Journal of Computer Engineering, Electronics and Information Technology (COELITE)

Journal homepage: http://ejournal.upi.edu/index.php/COELITE/

Smart Pet Feeder on Cat Food Portions Using Mamdani's Fuzzy Logic Inference System

*Muhammad Ayat Hidayat[1, *], Suriandi Jayakrista[2]*

[1]Computer Engineering, Department of Informatics and Computer Engineering, Faculty of Engineering, Universitas Negeri Makassar, Makassar, 90245, Indonesia

[2]Machine Engineering Department, Universitas Pasundan, Jl. Dr. Setiabudi No.193, Bandung, 40153, Indonesia

Correspondence: E-mail: m.ayat.hidayat@unm.ac.id

ABSTRACT

This is a system that can help cat owners provide the right amount of food for their cats. This system uses the Mamdani fuzzy logic inference system method which can process input in the form of information about the cat's body weight and make a decision about the amount of food to be given to the cat. This system is integrated with a smart pet feeder called FoodyPet which can dispense food according to the decision made by the system. By using this system, cat owners can easily provide the right amount of food for their cats and maintain their cat's health. In addition, this system can also help cat owners automatically schedule their cat's meal times so they don't have to worry about forgetting to give food to their cats. This system consists of several main components, namely Arduino UNO as a microcontroller that runs all data processing processes, an loadcell as a tool to measure the cat's body weight, an ultrasonic sensor as a tool to measure the level of food in the tank, and an LCD display used to display information about the food portion to be given to the cat. This system is also equipped with a buzzer that will signal the cat owner when the food is ready to be given to the cat.

ARTICLE INFO

Article History:

Submitted/Received 10 Feb 2023

First Revised 16 Feb 2023

Accepted 24 Mar 2023

First Available online 01 Apr 2023

Publication Date 01 Apr 2023

Keyword:

Arduino,

Control,

Embedded,

Fuzzy Logic,

Mamdani.

1. INTRODUCTION

Cats are animals that can be kept and are one of the most popular and widely kept pets today [1]. Cat owners come from various age groups and different backgrounds, therefore various problems arise in the procedures for raising and caring for cats at home. The problem that often occurs is that it is difficult for cat owners to provide food when leaving their pet cat for a long time and the portion of food that is not ideal can cause the cat to be malnourished or even obese [2]. So many pet feeder products were created beforehand to make it easier for cat owners.

IoT is a concept that is widely used in smart pet feeder systems [3][4] not only that, but also in other fields such as [5]. The use of the IoT concept makes it easier for cat owners to send orders to the smart pet feeder to provide food to their pet cats using a mobile application [6][7]. Unfortunately, most existing smart pet feeders do not pay attention to the ideal portion of food given to the pet cat itself [8]. To solve this problem, a system is needed that can regulate the ideal portion of a cat's meal. There are so many algorithms that can be used to design the system, one of which is Fuzzy Logic. [9]

Fuzzy logic is an artificial intelligence field that is intended to create intelligent systems [10] and is a mathematical framework utilized for managing uncertainty and imprecision in reasoning and decision-making. Unlike classical logic, which is based on binary true/false values, fuzzy logic permits various degrees of truth and membership in a set.[11] Membership functions are assigned to variables in fuzzy logic, which determine the extent to which an input value belongs to a specific set. These membership functions may be defined using linguistic terms such as "very high," "high," "medium," "low," and "very low."[12] Fuzzy logic finds numerous applications in areas such as artificial intelligence, control systems, and decision-making. It is particularly advantageous in managing complex systems that contain high levels of uncertainty or when accurate mathematical models are unavailable, as depicted in **Figure 1.**

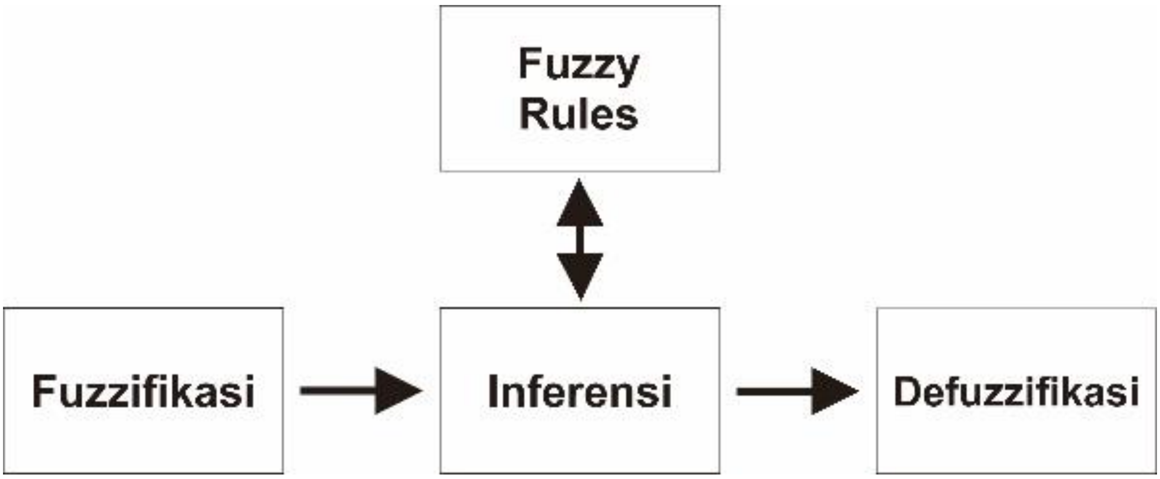

Figure 1. Fuzzy Logic Block Diagram.

