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Fuzzy Logic Algorithm Optimization for Safe Distance Control on Arduino-Based Reverse Parking System and SRF04 Sensor

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ABSTRACT

This research aims to develop a smart parking system that can accurately control the distance between vehicles and obstacles during reverse parking maneuvers. By integrating fuzzy logic algorithms into the system, this study seeks to improve the precision and reliability of distance control, thereby improving the overall safety of parking operations. The utilization of the Arduino platform and the SRF04 sensor allows real-time data processing and accurate distance measurement, i.e. this research contributes to the effectiveness of the proposed system. The results show that the fuzzy system successfully classifies parking distance conditions into three categories: Safe, Caution, and Danger, based on data from two ultrasonic sensors. Visualization in the Surface Viewer in MATLAB confirms that the optimal parking distance is highly dependent on the values obtained from the two sensors. The application of fuzzy logic optimization in this context is expected to provide a powerful solution for safe reverse parking, offering potential benefits in terms of comfort and accident prevention in parking scenarios, especially for cars that still do not have obstacle detection sensors at the rear of the car.

Keywords: Smart Parking, Fuzzy Logic, Arduino Sensor

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INTRODUCTION

In terms of automotive technology, more and more new cars have applied cutting-edge technology. Parking sensor systems are one of the increasingly popular technologies. The goal is to help drivers make it easier to park safely. Even with the widespread use of parking sensors in many newer car models, there are still many cars on the streets that still do not have parking sensors with a large percentage. A huge number of drivers face difficulties when parking in confined spaces because most vehicles do not have parking sensors, especially in metropolitan areas where parking spaces are scarce.

A parking sensor system is a tool that can help drivers measure the distance between their vehicle and the obstacles around them, such as walls, sidewalks, or other vehicles. By providing warnings in the form of sound and visuals, parking sensors help drivers avoid collisions and help facilitate precise parking. This system typically uses a proximity sensor mounted on the rear bumper of the vehicle to detect adjacent objects. As the driver approaches an obstacle, the sensor emits ultrasonic waves that bounce back when it hits the obstacle, allowing the system to calculate the distance and provide an alert at the right time(Dayus et al., 2022; Perdana et al., 2022; Pindrayana et al., 2018; Yudha & Sani, 2017).

The development of smart parking systems has been a major focus in recent research efforts, with the aim of improving the efficiency and safety of parking operations. Several studies have investigated new solutions that incorporate technologies such as the Arduino platform, sensors, and intelligent algorithms to optimize the parking process (Nosaria, 2023; Nandyal et al., 2017; Mahboob et al., 2020). However, there is a significant gap in the field of reverse parking systems, especially in ensuring safe distance control during maneuvers, especially for vehicles without rear obstacle detection sensors (Katanalp et al., 2019).

This research aims to address this gap by proposing a novel approach that integrates fuzzy logic algorithms into an Arduino uno-based reverse parking system equipped with an SRF04 sensor. Through the use of fuzzy logic optimization, this research seeks to improve the precision and reliability of distance control, thereby improving the safety of reverse parking operations. The realtime data processing capabilities of the Arduino platform and the accurate distance measurement provided by the SRF04 sensor further enhance the effectiveness of the proposed system (C, Santhosh et al., (2023). This research not only introduces fuzzy logic sensor devices for safe distance control during reverse parking, but also offers potential benefits in terms of comfort and accident prevention in parking scenarios, thus making a valuable contribution to the field of smart parking systems.

Previously there was research conducted in the same field which can be observed in table 1.

