 18) / (0.98 + 0.02) \\ &= (7.84 + 0.36) / (1) \\ &= (8.2 / 1) \\ &= 8.2 (\text{Very Near}) \end{aligned}$$

From the results of the theory that has been done, and referred to in the classification table of large levels of distance, the status of the distance level is said to be in the category of very close.

Table 2. Test results of ultrasonic sensors

| Data sensor | Information        |
|-------------|--------------------|
| 0           | No object detected |
| >2          | Object detected    |

Based on the data above, the data above only uses sensors to detect the presence / absence of objects that block the sensor so that it is less effective. Here are the results of the distance level test used using the fuzzy logic method:

Table 3. Test results of ultrasonic sensors using fuzzy logic method

| Mean Data Value | Classification Results |
|-----------------|------------------------|
| 0-299           | Very close             |

| Mean Data Value | Classification Results |
|-----------------|------------------------|
| 300-349         | Near                   |
| 350-599         | Keep                   |
| 600-649         | Far                    |
| 650-700         | Very far away          |

Based on research that has been done to build algorithms with the support of fuzzy logic methods, the data generated by the ultrasonic sensor HC-SR04 can result in a better classification compared to without fuzzy logic methods. By adding input data used as a determining variable for distance classification, it can be said that the data can be utilized properly with maximum work. Classification by utilizing only a range of distance values has drawbacks such as a difference of 1 certain value in a condition can affect the results. Classification of distances that are considered unfair. For example, 1-99 is a short range and 100-200 is a medium range. The distance between 99 and 100 is only 1 but even if the distance will result in a different classification, this is considered ineffective and may lead to countermeasures errors depending on the type of ultrasonic sensor system applied. With fuzzy logic methods, distance classification can be done better and reduce the risk of data errors, so that the cause and effect that will be carried out from that distance will be more targeted and effective.

## 5. Conclusions

This This Based on the research that has been done, several conclusions are outlined as follows: Fuzzy logic method can be used for classification needs of data taken from ultrasonic sensor HC-SR04 using Arduino Uno microcontroller. The use of delays on the sensor can result in data not being successfully received because the sensor may detect data while it is still in the process of delay. With fuzzy logic methods, the resulting data will be more accurate and can take into account many variables that determine the results of a data.

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