DOI: https://doi.org/10.17509/coelite.v2i1.56926
p- ISSN 2829-4157 e- ISSN 2829-4149

The way of working in Fuzzy Logic has a value of fuzzyness or gray between right and wrong and has a reasoning system that is similar to intuition or human feelings so that it can be used for systems that require a reasoning process [13]. One method in Fuzzy Logic that has a higher level of accuracy than other methods is the Mamdani Inference System method [14]. Researchers need several components to realize the system such as a microcontroller which is used as the main component and control center in the designed system. The microcontroller used is Arduino UNO ATmega328. Arduino UNO is a microcontroller board based on the ATmega328. The microcontroller is a single board electronic device with open source or open source nature [15] which is very easy to use both in terms of hardware and software as shown in **Figure 2**.

Figure 2. Arduino UNO ATmega328.

The Arduino UNO board comes equipped with 14 digital input/output pins (with 6 of them capable of being used as PWM outputs), 6 analog inputs, a 16MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button. It has everything necessary to support the microcontroller and only requires a connection to a computer via USB cable or an AC-DC adapter or battery to operate.[16]

DOI: https://doi.org/10.17509/coelite.v2i1.56926
p- ISSN 2829-4157 e- ISSN 2829-4149

The control system for the smart pet feeder that was designed is outfitted with servo motors, RTC, ultrasonic sensors, load cells, and buzzers. Servo motors are vital components used in several industries that require precise position control, such as numerically controlled machines, robotics, automation, and other mechanisms where quick and accurate start and stop functions are needed [17]. The microcontroller commands the servo motors to rotate.

The Real Time Clock (RTC) utilized in the control system is a module that serves as a timer and is composed of electronic chips. These chips can function with clocks in general and calculate seconds, minutes, and hours with great accuracy, and store these calculations in real-time [18]. The RTC in the control system acts as a time store to prevent it from continuously changing when the system is not powered [19]. The ultrasonic sensor is used to measure the percentage of leftover food in the system. Ultrasonic sensors operate by reflecting sound waves and are used to detect the distance or presence of a specific object using sound waves ranging from 20 kHz to 2 MHz [20]. The ultrasonic sensor consists of two components: the transmitter and the receiver.

2. METHODS

The tool design method of this system planning consists of block diagrams, flowcharts and interrelated mechanical designs. In addition to hardware, the system is also equipped with fuzzy logic to run effectively according to user needs.

2.1. Working Principle and Block Diagram

The working principle of the Arduino microcontroller-based smart pet feeder system which is equipped with several components works with 9V power which functions to move the servo as a food gate down and turn on several important components such as load cells, ultrasonic sensors, buzzers, and LCDs. The microcontroller is connected directly to the RTC (Real Time Clock) which functions as a cat feeding schedule, ultrasonic sensors which function to measure the remaining volume of cat feed, buzzer as an alarm when the feed is finished, and LCD which will display information on feeding time and remaining feed in the smart FoodyPet pet feeder. When the cat steps on the loadcell, the microcontroller will receive a signal to move the servo motor and open the feed gate and the cat can immediately enjoy the food without waiting for the owner to feed it conventionally.

The first step is to design a Cat Food Portion Control System on the Arduino UNO-Based Smart Pet Feeder FoodyPet Using the Mamdani Fuzzy Logic Inference System Method, namely by making a block diagram. The purpose of making the block diagram is as an initial planning for making the system as shown in **Figure 3.**

DOI: https://doi.org/10.17509/coelite.v2i1.56926
p- ISSN 2829-4157 e- ISSN 2829-4149