Table 1. Comparison of Previous Research Results

Researcher's Name/Year	Title	Research result	Equation	Difference
Dayus, Azhar Robbi Hutagalung, Jhonson Efendi Harahap, Indra Ramadona/2022	Application of Electric Car Braking and Parking System Using Arduino UNO-Based Ultrasonic Sensor	Making braking devices by utilizing arduino uno, distance sensors, servos, and buzzers as obstacle detection.	The use of arduino and distance detectors applied to cars.	The study did not use the fuzzy method and the placement of the sensors was not the same on 4 sides
Pindrayana, Kadek Indra Borman, Rohmat Prasetyo, Bagas Samsugi, Samsugi/2018	Prototype Car Parking Guide With Human Voice Output Using Arduino Uno Microcontroller	Making a prototype device on a toy car by utilizing arduino uno, distance sensor, Pear sensor, led, and buzzer as obstacle detection.	Utilization of arduino, distance detector and buzzer.	The study did not use the fuzzy method and the placement of sensors was not the same on the back, right and left sides.
Perdana, Adzriel Thoriq Helyo Irawan, Denny Astutik, Rini	Design and Build Car Parking Guidance System Using	Creating a prototype device using the Atmega Microcontroller, using a proximity	Utilization of Microcontroller, distance and sound detector	The study did not use the fuzzy method and the sound used human

Puji/2022	Ultrasonic and Sound Instruments	sensor and m3player support as a sound player.		recorded voices as parker guides.
Yudha, Putra Stevano Frima Sani, Ridwan Abdullah/2017	Implementation of HC-SR04 ultrasonic sensor as arduino-based car parking sensor	Prototype of an ultrasonic sensor-based car parking aid	Utilization of Microcontroller, buzzer and LCD distance detector	The study did not use the fuzzy method and focused more on distance accuracy on sensor readings.
Savitri, chyntia eka, Paramytha, nina, 2022	Esp32 Microcontroller-based Car Parking Monitoring System	Prototype of car parking monitoring based on application sensor	Discussing the parking system with the utilization of the Esp32 microcontroller	The study did not use the fuzzy method and did not discuss the parking system in cars

Source : Previous Research

Several studies in table 1 show the lack of use of fuzzy applied to the parking system. Therefore, this study is for the development of the previous research, the use of the fuzzy algorithm used in order to improve the accuracy of the classification of the JarakAman category during parking conditions. The use of fuzzy will use fuzzy inference as carried out in research (Choiri et al., 2022).

METHOD

In this method, there are several stages in the research process carried out, which are as follows:

A. Problem

Analyze the problems that have been defined, then look for some supporting arguments from various relevant sources that can be used as a reference with the aim of finding a relationship between each other and finding what is the right solution for the research carried out. So that the right case study can be found for the research to be taken. This study will examine the problem of accuracy of safe distance classification in a smart parking system based on fuzzy logic, optimization of fuzzy algorithms for ultrasonic sensor data processing, and challenges in integrating Arduino technology and SRF04 sensors for real-time systems. Classification accuracy is very important to reduce the risk of accidents, while optimization of fuzzy algorithms is needed so that the system can provide accurate and fast recommendations. In addition, challenges in technology integration also need to be overcome to ensure the system can operate in real-time. This study will also include system testing and validation in various environmental conditions to ensure system reliability in the field. This study will be supported by various relevant sources that discuss the application of fuzzy logic, technology integration, and testing techniques in similar contexts, so that the right solution can be formulated.

B. Observational Data Collection

Collects dataset of each component that supports the work process of the system. This is intended to find the standard value that each variable has so that on the basis of this reference it can facilitate the collection of subsequent data. As well as looking for various research sources and other sources as research support as literature and theory reviews.

C. Fuzzy System Analysis

Analyze and simulate the fuzzy system of the research to be carried out and look for several papers or reference sources that will be used as decision support in this study by comparing with each previous trial. whether the system can be applied to the system or not so that the results can be applied as expected.

D. Fuzzy System Design

Designing fuzzification components in the formation of variables and fuzzy sets for each variabe as shown in table 2.

Table 2. Variable and Fuzzy Set

Variable	Fuzzy Set	Domain
	SangatDekat	[0, 0, 20, 80]
SensorUltra1	Dekat	[40, 80, 120]
	Jauh	[100 140 200 300]
	SangatDekat	[0, 0, 20, 80]
SensorUltra2	Dekat	[40, 80, 120]
	Jauh	[100 140 200 300]
	Bahaya	[0, 0, 30 60]
JarakAman	Hati-Hati	[30, 60, 90]
	Aman	[80, 100, 150]

Source : Research (2024)

The next step is the formation of an input membership function on each variable with each having 3 fuzzy sets, namely VERY CLOSE, CLOSE, and FAR while the Output has 1 variable with 3 fuzzy sets, namely DANGER, CAUTION and SAFE. The following is the form of the fuzzy input and output variables:

