CHAPTER 4
ANALYSIS AND DESIGN

4.1. Analysis

4.1.1 Arduino

Arduino is an open source single board microcontroller / micro controller and is one of the most popular Open Source Hardware projects. to facilitate the use of electronics in various fields. The hardware has an Atmel AVR processor. The software consists of several tools namely Integrated Development Environment (IDE), Text-Editor, Compiler, Serial Monitor, and Serial ISP Programmer.

4.1.2 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.

Illustration 4.1.2 : image arduino nano

4.1.3 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.
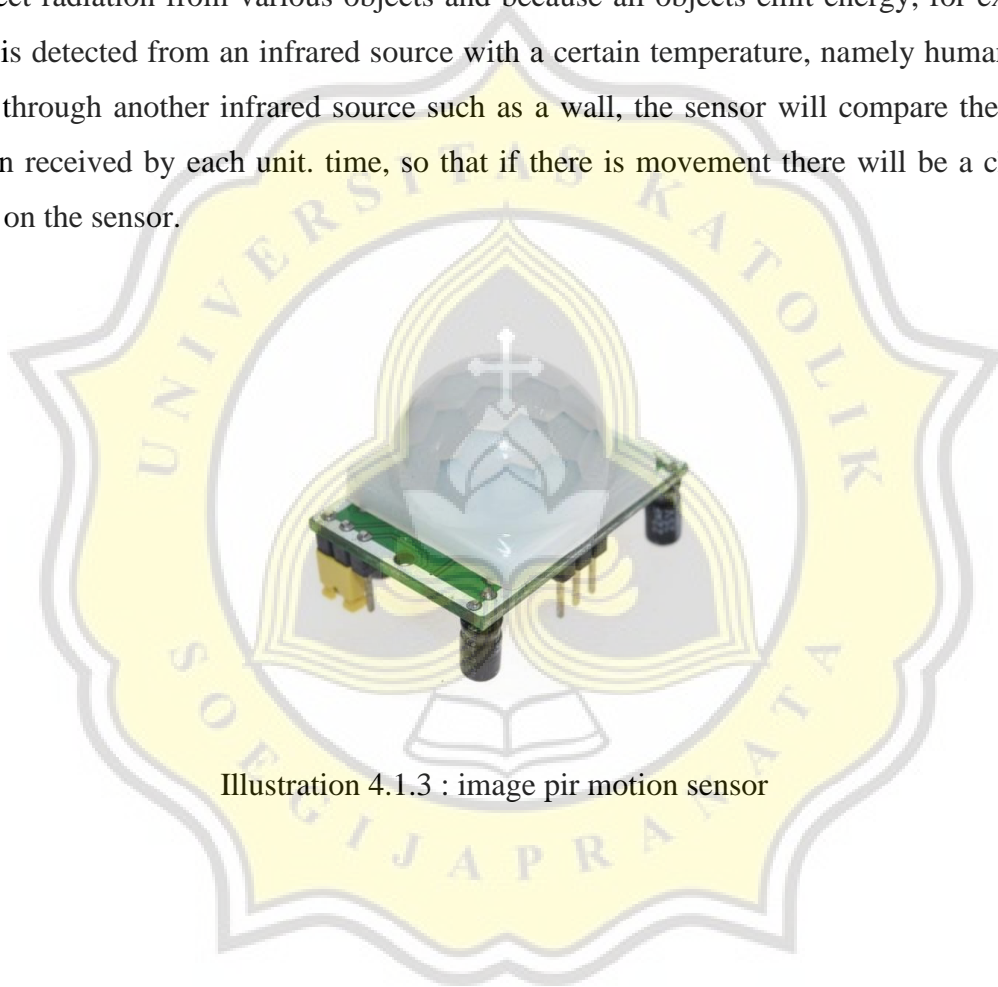

