FUZZY LOGIC CONTROLLER FOR CAPACITY MONITORING ON TRASH CAN BASED ON HEIGHT AND WEIGHT USING ULTRASONIC AND HX711 SENSOR

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ABSTRACT

Until now, waste management in an environment has not been evenly distributed in various countries. In fact, poor waste management can lead to negative things such as the emergence of several diseases. Therefore the automatic opening feature and monitoring system is a good thing to complete a trash can. Weight sensors and ultrasonic sensors can assist performance in part monitoring. The pear sensor will assist in detecting human movement, then closing the trash can will be moved with the help of a servo. A monitoring system with the help of fuzzy logic to determine the value of the obscurity will help in this regard. These main features will certainly help in improving waste management in an environment.

Keywords: Smart Trash Can, Fuzzy Mamdani, Fuzzy logic

INTRODUCTION

According to the news on internet written by Silmi Nurul Utami [1], Human life is inseparable from the existence of waste. Plastic bags, food and beverage wrappers, used clothes, damaged furniture, as well as leftovers or spoiled food are all waste. Reporting from the World Bank Group, Indonesia produces 175,000 tons of waste every day and 20% of it ends up in rivers and beaches. Not only in Indonesia, all countries in the world also produce waste every day. Organic waste such as paper, food scraps, and wood can be degraded in not too long. However, plastic waste is very difficult to degrade in the lifespan of up to hundreds of years! Waste reduction is carried out intensively, for example from supermarkets which now do not provide plastic bags so buyers bring their own bags. The accumulation of garbage in a place is of course related to environmental quality. Garbage that accumulates irregularly will reduce the quality of the cleanliness of an environment However, if the waste management in an environment is carried out properly, it will improve the quality of the environment, for example a decrease in the number of victims affected by diseases caused by garbage. Because according to the article written by Mitra Tarigan [2] from gaya.tempo.co, the bad effects of littering are diseases such as tetanus, hepatitis A, intestinal worms, dengue fever, food poisoning, skin infections, trachoma. There are also salmonella infections, shigellosis, gastroenteritis. Diseases such as hepatitis A and dengue fever are highly contagious. The smart waste that I designed here will certainly improve the quality of waste management in an area. With this automatic trash lid opener, of course, there will be direct contact between the trash can and humans. Why avoid direct contact with trash? By touching any part of the waste, of course, there will be bacteria or germs attached, because the garbage is a nest

for these objects. In addition, if we can monitor the fullness of our trash cans, the trash will be more useful and the trash will not be scattered everywhere. Pear sensor will help me in dealing with people who come close to the smart trash I make. I'll also be using the monitoring feature to help create this smart trash can. If we know our trash is full, then we'll throw it in the next trash can. What I often encounter is that when people see that the trash can is full and want to take out the trash, they will still throw the trash in the lid or around the trash, which causes a decrease in the cleanliness level of an environment. Therefore the monitoring feature here will be useful to complement this smart trash can.

LITERATURE STUDY

After I read several journals related to the project I wanted to make, I felt that the pirr sensor that I chose from the beginning here was indeed the most appropriate. Because if there is an inanimate object sitting in front of this trash can for a long time, then the trash can will always be open. If you use a PIR sensor, it will certainly be more optimal in detecting human movement. For the weight sensor here, I think it is very necessary because if the trash can is overweight, damage can also occur from the trash can, even though from several journals I read most do not use weight sensors.

ARDUINO NANO

Arduino Nano is a microcontroller board that is small, complete and supports the use of breadboards. Arduino Nano is based on the ATmega328 (for Arduino Nano version 3.x) or Atmega 16 (for Arduino version 2.x) microcontrollers.

Figure 1.1 Picture of arduino nano

HC-SR501 PIR MOTION SENSOR

HC-SR501 PIR Motion Sensor Human Motion. This PIR Sensor module allows to detect human movement within a certain distance. This small size sensor is very easy to use. Output LOW if motion is detected and output HIGH if not detected. PIR sensor or also called Passive Infra Red is a sensor that is used to detect the presence of infrared rays from an object. As the name implies, the PIR sensor is passive, which means that this sensor does not emit infrared light but can only receive infrared radiation from the outside. The PIR sensor can detect radiation from various objects and because all objects emit energy, for example a motion is detected from an infrared source with a certain temperature, namely humans trying to pass through another infrared source such as a wall, the sensor will compare the infrared emission received by each unit. time, so that if there is movement there will be a change in reading on the sensor.