- SensorUltra1 (Sensor Ultrasonic 1)

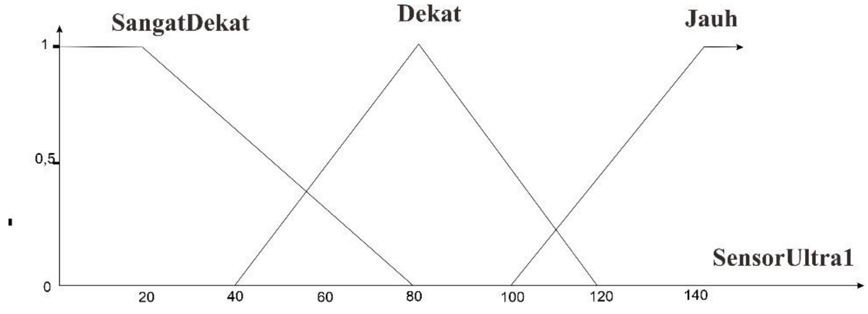

Figure 1. Ultrasonic Sensor Membership Function 1
Source : Research (2024)

Therefore, the formation of the membership function of ultrasonic sensor 1 is as shown in the following table 3:

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Table 3. Ultrasonic Sensor Membership Function 1

Membership	Function Set	
µaSangatDekat(x)	**{(1;(80 - x)/(80 - 20);0;)** $x \leq 20$, $20 \leq x \leq 80$, $x \geq 80$	(1)
µaDekat(x)	**{(0; (x-40)/(80- 40); (120-x)/(120 - 80);)** **x ≤ 40 atau x ≥ 120, 40 ≤ x ≤ 80, 80 ≤ x ≤ 120**	(2)
µaJauh(x)	**{(0; (x-100)/(140 - 100); 1;)** **x ≤ 100, 100 ≤ x ≤ 140, x ≥ 140**	(3)

Source : Research (2024)

- SensorUltra1 (Sensor Ultrasonic 2)

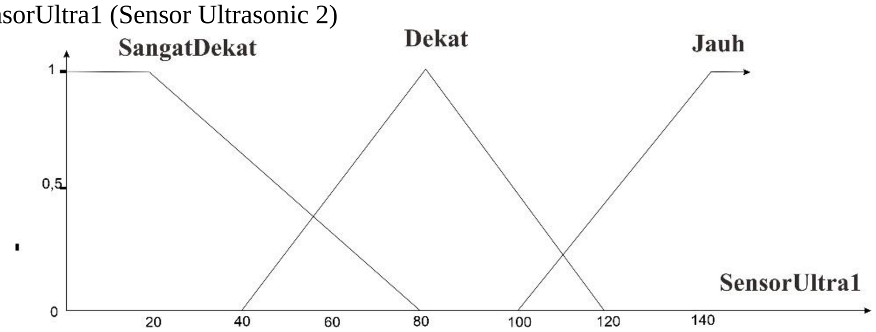

Figure 2. Ultrasonic Sensor Membership Function 2
Source : Research (2024)

Then the formation of the Ultrasonic Sensor 2 membership function is as shown in the following table 4

Table 4. Ultrasonic Sensor Membership Function 2

Membership	Function Set	
µbSangatDekat(x)	**{(1;(80 - x)/(80 - 20);0;)** $x \leq 20$, $20 \leq x \leq 80$, $x \geq 80$	(4)
µbDekat(x)	**{(0; (x-40)/(80- 40); (120-x)/(120 - 80);)** **x ≤ 40 atau x ≥ 120, 40 ≤ x ≤ 80, 80 ≤ x ≤ 120**	(5)
µbJauh(x)	**{(0; (x-100)/(140 - 100); 1;)** **x ≤ 100, 100 ≤ x ≤ 140, x ≥ 140**	(6)

Source : Research (2024)

- JarakAman (Output Fuzzy)