Illustration 4.1.3 : image pir motion sensor

4.1.4 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.
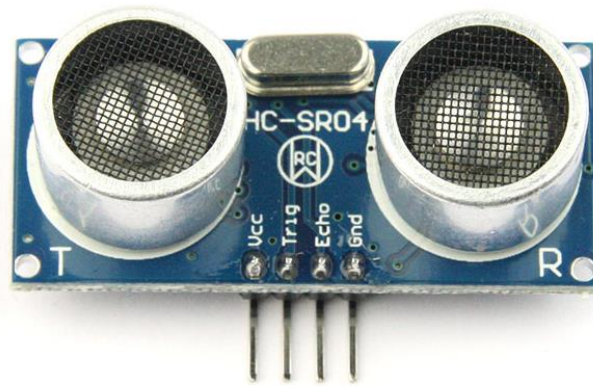
Illustration 4.1.4 : image ultrasonic sensor

4.1.5 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.

Illustration 4.1.5 : image load cell

4.1.6 HX-711 module

The HX711 module is an amplifier module (signal amplifier) as well as an Analog to Digital Converter (ADC) module which functions to condition analog signals from load cell sensors while converting them into digital signals.
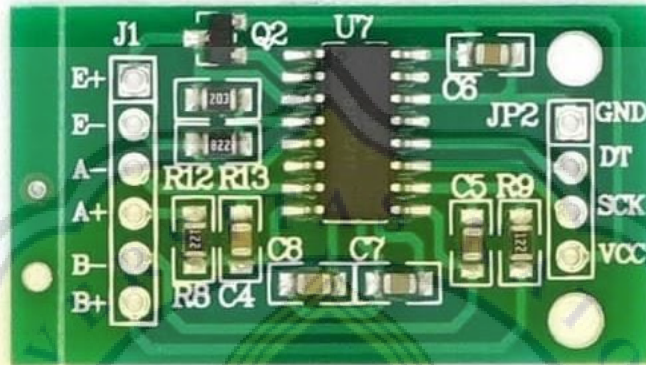
Illustration 4.1.6 : image HX-711 module

4.1.7 LCD 1602 Char green backlight with i2c serial interface module

LCD (Liquid Crystal Display) 16x2 is a type of display media or display made of liquid crystal material as the main viewer. 16x2 LCD can display as many as 32 characters consisting of 2 lines with each line displaying 16 characters. The I2C module is a two-way serial communication standard using two channels specifically designed to send and receive data. The I2C system consists of SCL (Serial Clock) and SDA (Serial Data) channels that carry data information between the I2C and the controller. This tool will be used to display the capacity of the trash can.

Illustration 4.1.7 : image lcd 1602 with i2c module

4.1.8 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.

Illustration 4.1.8 : image servo MG996R

4.1.9 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:

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

   Keterangan simbol diatas adalah :

