DESIGNING A CAT FEEDING AUTOMATION SYSTEM USING MICROCONTROLLER APPLICATION-BASED SCHEDULING

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Abstrak

Suatu alat yang dapat memberikan makanan untuk kucing secara otomatis yang bisa dikendalikan melalui *smartphone,tablet,laptop & pc*. Alat ini berbasis Iot yang mana akan terhubung ke internet sehingga bisa dikontrol dimana saja tanpa mengenal jarak. Aplikasi yang digunakan dalam alat ini adalah Telegram. Telegram menyediakan bot agar bisa dipakai dan digunakan untuk banyak keperluan, salah satunya pengendali alat ini. Alat yang digunakan bisa bekerja dalam keadaan *online* maupun *offline* dari jaringan internet. Sebab, sudah program sedemikian rupa agar alat bisa dipakai dalam kondisi apapun. Fitur yang disediakan cukup banyak sehingga memudahkan pengguna untuk memakainya. Diharapkan alat ini bisa dapat mempermudah dalam memberi makan hewan peliharaan khususnya kucing. Makanan yang bisa dioperasikan disini ialah makanan kering. Makanan kering untuk kucing sangat banyak beredar di pasaran sehingga sangat mudah untuk mencarinya. Akan tetapi tetap ada batasan ukuran makanan yang bisa dipakai di alat ini. Pemberian makanan pada kucing harus rutin dan sesuai porsinya. Denga alat pemberi makan otomatis ini akan mengeluarkan makanan dari tangki ke mangkuk. Mangkuk diberi magnet pada bagian bawah serta sensor loadcell agar memudahkan dalam mencuci dan membersihkannya. Ketika ada seekor kucing berada pada <15cm dengan sensor *ultrasonic* yang ada di atas piring, maka makanan akan dikeluarkan sesuai porsinya yaitu 1-2gram, dengan *error percentage* 8-67%. Alat tidak akan mengeluarkan makanan jika sensor *loadcell* masih membaca berat makanan >1gram yang ada di dalam mangkuk. Dengan bantuan telegram, pengguna dapat mengontrol dan menerima informasi dari alat ini. *Delay* yang didapat ketika mengirim pesan ke telegram hingga menerima pesan ialah 1-7 detik. Sementara untuk kamera hingga gambar diterima bisa sampai 12 detik maksimal. Penambahan antenna sangat penting untuk mencegah putusnya koneksi *wifi*.

Kata Kunci: Esp32, Servo, Telegram bot, Ultrasonic, Sensor.

Abstract

A device that can provide food for cats automatically that can be controlled via *smartphones, tablets, laptops & PCs*. This tool is IoT-based which will be connected to the internet so that it can be controlled anywhere without knowing the distance. The application used in this tool is Telegram. Telegram provides bots so that they can be used and used for many purposes, one of which is controlling this tool. The tools used can work online or *offline* from the internet network. Because, it has been programmed in such a way that the tool can be used in any condition. The features provided are quite a lot so that it makes it easier for users to use it. It is hoped that this tool can make it easier to feed pets, especially cats. Food that can be operated here is dry food. Dry food for cats is so widely circulated on the market that it is very easy to find it. However, there is still a limit to the size of food that can be used in this tool. Feeding cats should be routine and according to portions. With this automatic feeding device will remove food from the tank to the bowl. The bowl is magnetized at the bottom and a loadcell sensor to make it easier to wash and clean. When there is a cat at <15cm with an *ultrasonic* sensor on the plate, the food will be removed according to the portion, which is 1-2 grams, with *an error percentage* of 8-67%. The device will not remove food if the *loadcell* sensor still reads the weight of the food >1gram in the bowl. With the help of telegram, users can control and receive information from this tool. *The delay* obtained when sending a message to telegram to receive a message is 1-7 seconds. As for the camera until the image is received can be up to 12 seconds maximum. The addition of an antenna is very important to prevent the breakdown of the *wifi connection.*

Keywords: Esp32, Servo, Telegram bot, Ultrasonik, Sensor.