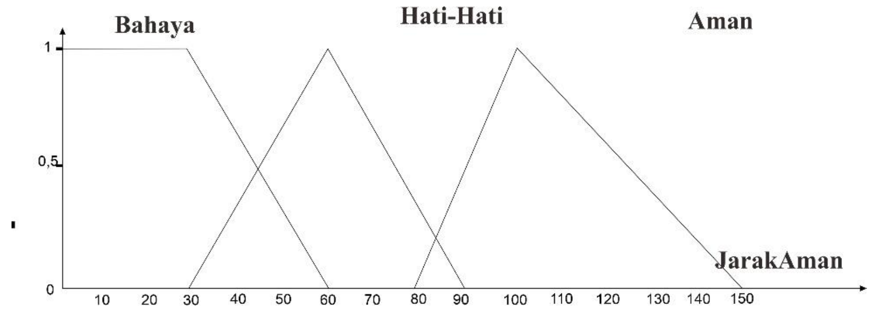

Figure 3. Distance Membership Function Fuzzy Output Safe
Source : Research (2024)

Therefore, the formation of the membership function of the Fuzzy Output Distance is as shown in the following table 5:

Table 5. Distance Membership Function Fuzzy Output Safe

Membership	Function Set	
µBahaya(x)	**{(1;(60 - x)/(60 - 30);0;)** $x \leq 30,\ 30 \leq x \leq 60,\ x \geq 60$	(7)
µHatiHati (x)	**{(0; (x-30)/(60- 30); (90-x)/(90 - 60);)** **x ≤ 30 atau x ≥ 90, 30 ≤ x ≤ 60, 60 ≤ x ≤ 90**	(8)
µAman(x)	**{(0; (x-80)/(100- 80); (150-x)/(150 - 100);)** **x ≤ 80 atau x ≥ 150, 80 ≤ x ≤ 100, 100 ≤ x ≤ 150**	(9)

Source : Research (2024)

The next process is the formation of the fuzzy design as shown in "Fig. 4" according to the specifications described in table 2. Fuzzy's design consists of 2 inputs and 1 output. Then the fuzzy output result is forwarded to the sound and the Danger, Caution and Safe text information is displayed to the LCD.

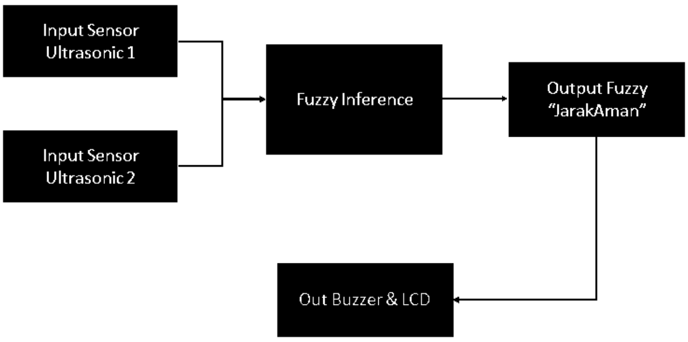

Figure 4. Desain Fuzzy Inference
Source : Research (2024)

So based on several categories that refer to the fuzzy set data, rules can be formed in the form of rules that will be applied to the Fuzzy Parking System which consists of 9 rules as follows:

R[1] IF (SensorUltra1 is SangatDekat) AND (SensorUltra2 is SangatDekat) THEN (JarakAman is Bahaya)
R[2] IF (SensorUltra1 is Dekat) AND (SensorUltra2 is Dekat) THEN (JarakAman is HatiHati)
R[3] IF (SensorUltra1 is Jauh) AND (SensorUltra2 is Jauh) THEN (JarakAman is Aman)
R[4] IF (SensorUltra1 is SangatDekat) AND (SensorUltra2 is Dekat) THEN (JarakAman is Bahaya)
R[5] IF (SensorUltra1 is Dekat) AND (SensorUltra2 is SangatDekat) THEN (JarakAman is Bahaya)
R[6] IF (SensorUltra1 is SangatDekat) AND (SensorUltra2 is Jauh) THEN (JarakAman is Bahaya)
R[7] IF (SensorUltra1 is Jauh) AND (SensorUltra2 is SangatDekat) THEN (JarakAman is Bahaya)
R[8] IF (SensorUltra1 is Dekat) AND (SensorUltra2 is Jauh) THEN (JarakAman is HatiHati)
R[9] IF (SensorUltra1 is Jauh) AND (SensorUltra2 is Dekat) THEN (JarakAman is HatiHati)