Figure 1.2 Pir motion sensor

HC-SR04 ULTRASONIC DISTANCE MEASURING TRANSDUCER SENSOR

The ultrasonic sensor type HCSR04 is a device used to measure the distance from an object. The range of the measurable distance is about 2-450 cm. This device uses two digital pins to communicate the read distance. Ultrasonic sensor is a sensor that works based on the principle of reflection of sound waves and is used to detect the presence of a certain object in front of it, its working frequency is in the area above the sound wave from 40 KHz to 400 KHz.

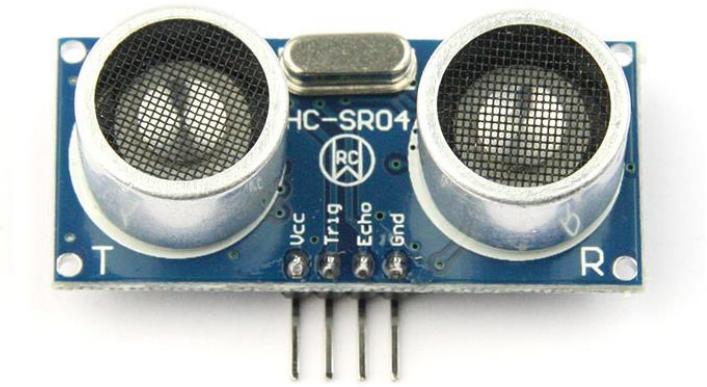

Figure 1.3 Picture of ultrasonic sensor

LOAD CELL – 5KG, STRAIGHT BAR (TAL220B)

Load Cell is an electromechanical device commonly called a Transducer, which is a force that works based on the principle of deformation of a material due to a working mechanical stress, then converts the mechanical force into an electrical signal. Changes in electrical voltage depending on the pressure that comes from loading. The load cell sensor contains a strain gauge, which is an electronic component used to measure pressure. The strain gauge is configured to be a Wheatstone bridge circuit. The Wheatstone bridge consists of four resistors in series and in parallel. Ultrasonic sensors will be used to measure the height of the garbage in this trash can.

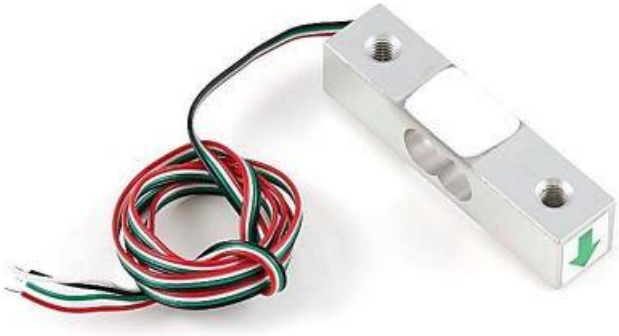

Figure 1.4 Picture of load cell

SERVO MG996R

Servo motor is a device as a rotary actuator (motor) which is designed with a closed loop feedback control system (servo), so that it can be adjusted or adjusted to determine and ensure the angular position of the motor output shaft. The servo in this trash can will function as a driver so that the lid of the trash can is opened automatically.

Figure 1.5 Picture of Servo MG996R

Fuzzy Mamdani

Fuzzy Mamdani was first proposed by Ebrahim Mamdanix in 1975. The Mamdani method is also often used in applications because of its simple structure, using the MIN-MAX method. The Fuzzy Mamdani method has 4 stages, namely:

1. Fuzzyfication

   The formation of the membership function of the input variables to be used.
2. The formation of rules in the form of IF THEN

   Create a rule using IF....THEN which will be used to determine the fuzzy output.
3. Inference Engine

   Apply the implication function by using the MIN operation and the composition between the rules by using the MAX operation which results in a conclusion in the form of a value.
4. Defuzzyfikasi

After getting the conclusion value from the inference engine process, it will then be calculated using the centroid method.

a. Centroid method

This method is often referred to as the Center of Area or Center of Gravity. The formula for calculating crisp in this method is as follows:

$$x^* = \frac{\int y\, \mu_{\mathrm{R}}(x)\mathrm{dq}}{\int \mu_{\mathrm{R}}(x)\mathrm{dq}}$$

Keterangan simbol diatas adalah :