   x^* : nilai *crisp*

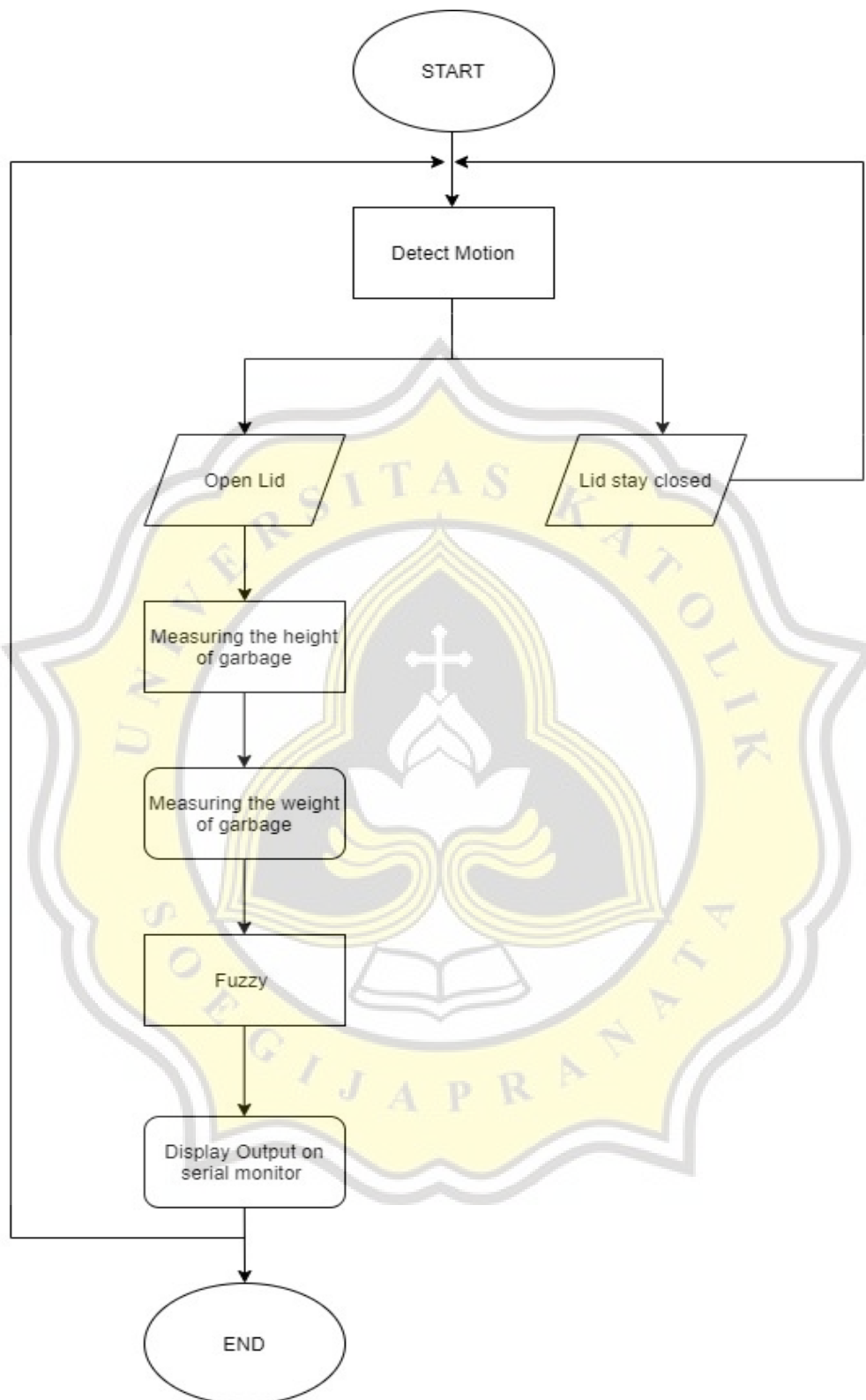 $\mu_R(x)$: derajat keanggotaan dari y

4.2 Design

Illustration 4.2 : Flowchart

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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.

Variable Ketinggian
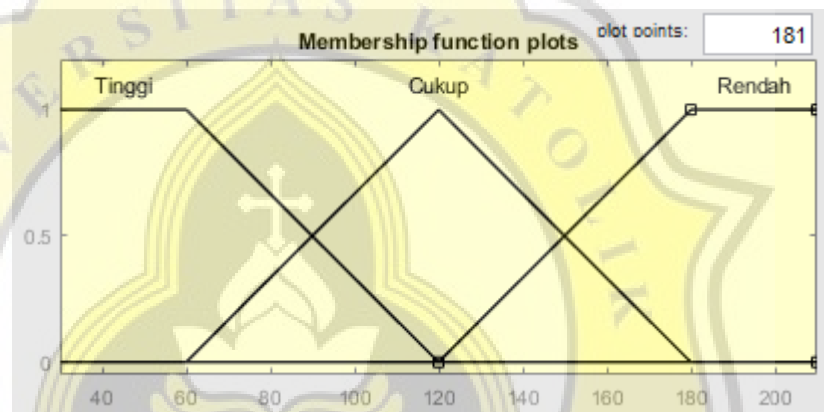

Illustration 4.3 : Kurva Variabel Ketinggian

The formulas formed include:

$$\mu \, Tinggi[x] = \begin{cases} 1; & x \le 60 \\ \dfrac{120 - x}{120 - 60}; & 60 \le x \le 120 \\ 0; & x \ge 120 \end{cases}$$

$$\mu \, Cukup[x] = \begin{cases} 0; & x \le 60 \; atau \; x \ge 180 \\ \dfrac{x - 60}{120 - 60}; & 60 \le x \le 120 \\ \dfrac{180 - x}{180 - 120}; & 120 \le x \le 180 \end{cases}$$

$$\mu \, Rendah[x] = \begin{cases} 0; & x \le 120 \\ \dfrac{x - 120}{180 - 120}; & 120 \le x \le 180 \\ 1; & x \ge 180 \end{cases}$$

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The height of this trash can is around 200mm, so if you divide it by 3 you will get a result of about 60mm. Therefore, I distributed 3 parts with a distance of 60mm. Then the numbers 60,120 and 180 will be found. 60,120 and 180 are only limitations, the data inputted from the trash will be included in the fuzzy calculation again.
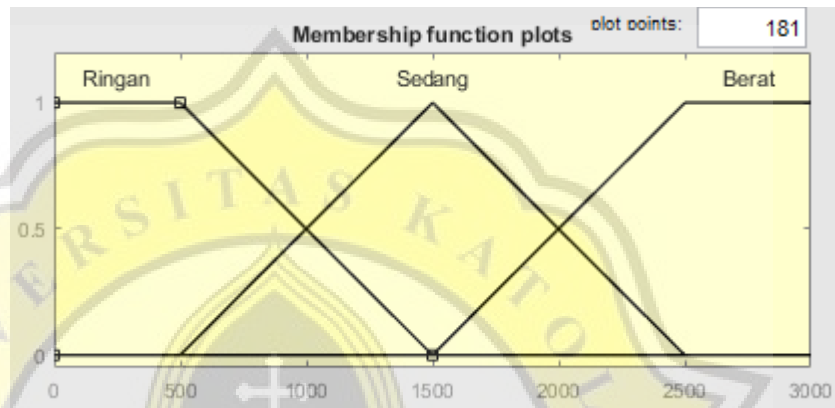
Variabel Berat

Illustration 4.4 : Kurva Variabel Berat

The formulas formed include:

$$\mu \text{ Ringan } [x] = \begin{cases} 1; & x \leq 500 \\ \dfrac{1500 - x}{1500 - 500}; & 500 \leq x \leq 1500 \\ 0; & x \geq 1500 \end{cases}$$

$$\mu \text{ Sedang } [x] = \begin{cases} 0; & x \leq 500 \; atau \; x \geq 2500 \\ \dfrac{x - 500}{1500 - 500}; & 500 \leq x \leq 1500 \\ \dfrac{2500 - x}{2500 - 1500}; & 1500 \leq x \leq 2500 \end{cases}$$

$$\mu \text{ Berat } [x] = \begin{cases} 0; & x \leq 1500 \\ \dfrac{x - 1500}{2500 - 1500}; & 1500 \leq x \leq 2500 \\ 1; & x \geq 2500 \end{cases}$$

For the weight sensor here I give a limit in fuzzy calculations, max 3000gram so that the sensor can work optimally. So I split 3000gram into 3 output parts. 500 grams for light parts, 1500 grams for medium parts, 3000 grams for heavy parts. The data that is inputted from the garbage will be put back into the fuzzy calculation.