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E. Hardware and Software Design

Designing the parking system module starting from hardware and software design, in "Fig. 5" the following is a general overview that can be applied with the Fuzzy Inference method. There are 3 inputs from the system as a whole but what fuzzy processes is only 2 inputs from the ultrasonic sensor. The fuzification process is carried out in the arduino nano microcontroller and then it will display the fuzification results to the 16x2 LCD and emit a warning sound from a different buzzer according to the fuzzy set on the JarakAman output. When the obstacle is still "Safe", the sound will sound once every 3-second time interval, if it is in the "Careful" category, it will sound once every 1-second time interval, while for the "Dangerous" category, it will sound once every 0.5 second time interval. The system's 5V power source is taken from the USB on the car used.

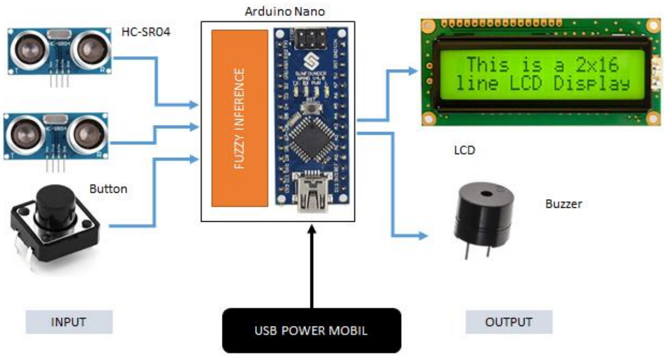

Figure 5. Overview of Fuzzy Parking System
Source : Research (2024)

The overall design of the sensor sensor will be installed on the back of the car with a width of 1.7 meters. The placement method is to look at the scanning area owned by the ultrasonic sensor used. So the midpoint of the rear car is measured and then added about 42 cm in the right and left directions for the placement of the unultrasonic sensor used as shown in figure 6.

Figure 6. Fuzzy Parking System Installation
Source : Research (2024)

F. Testing

Testing is carried out on cars that do not have parking sensors to find out if the system can run properly, detect obstacles and provide indicators that are compatible with the Simulink fuzzy application.

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RESULTS AND DISCUSSION

Discussion of the fuzzification process of several input variables and Sample selected data taken from random data in table 6 which is used in the example of a case discussion of sensor readings in one of the conditions.

Table 6. Sensor Reading Case Study Data

SensorUltra1	SensorUltra2	JarakAman	
107	176	72	HatiHati

Source : Research (2024)

A. Calculating Sets on Input Variables

The calculation process is mathematically carried out using the formula in table 3 to find the degree of membership in each set against the fuzzy sensor input variable. So the result is as in the following table X.

Table 7. Membership Degree Fuzzy Input Value

Variable	Fuzzy Set	Degree of Membership $\boldsymbol{\mu(x)}$
SensorUltra1	$\mu aDekat(107)$	0.325
	$\mu aJauh(107)$	0.175
SensorUltra2	$\mu bJauh(176)$	1
JarakAman	$\mu HatiHati(72)$	0.867

Source : Research (2024)

B. Fuzzy Operator Implementation

Then apply the calculation of the MAX method of the function with implications on the rule using the MIN function.

R[8] IF (SensorUltra1 is Dekat) AND (SensorUltra2 is Jauh) THEN (JarakAman is HatiHati)

α_8 = min(µaDekat(107), µbJauh(176), µBahaya(36))
= min(0.325, 1, 0.867)
= 0.325

C. Function Implications

In the descending linear representation part, it must be calculated to find the value x of the HatiHati value of the YarakAman output membership from the formula in table 5 in the HatiHati category. Calculation of the 8th rule:

α_8 = 0.325

Ascending Linear Representation

0.325 = (x-30)/(60-30)
0.325 = (x-30)/30
0.325 = (x/30)-1
x = 39,75

Down Linear Representation

0.325 = (90-x)/(90-60)
0.325 = (90-x)/30
0.325 = 3 – (x/30)
x = 80,25

C. Compose All DistanceSafe Outputs

The result of the calculation of the 8th rule has determined that x of the linear representation up = 39.75 and the linear representation of the down = 80.25. then the calculation can determine the membership function in the HatiHati set from equation (8). then it can look for the area and moment of the implication area for the defuzzification process.