x^* : nilai *crisp*

$\mu_{\mathrm{R}}(x)$: derajat keanggotaan dari y

DESIGN

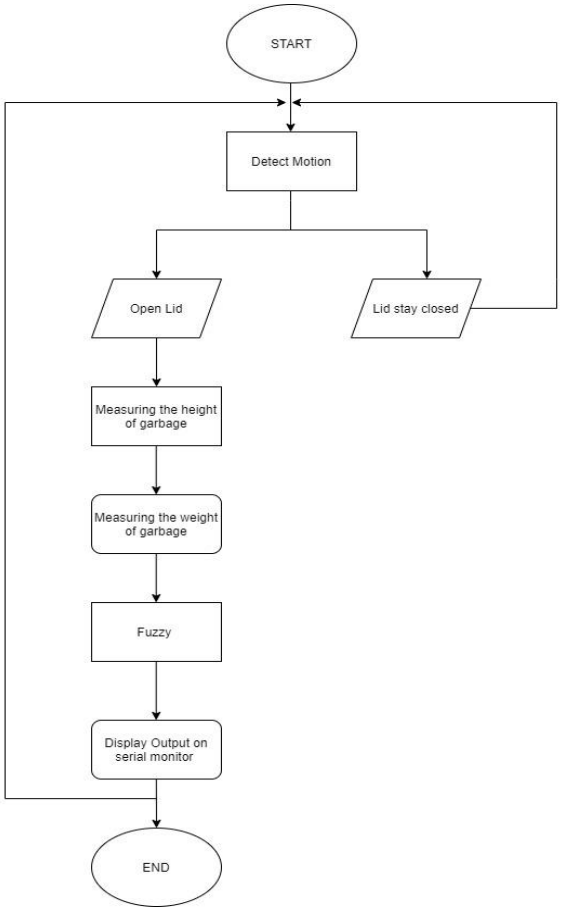

Figure 1.6 Flowchart

This trash can detects it first using the PIR Motion Sensor HC-SR501. If the PIR sensor detects motion, the Servo MG996R will make the trash can lid open. If the sensor does not detect any movement, the trash can remains closed. After the lid of the trash can is opened, the user can put the trash into the trash can, after which the load sensor and ultrasonic sensor will work. The load sensor will measure the weight of the trash can and the ultrasonic sensor will measure the height of the trash can. After measuring weight and height, the two data will begin to enter into fuzzy calculations.

Implementation and Result

Testing Method Using Integral

Sample : Object weighing 1200grams and height 80mm

1. Fuzzyfikasi

The object height variable must be subtraction with 210mm first, because the data obtained by the ultrasonic sensor is the distance from the sensor to the object. So when the object's height is 125mm, then the x value will be obtained from subtracting 210mm by 125mm.

$$\mu \text{ Rendah} = \frac{x - 120}{180 - 120}$$

$$\mu \text{ Rendah} = \frac{130 - 120}{180 - 120}$$

$$\mu \text{ Rendah} = \frac{10}{60}$$

$$\mu \text{ Rendah} = 0.16$$

$$\mu \text{ Cukup} = \frac{180 - x}{180 - 120}$$

$$\mu \text{ Cukup} = \frac{180 - 130}{180 - 120}$$

$$\mu \text{ Cukup} = \frac{50}{60}$$

$$\mu \text{ Cukup} = 0.83$$

$$\mu \text{ Ringan} = \frac{1500 - x}{1500 - 500}$$

$$\mu \text{ Rringan} = \frac{1500 - 1200}{1500 - 500}$$

$$\mu \text{ Ringan} = \frac{300}{1000}$$

$$\mu \text{ Ringan} = 0.3$$

$$\mu \text{ Sedang} = \frac{x - 500}{1500 - 500}$$

$$\mu \text{ Sedang} = \frac{1200 - 500}{1500 - 500}$$

$$\mu \text{ Sedang} = \frac{700}{1000}$$

$$\mu \text{ Sedang} = 0.7$$

2. Inferensi

Ketinggian / Berat	Tinggi	Cukup	Rendah
Ringan	Penuh	Sedikit	Sedikit
Sedang	Penuh	Lumayan	Sedikit
Berat	Penuh	Penuh	Lumayan

*Conjuction :

IF Ketinggian (Cukup) = 0.83 AND Berat (Sedang) = 0.7 THEN Kapasitas (Lumayan) = 0.7

IF Ketinggian (Rendah) = 0,16 AND Berat (Sedang) = 0.7 THEN Kapasitas (Sedikit) = 0.16

IF Ketinggian (Cukup) = 0.83 AND Berat (Ringan) = 0.3 THEN Kapasitas (Sedikit) = 0.3

IF Ketinggian (Rendah) = 0.16 AND Berat (Ringan) = 0.3 THEN Kapasitas (Sedikit) = 0.16

*Disjunction:

Capacity : 1. Lumayan 0.7

2. Sedikit 0.3

3. Deffuzifikasi

$$x^* = \frac{\int y\mu_R(x)dq}{\int \mu_R(x)dq} => \frac{Momen}{Luas}$$

$$\frac{t1-20}{40-20} = 0.3 => t1 = 20 + (0.3 * 20) = 26$$

$$\frac{t2-20}{40-20} = 0.7 => t2 = 20 + (0.7 * 20) = 34$$

$$\frac{80-t3}{80-60} = 0.7 => t3 = 80 - (0.7 * 20) = 66$$

$$t4 = 80$$

$M1 = \int_0^{26} 0.3x\, dx = 101{,}4$ $\quad$ $A1 = \int_0^{26} 0.3\, dx = 7{,}8$