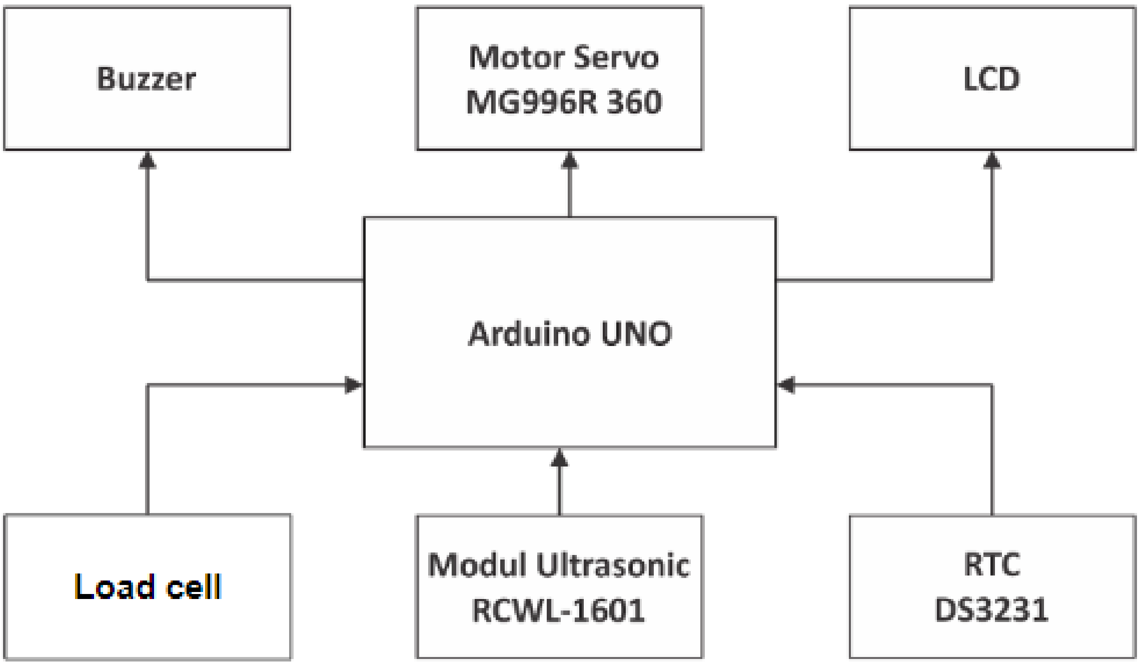

Figure 3. Proposed System Block Diagram.

There are three input components and three output components. The load cell will weigh the cat's body weight so that the portion of the cat's feed will be adjusted according to the cat's body weight assisted by fuzzy logic.

2.2. Wiring Diagram

All components that have been designed and designed are then connected according to the pins needed. The design of this wiring diagram is done using the Tinkercad simulator which is depicted in **Figure 4.**

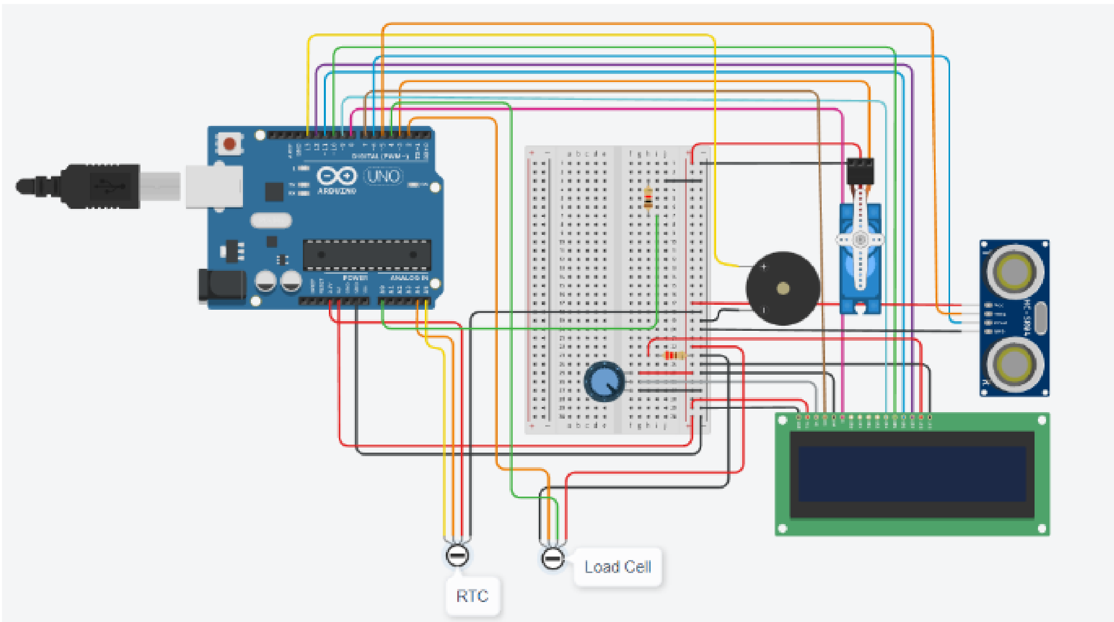

Figure 4. Proposed Wiring Diagram.

DOI: https://doi.org/10.17509/coelite.v2i1.56926
p- ISSN 2829-4157 e- ISSN 2829-4149

2.3. System Flowchart

Flowcharts or can also be referred to as flowcharts in the system will be made with the working principle of the tool to be produced. The flowchart starts from when the system is turned on until the final process in the system, depicted in **Figure 5.**