Table 8. Membership Function of the HatiHati Set Output

Variabel	Himpunan Fuzzy	
μ_SFJarakAman (x)	0; (x-30)/(60- 30); 0,325; (90-x)/(90-60; {0; 0,03x-1; 0,325; 3-0,03x;}	(10)
	x ≤ 30 atau x ≥ 90, 30 ≤ x ≤ 60, 0,325, 60 ≤ x ≤ 90	

Source : Research (2024)

D. Deffuzification

The next step is to calculate the moment and area as follows;

1. Calculating Area

A1 = ((39,75 - 30) X 0.325)/2= 1,584375
A2 = ((80,25 - 39,75) X 0.325)= 13,1625
A3 = ((90 – 80,25) X 0.325)/2= 1,584375

2. Counting Moments

Perform integral calculations to find the following moments:

- $M1 = \int_{30}^{39,75} (\mathbf{0,03x - 1}) z\, dz = \mathbf{368,06}$
- $M2 = \int_{39,75}^{80,25} (\mathbf{0.325}) z\, dz = \mathbf{789,75}$
- $M3 = \int_{80,25}^{90} (\mathbf{3 - 0,03x}) z\, dz = \mathbf{18,04}$

3. Centroid Functions

Then after the area and moment have been calculated, then we can calculate the center point (Centroid) can be obtained from:

Z* = (M1+M2+M3)/(A1+A2+A3)
= (368,06 + 789,75+ 18,04)/(1,584375+13,1625 +1,584375)
= 1175,85/16,33125
= 72

So the result of R[8] = IF (SensorUltra1 is Near) AND (SensorUltra2 is Far) THEN (Distance: Safe is Careful) is with a value of 72.

E. Testing

1. System Testing

This test is carried out to determine the performance of the fuzzy inference system and to find out whether it is in accordance with the rules that have been made. Table 9 shows that the system test for the condition that one detects an obstacle and the other sensor does not detect an obstacle in a short distance.

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Table 9. Test Data

Sensor Ultrasonic 1	Sensor Untrasonic 2	Output Fuzzy	
200	195,5	93,7	Aman
186,2	195,5	93,7	Aman
164,2	195,2	93,7	Aman
144	195,5	93,7	Aman
127,5	195,1	93,1	Aman
111	195,2	68,2	HatiHati
87,16	180,9	60,1	HatiHati
70,64	180,9	53,3	HatiHati
50,46	179	36,6	Bahaya
37	175,5	24,8	Bahaya

Source : Research (2024)

The data in Table 9 shows the results of the system testing of the various detection distances generated by the two ultrasonic sensors. The system successfully classifies environmental conditions into three categories, namely Safe, Careful, and Hazard, based on the combination of the detection distance of the two sensors. The closer the detection distance to the obstacle, the higher the level of danger indicated by the system.

2. Simulink Fuzzy

Surface Viewer is one of the important components in the Fuzzy Logic Toolbox in MATLAB. Its function is to provide a three-dimensional visualization of the relationship between input and output in a fuzzy inference system.

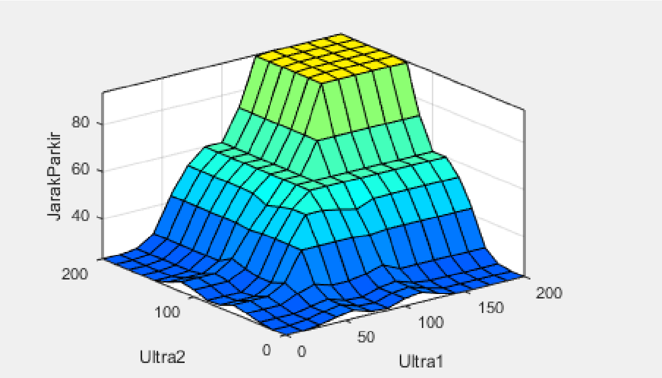

Figure 7. Surface Viewer Fuzzy Parking System
Source : Research (2024)

The surface image in figure 7 presents a visual representation of the relationship between two inputs (Ultra1 and Ultra2) and one fuzzy output (Parking Distance). This visualization is very useful for understanding how fuzzy systems process data from ultrasonic sensors to determine optimal parking distances. It can be observed that the ideal parking distance is highly dependent on the values obtained from both ultrasonic sensors.