Variabel Capacity

Berikut adalah bentuk kurva dari variabel Kapasitas :
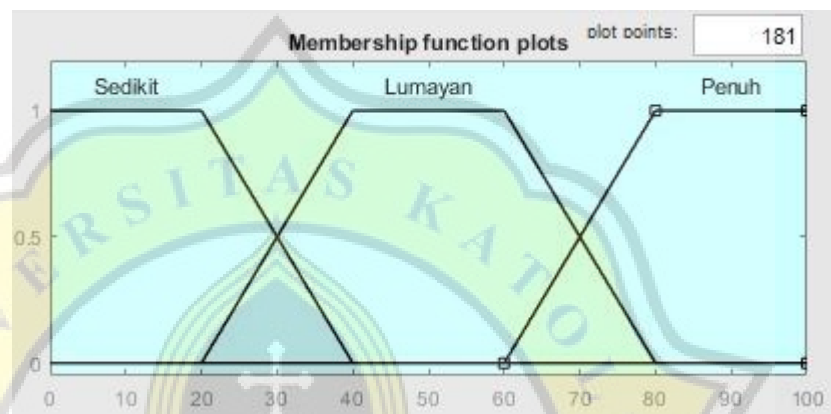

Illustration 4.5 : Kurva Variabel Kapasitas

The formulas formed include:

$$\mu \text{ Sedikit } [x] = \begin{cases} 1; & x \leq 20 \\ \dfrac{40 - x}{40 - 20}; & 20 \leq x \leq 40 \\ 0; & x \geq 40 \end{cases}$$

$$\mu \text{ Lumayan } [x] = \begin{cases} 0; & x \leq 20 \; atau \; x \geq 80 \\ \dfrac{x - 20}{40 - 20}; & 20 \leq x \leq 40 \\ 1; & 40 \leq x \leq 60 \\ \dfrac{80 - x}{80 - 60}; & 60 \leq x \leq 80 \end{cases}$$

$$\mu \text{ Penuh } [x] = \begin{cases} 0; & x \leq 60 \\ \dfrac{80 - x}{80 - 60}; & 60 \leq x \leq 80 \\ 1; & x \geq 80 \end{cases}$$

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For the capacity (output) curve I specify 4 parts of values 0-100. The reason for using 4 numbers is because for the capacity curve section using a trapezoid function so it requires 4 numeric sections. 100 if I divide by 4 then the result is 20, therefore the 4 limit numbers here are multiples of 20, namely 20,40,60,80.

After entering into fuzzy calculations, the results of these calculations will enter the inference stage. The inference stage here is based on the rule base that has been created. below are 9 conditions that will occur in tabular form :

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

Illustration 4.6 : Table of Rulebase

If the table above is in the form of IF THEN it will be like this :

1. If (Ketinggian is Tinggi) and (Berat is Ringan) then (output is Penuh)
2. If (Ketinggian is Cukup) and (Berat is Ringan) then (output is Sedikit)
3. If (Ketinggian is Rendah) and (Berat is Ringan) then (ouput is Sedikit)
4. If (Ketinggian is Tinggi) and (Berat is Sedang) then (output is Penuh)
5. If (Ketinggian is Cukup) and (Berat is Sedang) then (output is Lumayan)
6. If (Ketinggian is Rendah) and (Berat is Sedang) then (output is Sedikit)
7. If (Ketinggian is Tinggi) and (Berat is Berat) then (output is Penuh)
8. If (Ketinggian is Cukup) and (Berat is Berat) then (output is Penuh)
9. If (Ketinggian is Rendah) and (Berat is Berat) then (output is Lumayan)

After doing the inference, it will go directly to the deffuzification stage. Deffuzification here will have 2 stages, namely clipping and centroid. Before entering the centroid calculation, clipping will be done first. After the inference process, 2 results will be found, these 2 results will enter the clipping process. Clipping is simply the process of estimating a curve. After passing the clipping, it will enter into the calculation using the 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:

$$q^* = \frac{\int y \, \mu_R(q) \, dq}{\int \mu_R(q) \, dq}$$

Description of the symbol above :

q^* : nilai *crisp*

$\mu_R(q)$: derajat keanggotaan dari y

From the results of the above calculations, these results will be the final calculation output. For the testing method, I will use items that have a specific weight and height. For example, a mineral water bottle weighing 500grams and a height of 150mm. 500 grams and 150 mm will be included in the fuzzy calculation to get one output.