$M2 = \int_{26}^{34} \frac{x-26}{34-26} x\, dx = 125{,}3$ $\quad$ $A2 = \int_{26}^{34} \frac{x-26}{34-26}\, dx = 4$

$M3 = \int_{34}^{66} 0.7\, x\, dx = 1120$ $\quad$ $A3 = \int_{34}^{66} 0.7\, dx = 22{,}4$

$M4 = \int_{66}^{80} \frac{80-x}{80-66} x\, dx = 494{,}6$ $\quad$ $A4 = \int_{66}^{80} \frac{80-x}{80-66}\, dx = 7$

$$x^* = \frac{M1 + M2 + M3 + M4}{A1 + A2 + A3 + A4}$$

$$x^* = \frac{101{,}4 + 125{,}3 + 1120 + 494{,}6}{7{,}8 + 4 + 22{,}4 + 7}$$

$$x^* = 44.03 \text{ (lumayan)}$$

Next is testing the fuzzy calculating program, this test aims to find out whether the system with the application of this fuzzy method can produce output in accordance with the design that has been made previously. The test results can be seen in the table.

Tinggi (asli)	Berat (asli)	Defuzzyfikasi (Arduino)	Defuzzyfikasi (Manual)	Tingkat Kepenuhan	Error %
200mm	500g	79.95	79.95	Penuh	0
125mm	320g	55.08	54.27	Penuh	1.4
95mm	175g	25.22	25.02	Sedikit	0.7
170mm	200g	79.95	79.95	Penuh	0
90mm	150g	20.25	20.25	Sedikit	0
80mm	1200g	39.03	39.02	Lumayan	0.02
76mm	1500g	40.82	40.90	Lumayan	0.1
55mm	720g	27.60	27.62	Sedikit	0.07
135mm	320g	65.02	65.02	Penuh	0
0(kosong)	0(kosong)	20.25	20.25	Sedikit	0
			Total Error		2.29
			Average Error		0.22

Table 1.1 : Table result of fuzzy calculation with real and height

For the results of fuzzy testing with manual object measurements, good calculation accuracy is obtained. The interval between manual calculations and calculations from Arduino gets an average error of 0.22 %. This results show that the fuzzy inference system that has been run properly and produces output can meet the rules that have been designed.

Tinggi (Sensor)	Berat (Sensor)	Defuzzyfikasi (Arduino)	Defuzzyfikasi (Manual)	Tingkat Kepenuhan	Error %
188mm	485g	79.95	79.95	Penuh	0
124mm	205g	54.08	54.27	Penuh	0.3
90mm	135g	20.25	20.25	Sedikit	0
174mm	155g	79.95	79.95	Penuh	0
91mm	123g	21.24	21.44	Sedikit	0.9
78mm	1180g	38.49	38.49	Lumayan	0
75mm	1425g	40.37	40.36	Lumayan	0.02
53mm	700g	26.82	26.79	Sedikit	0.1
134mm	260g	64.03	63.83	Penuh	0.3
6mm(kosong)	0(kosong)	20.25	20.25	Sedikit	0
			Total Error		1.62
			Average Error		0.16

Table 1.2 : Table result of fuzzy calculation sensor measurement

Based on the test in the table above and the analysis of fuzzy inference system calculations in real conditions through ultrasonic readings and weight sensors, the results show that the fuzzy inference system that has been run properly and produces output can meet the rules that have been designed. The table shows that an empty trash can when compared to trash weighing 135 grams and a height of 90 mm can produce the same output. The 2 tables above also show that from manual measurements and sensor measurements the results of the fuzzy calculations are also not much different, the difference is the accuracy of the sensors in measuring existing goods. So in my opinion fuzzy logic here can produce output correctly because if the trash can is empty or filled a little then it is included in the small category, meaning that fuzzy logic here has succeeded in determining the value of the existing obscurity.

Conclusion

So in conclusion, fuzzy mamdani here can help in making this trash can. Fuzzy mamdani makes it easy for users to know the waste capacity properly. Fuzzy mamdani can display one output from the 2 existing parameters, this of course makes it easier to monitor the full level of this trash can. The combination of the use of PIR sensors, ultrasonic and load sensors can also help this tool run properly. With a relatively cheap price, these 3 sensors can produce runs well too. It is evident from the testing of ultrasonic sensors and load sensors, both of which have good accuracy in processing data. Although good accuracy results are obtained on the load sensor, behind that there

Demo video links

https://www.youtube.com/watch?v=FuPANg4hCDo

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