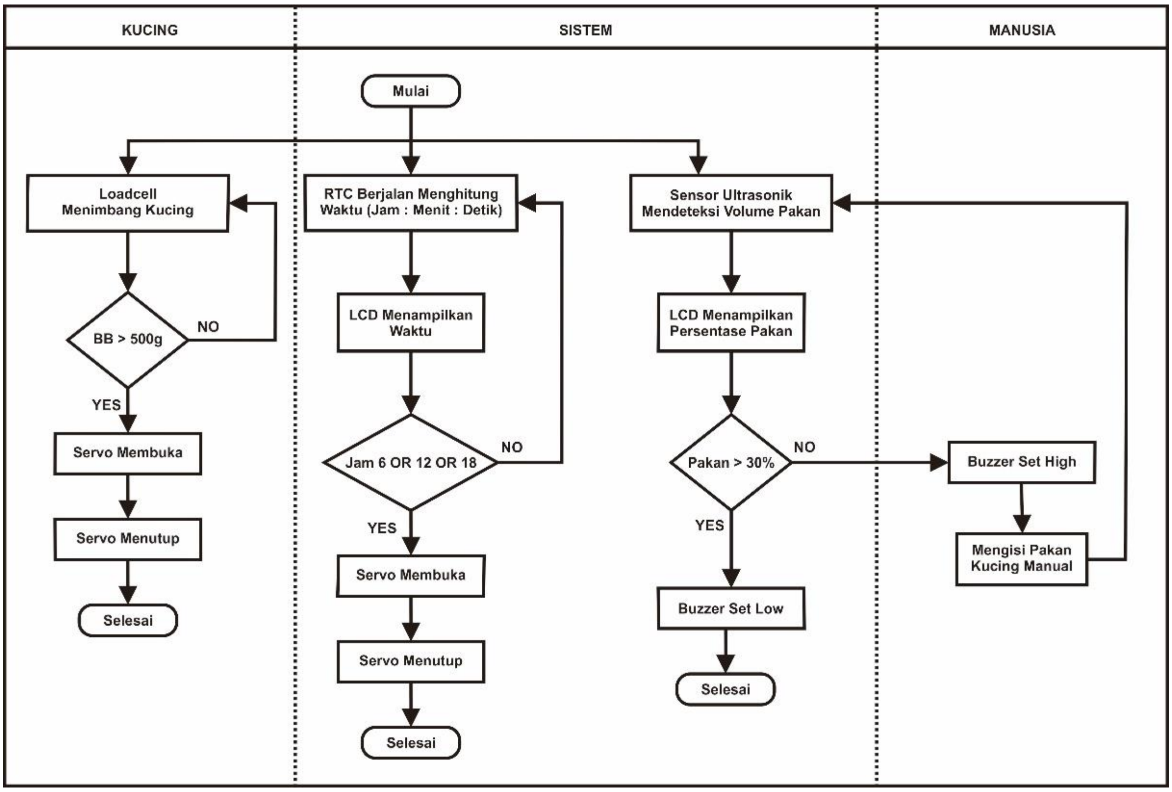

Figure 5. Proposed flowchart system.

3. RESULTS AND DISCUSSION

To determine whether the tool works according to design it is necessary to do testing. However, before testing is carried out, it is necessary to implement fuzzy logic on the system that has been made.

3.1. Variables and Fuzzy Sets

Fuzzy variables are variables that are operated and used to temporarily store input values into crisp values in a fuzzy system. There are 2 interrelated attributes in the fuzzy set, namely linguistic values and numerical values. This system has 3 fuzzy variables used, which include 2 input variables and 1 output variable. Variables and fuzzy sets can be seen in **Table 1.** as follows.

DOI: https://doi.org/10.17509/coelite.v2i1.56926
p- ISSN 2829-4157 e- ISSN 2829-4149

Table 1. Variables and Fuzzy Sets.

Variable Fuzzy	**Variable Name**
Variable input	Body Weigh
	Time
Variable output	Meal portion

3.2. Membership Functions

Based on the variables and fuzzy sets that have been determined, there are membership function equations and their curves that will be used in the ideal cat food portion control system.

1) Equation and membership curve of variable body weight

There are 4 linguistic values that are owned by the weight variable, including {small, normal, large, obese}. The linguistic value can be seen in the membership function in **Figure 6.** and Equation [1-4] as follows:

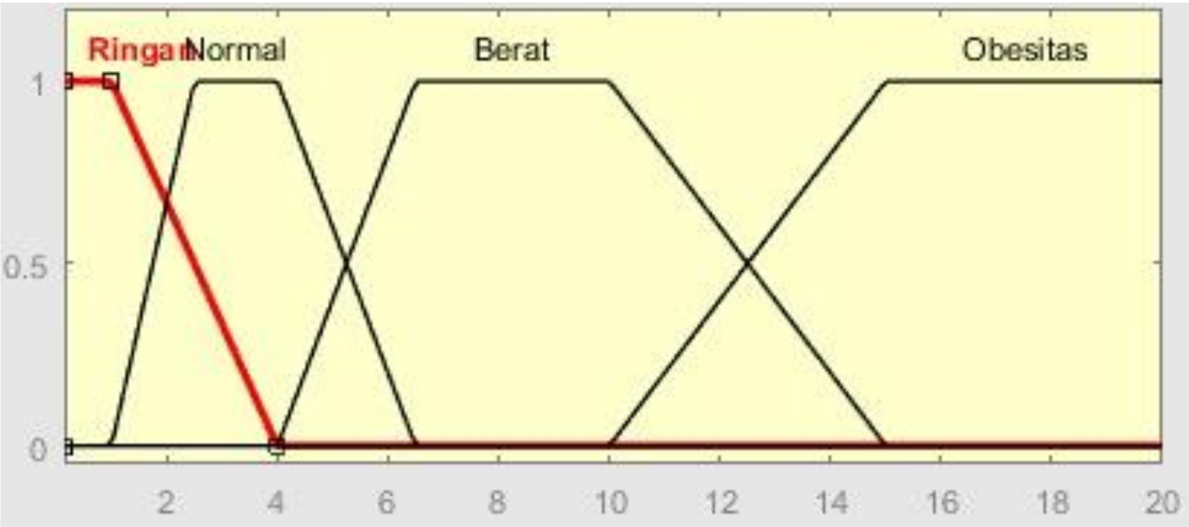

Figure 6. Member Function Weight Curve.