CONCLUSION

This study successfully showed that the fuzzy inference system developed was able to classify safe distance conditions with good accuracy based on data from two ultrasonic sensors. The test results show that the system can clearly distinguish between Safe, Caution, and Hazard conditions. and

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The use of fuzzy logic algorithms in reverse parking systems has proven to be effective in helping drivers monitor safe distances during the parking process, which improves safety and reduces the risk of accidents. As well as the utilization of the SRF04 ultrasonic sensor in combination with Arduino as the main controller proves that this technology can be well integrated to create a reliable safe distance warning system in vehicle parking situations.

REFERENCES

C, Santhosh., M, Thilakkumar., J, Joyce Jacob. (2023). Smart car parking system. International Journal for Multidisciplinary Research, 5(5). https://doi.org/10.36948/ijfmr.2023.v05i05.8275

Choiri, A. F., Sains, I., Teknologi, D., Sains, I., Teknologi, D., Chandra, F. H., Sains, I., & Teknologi, D. (2022). Sistem IoT Berbasis Fuzzy Inference Engine Untuk Penilaian Kualitas Udara Dalam Ruangan. Jurnal Teknologi Informasi Dan Terapan (J-TIT), 9(2), 101–110.

Dayus, A. R., Hutagalung, J. E., & Harahap, I. R. (2022). Penerapan Sistem Pengereman dan Parkir Mobil Listrik Menggunakan Sensor Ultrasonik Berbasis Arduino UNO. *J-Com (Journal of Computer)*, *2*(2), 101–106. https://doi.org/10.33330/j-com.v2i2.1728

Katanalp, B., Nennioğlu, A., Özinal, Y., Eren, E., & Yıldırım, Z. (2019). Engelli bireylere ayrilmiş park yeri işgallerinin önlenmesine yönelik bir tasarim: ceps (caydirici engelli park sistemi). Eskişehir Osmangazi Üniversitesi Mühendislik Ve Mimarlık Fakültesi Dergisi, 27(3), 242-251. https://doi.org/10.31796/ogummf.594213

Mahboob, K., Rehman, I., Ali, M., Khan, M., & Nazir, M. (2020). Development of android controlled arduino based intelligent car parking system. International Journal of Wireless and Microwave Technologies, 10(1), 48-61. https://doi.org/10.5815/ijwmt.2020.01.05

Nandyal, S., Sultana, S., & Anjum, S. (2017). Smart car parking system using arduino uno. International Journal of Computer Applications, 169(1), 13-18. https://doi.org/10.5120/ijca2017914425

Nosaria, A. (2023). Navigation and reservation based smart parking platfrom for smart cities. International Journal for Research in Applied Science and Engineering Technology, 11(5), 2200-2205. https://doi.org/10.22214/ijraset.2023.51780

Perdana, A. T. H., Irawan, D., & Astutik, R. P. (2022). Rancang Bangun Sistem Pemandu Parkir Mobil Menggunakan Ultrasonic Dan Instrumen Suara. *E-Link: Jurnal Teknik Elektro Dan Informatika*, *17*(2), 26. https://doi.org/10.30587/e-link.v17i2.4641

Pindrayana, K., Indra Borman, R., Prasetyo, B., & Samsugi, S. (2018). Prototipe Pemandu Parkir Mobil Dengan Output Suara Manusia Mengunakan Mikrokontroler Arduino Uno. *CIRCUIT: Jurnal Ilmiah Pendidikan Teknik Elektro*, *2*(2), 71–82. https://doi.org/10.22373/crc.v2i2.3705

Yudha, P. S. F., & Sani, R. A. (2017). IMPLEMENTASI SENSOR ULTRASONIK HC-SR04 SEBAGAI SENSOR PARKIR MOBIL BERBASIS ARDUINO. *Jurnal Einstein*, *5*(3), 19–26. http://jurnal.unimed.ac.id/2012/index.php/inpafie-issn:2407-747x,p-issn2338-1981