$$\mu\ Ringan\ [x]\begin{cases} 0; & x \geq 4 \\ \frac{4-x}{4-1}; & 1 < x < 4 \\ 1; & x \leq 1 \end{cases} \quad (1)$$

$$\mu\ Normal\ [x]\begin{cases} 0; & x \leq 1, x \geq 6{,}5 \\ \frac{x-1}{4-1}; & 1 < x < 4 \\ \frac{6{,}5-x}{6{,}5-4}; & 4 < x < 6{,}5 \\ 1; & x = 4 \end{cases} \quad (2)$$

DOI: https://doi.org/10.17509/coelite.v2i1.56926
p- ISSN 2829-4157 e- ISSN 2829-4149

$$\mu\, Berat[x] \begin{cases} 0; & x \leq 4, x \geq 15 \\ \dfrac{x-4}{6{,}5-4}; & 4 < x < 6{,}5 \\ \dfrac{15-x}{15-10}; & 10 < x < 15 \\ 1; & 6{,}5 < x < 10 \end{cases} \tag{3}$$

$$\mu\, Obesitas\,[x] \begin{cases} 0; & x \leq 10 \\ \dfrac{x-10}{15-10}; & 10 < x < 15 \\ 1; & x \geq 15 \end{cases} \tag{4}$$

2) Equation and time variable membership curve

There are 3 linguistic values that are owned by the time variable, including {morning, afternoon, evening}. The linguistic value can be seen in the membership function in **Figure 7.** and Equation [5-7] as follows:

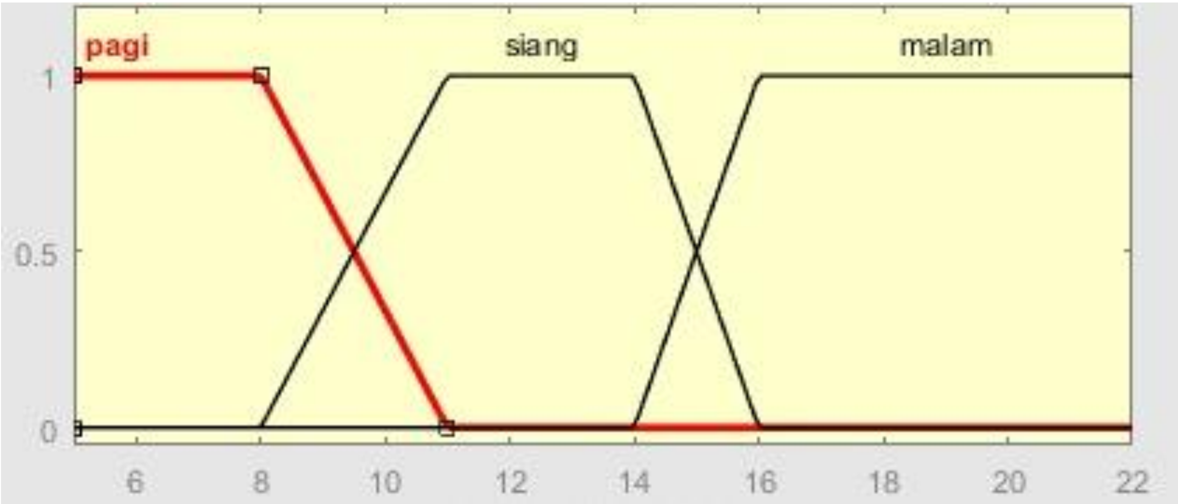

Figure 7. Time Member Function Curve.

$$\mu\, Pagi\,[x] \begin{cases} 0; & x \geq 11 \\ \dfrac{11-x}{11-8}; & 8 < x < 11 \\ 1; & x \leq 8 \end{cases} \tag{5}$$

$$\mu\, Siang\,[x] \begin{cases} 0; & x \leq 8, x \geq 16 \\ \dfrac{x-8}{11-8}; & 8 < x < 11 \\ \dfrac{16-x}{16-14}; & 14 < x < 16 \\ 1; & 11 < x < 14 \end{cases} \tag{6}$$

$$\mu\, Malem\,[x] \begin{cases} 0; & x \leq 14 \\ \dfrac{x-14}{16-14}; & 14 < x < 16 \\ 1; & x \geq 16 \end{cases} \tag{7}$$

DOI: https://doi.org/10.17509/coelite.v2i1.56926
p- ISSN 2829-4157 e- ISSN 2829-4149

3) Portion membership equations and curves

There are 3 linguistic values that are owned by the portion variable, including {Little, Moderate, Many}. The linguistic value can be seen in the membership function in **Figure 8.** and Equation [8-10] as follows:

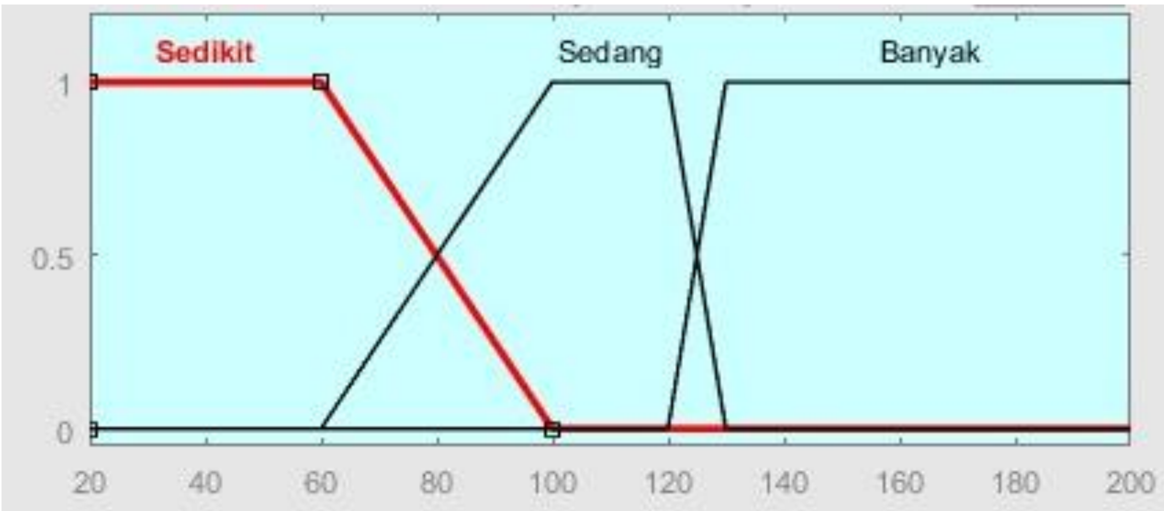

Figure 8. Feed Portion Member Function Curve.

$$\mu\,Sedikit\,[x]\begin{cases} 0; \quad x \geq 100 \\ \dfrac{100-x}{100-60}; \quad 60 < x < 100 \\ 1; \quad x \leq 60 \end{cases} \tag{8}$$

$$\mu\,Sedang\,[x]\begin{cases} 0; \quad x \leq 60, x \geq 130 \\ \dfrac{x-60}{130-60}; \quad 60 < x < 130 \\ \dfrac{120-x}{120-100}; \quad 100 < x < 120 \\ 1; \quad 100 < x < 120 \end{cases} \tag{9}$$

$$\mu\,Banyak\,[x]\begin{cases} 0; \quad x \leq 120 \\ \dfrac{x-120}{130-120}; \quad 120 < x < 130 \\ 1; \quad x \geq 130 \end{cases} \tag{10}$$

3.3. System Testing

System testing is carried out to ensure that all components work as they should. There are five components tested, namely the ultrasonic sensor, load cell, RTC, LCD, and buzzer. Each component is tested ten times on a regular basis to show the level of accuracy the component runs. At the end of the test, a thorough test will also be carried out when all the components have been combined into one final prototype.

1) Ultrasonic Sensor Testing

Ultrasonic sensors in this study are used to measure the height of food contained in food tanks. The results of the tests carried out in **Table 2.** as follows:

Table 2. Ultrasonic Sensor Testing.

Testing Number	Persentage Real	Persentage Ultrasonic
1	50%	50%
2	78%	0%
3	80%	80%
4	30%	100%
5	30%	30%
6	0%	0%
7	100%	100%
8	100%	0%
9	48%	48%
10	93%	93%

Based on the test data contained in the ultrasonic sensor testing table in **Table 2.**, it can be seen that of the ten tests carried out, seven tests got accurate results and three tests got distorted results. The accuracy rate of using ultrasonic sensors is 70%. This indicates that the ultrasonic sensor is running quite well.

2) Loadcell Testing

The load cell in this study is used to measure the weight of the cat's meal and trigger the servo motor to move. The results of the tests carried out in **Table 3.** as follows:

Table 3. Loadcell Testing.

Testing Number	Detected Massa
1	Yes
2	Yes
3	No
4	Yes
5	Yes
6	Yes
7	Yes
8	Yes
9	Yes
10	Yes

DOI: https://doi.org/10.17509/coelite.v2i1.56926
p- ISSN 2829-4157 e- ISSN 2829-4149

Based on the test data contained in the loadcell testing table in **Table 3.**, it can be seen that of the ten tests carried out, nine tests triggered the servo to move and one test did not detect any mass above the loadcell. The accuracy rate of using ultrasonic sensors is 90%. This indicates that the loadcell is running well.

3) Real-Time Clock (RTC) Testing

The RTC or real time clock in this study is used to measure real time so that the portion of food is in accordance with the time. The results of the tests carried out in **Table 4**. as follows:

Table 4. Real-Time Clock (RTC) Testing

Testing Number	Accurate Real-Time
1	Yes
2	Yes
3	Yes
4	Yes
5	Yes
6	Yes
7	Yes
8	Yes
9	Yes
10	Yes

Based on the test data contained in the RTC testing table in **Table 4.** , it can be seen that of the ten tests performed, all tests showed accurate real-time results. The level of accuracy from the use of ultrasonic sensors is 100%. This indicates that the RTC is running very well.

4) LCD Testing

LCD or liquid-crystal display in this study is used to display information and become the interface of foodypet. The results of the tests carried out in **Table 5.** as follows:

DOI: https://doi.org/10.17509/coelite.v2i1.56926
p- ISSN 2829-4157 e- ISSN 2829-4149

Table 5. LCD Testing.

Testing Number	LCD Displays Information Accurately
1	Yes
2	Yes
3	Yes
4	No
5	No
6	Yes
7	Yes
8	No
9	Yes
10	Yes

Based on the test data contained in the LCD testing table in **Table 5**, it can be seen that of the ten tests carried out, nine tests showed that the LCD displayed information as it should and one test showed inappropriate results. The accuracy rate of using the LCD is 70%. This indicates that the LCD is running well.

5) Motor Servo Testing

The servo motor in this study is used to open and close the feed exit hole from the tank. The following are the results of the tests that have been carried out shown in **Table 6.**

Table 6. Motor Servo Testing.

Testing Number	Servo Motor Moves
1	Yes
2	Yes
3	Yes
4	Yes
5	Yes
6	Yes
7	Yes
8	Yes
9	Yes
10	Yes

DOI: https://doi.org/10.17509/coelite.v2i1.56926
p- ISSN 2829-4157 e- ISSN 2829-4149

Based on the test data contained in the servo motor testing table in **Table 6**, it can be seen that of the ten tests carried out, all tests showed that the servo motor moved as it should. The level of accuracy from using a servo motor is 100%. This indicates that the servo motor is running very well.

6) Buzzer Testing

The buzzer in this study is used to issue a sound as a form of warning when the food in the tank shows a percentage below 30%. The following are the results of the tests that have been carried out in **Table 7.**

Table 7. Buzzer Testing.

Testing Number	Tank Percentage	Buzzer is sounding	Buzzer is silent
1	76%	No	Yes
2	26%	Yes	No
3	0%	Yes	No
4	93%	No	Yes
5	29%	Yes	No
6	50%	No	Yes
7	12%	Yes	No
8	14%	Yes	No
9	90%	No	Yes
10	64%	No	Yes

Based on the test data contained in the buzzer testing table in **Table 7.**, it can be seen that of the ten tests carried out, all tests showed that the buzzer turned on and off according to the settings. The accuracy rate of using the buzzer is 100%. This indicates that the buzzer is running very well.

3.4. Compilation of Program Code

The preparation of the program code is done by entering the program code into the Arduino Uno through the Arduino IDE software. Before implementing into the tool, the program code is tested first using the Tinkercad simulator.

DOI: https://doi.org/10.17509/coelite.v2i1.56926
p- ISSN 2829-4157 e- ISSN 2829-4149

3.5. Design Result

The results of the final FoodyPet prototype design can be seen in **Figure 9.** The entire system is stored in a different place from the storage tank. The ultrasonic sensor is placed above the food tank to measure the percentage of available food and the LCD is placed in front of the tool to make it easier for users to see food depicted in **Figure 9.**

Figure 9. FoodyPet Prototype Design Results.

4. CONCLUSION

Based on the results of this discussion, it can be concluded that the problem that often occurs in cat maintenance is the difficulty for cat owners to provide food to their cats when they are not at home and the portion of food that is not suitable can cause cats to be malnourished or obese. To solve this problem, we need a system that can regulate the ideal portion of a cat's meal, which uses the Fuzzy Logic algorithm. One method in Fuzzy Logic that has a higher level of accuracy is the Mamdani Inference System method. Researchers needed several components to realize the system, including the Arduino UNO ATmega328 microcontroller, which is an easy-to-use, open-source microcontroller board based on the ATmega328.

To ensure that the designed system is effective in regulating cat food portions, researchers will conduct trials on the system using several variables as input, such as cat body weight, cat age, and cat activity. The results of the trial will be used to determine the appropriate portion of food for the cat. In addition, researchers will also develop a mobile application that can be

DOI: https://doi.org/10.17509/coelite.v2i1.56926
p- ISSN 2829-4157 e- ISSN 2829-4149

used by cat owners to send commands to the system and monitor the cat's food portion. Thus, this system is expected to provide convenience for cat owners in providing appropriate food to their pet cats and avoid malnutrition or obesity problems.

In addition, the designed system will also be equipped with a notification feature to cat owners if cat food runs out or if there is a disturbance in the system. This feature will help cat owners to always monitor the condition of cat food and refill it immediately if needed. Thus, this system is expected to provide convenience and comfort for cat owners in caring for their pet cats.

5. AUTHORS' NOTE

The authors declare that there is no conflict of interest regarding the publication of this article. Authors confirmed that the paper was free of plagiarism.

6. REFERENCES

[1] Rahmalisa, U., Mardeni, M., Helmi, R., dan Linarta, A. (2020). Pemberi makan otomatis pada kucing menggunakan raspberry pi berbasis android. *Jurnal Teknologi dan Open Source, 3*(2), 298-308.

[2] Tribudiman, A., Rahmadi, R., dan Fadhila, M. (2021). Peran pet attachment terhadap kebahagiaan pemilik hewan peliharaan di kota Banjarmasin. *Jurnal Al-Husna, 1*(1), 60-77.

[3] Khoiroh, S. H., Ridwan, M., dan Maftukhah, S. (2022). Penerapan logika fuzzy pada rancang bangun alat pakan kucing otomatis dan monitoring sisa pakan dengan aplikasi Blynk. *Jutis (Jurnal Teknik Informatika), 10*(2), 206-218.

[4] Devitasari, R., dan Kartika, K. P. (2020). Rancang bangun alat pemberi pakan kucing otomatis menggunakan mikrokontroler nodemcu berbasis internet of thing (IoT). *Antivirus: Jurnal Ilmiah Teknik Informatika, 14*(2), 152-164.

[5] Suteddy, W., Atmanto, D. A., Nuriman, R., and Ansori, A. (2022). Prototype application of crowd detection system for traditional market visitor based on iot using RFID MFRC522. *Jurnal Teknologi Informasi Universitas Lambung Mangkurat (JTIULM), 7*(1), 23-30.

[6] Valendio, B. J., Susilawati, S., dan Sembiring, Z. (2022). Perancangan prototype pemberi pakan kucing otomatis berdasarkan umur berbasis sms gateway. *Jurnal Ilmiah Teknik Informatika dan Elektro (JITEK), 1*(2), 57-65.

[7] Samsugi, S., Neneng, N., dan Suprapto, G. N. F. (2021). Otomatisasi pakan kucing berbasis mikrokontroller intel galileo dengan interface android. *J-SAKTI (Jurnal Sains Komputer dan Informatika), 5*(1), 143-152.

[8] Afrizal, M. R. (2022). Smart pet feeder menggunakan ESP8266 nodeMCU dan Blynk app berbasis smartphone. *Jurnal Ilmiah Indonesia, 7*(12), 19436-19448.

[9] Saputro, R., dan Suhendi, H. (2021). Sistem monitoring dan automatic feeding hewan peliharaan menggunakan android berbasis internet of things. *eProsiding Teknik Informatika (PROTEKTIF), 1*(1), 1-12.

[10] Aldisa, R. T., dan Soleha, P. A. (2022). Penerapan metode fuzzy logic pada tempat pemberi pakan kucing menggunakan sensor HC-SR04. *JURIKOM (Jurnal Riset Komputer), 9*(5), 1569-1574.

DOI: https://doi.org/10.17509/coelite.v2i1.56926
p- ISSN 2829-4157 e- ISSN 2829-4149

[11] Gusman, A. P., dan Kurniawan, H. (2018). Fuzzy logic dalam menganalisa pengaruh konsep halal tourism terhadap perilaku masyarakat sumatera barat. *Jurnal Matematika UNAND, 7*(2), 235-242.

[12] Setia, B. (2019). Penerapan logika fuzzy pada sistem cerdas. *Jurnal Sistem Cerdas, 2*(1), 61-66.

[13] Prayudha, J., Pranata, A., dan Al Hafiz, A. (2018). Implementasi metode fuzzy logic untuk sistem pengukuran kualitas udara di kota Medan berbasis internet of things (IoT). *JURTEKSI (Jurnal Teknologi dan Sistem Informasi), 4*(2), 141-148.

[14] Situmorang, E., and Rindari, F. (2019). Decision support system for selection of the best doctors in sari mutiara hospital using fuzzy tsukamoto method. *Jurnal Teknik Informatika CIT Medicom, 11*(2), 45-50.

[15] Mahardika, P. S., and Gunawan, A. N. (2022). Modeling of water temperature in evaporation pot with 7 DS18B20 sensors based on atmega328 microcontroller. *Linguistics and Culture Review, 6*(S3), 184-193.

[16] Ismailov, A. S., and Jo‘Rayev, Z. B. (2022). Study of arduino microcontroller board. *Science and Education, 3*(3), 172-179.

[17] Tahir, N. H. M., Mohamad, S. N., Azimi, F. H., Aw, S. R., Tarmizi, W. F. W., and Zain, M. L. M. (2022). Development of real time cat auto feeder dispenser using arduino. *International Journal of Synergy in Engineering and Technology, 3*(1), 52-57.

[18] Ginting, R. C., Ishak, I., dan Yakub, S. (2021). Implementasi real time clock (RTC) pada robot line follower untuk vacuum cleaner berbasis arduino. *Jurnal Teknisi, 1*(1), 8-12.

[19] Mubarok, S., Wahyudi, D. W. D., Octaviany, D., dan Karno, K. (2018). Pemanfaatan modul RTC berbasis arduino mega sebagai penentu variabel nutrisi pada sistem kontrol hidroponik. *TRANSISTOR Elektro dan Informatika, 3*(1), 5-8.

[20] Marwan, M., Rifqan, R., dan Syamsudin, F. (2019). Karakterisasi sifat fisik batupasir daerah Jantho dan Krueng Raya menggunakan uji gelombang ultrasonik. *POSITRON, 9*(1), 8-12.

DOI: https://doi.org/10.17509/coelite.v2i1.56926
p- ISSN 2829-4157 e- ISSN 2829-4149