1. INTRODUCTION

There are 2 types of cat food that we can give are wet and dry food. Wet food can only last less than 24 hours. But dry food can be up to days as long as it is not wet or exposed to water. Cats can regulate their food intake according to their needs, but 25% to 40% of cats observed by veterinarians show signs of being overweight. Therefore, caretakers must be vigilant in the feeding of these cats. In domestic cats, overweight is a growing problem everywhere. Outdoors, a 4-kilogram cat needs about 300 kcal/day, while an indoor cat only needs 200 kcal/day or 30% less than an outdoor cat (Devitasari & Kartika, 2020).

The problem that will arise here is that most house cats are not given permission to leave the house, which means that the cat is only inside the house and cannot look for food outside. While the master sometimes does not have time to give food because of his busyness and even forgets, thus making the cat starve and it is not good for his health. Therefore, a tool is needed that can provide food for cats automatically so that they can eat whenever they want and according to the portion that we set in the tool later (Wijaya, 2019).

So this inquire about points to form a model of a cat nourishing instrument with Ultrasonic HS-SR04 sensor, RTC DS3233 module, IoT-based Wemos D1R2. Cat nourish can be followed by means of wire utilizing Web of Things (IoT) thoughts and ultrasonic sensors.Feeding the cat is done 2 times a day but for great nourishing the proprietor must too degree and check the accessibility of cat nourishment at the cat feeder so that the cat does not starve (Adella et al., 2020). But not each day the proprietor can control the accessibility of cat food when the proprietor isn't at domestic at that point the cat will have trouble finding nourishment but with the framework that will be designed to eat the proprietor does not got to stress almost taking off his favorite pet by utilizing the wire application and employing a microcontroller sensor the cat will be given nourishment naturally at certain hours and on the off chance that the nourishment runs out the framework will consequently feed.Microcontroller could be a tall thickness IC. Where all the parts required for a controller have been bundled in one chip. Microcontroller within the supposition of (Edy Widodo, 2020).

2. METHOD

2.1 Research Method

There are several steps of research in this project from literature study, system analysis, until data analysis at the final.For more detail, information are below:

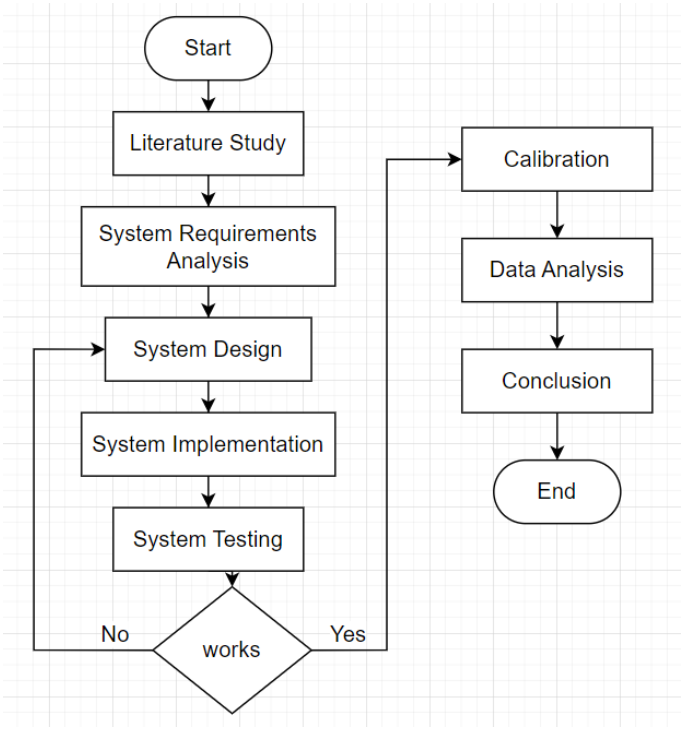

Figure 1. Flowchart of Research Method

2.1.1 Literature Study

This section contains the stage where studying and conducting studies to find and collect some information obtained from journals, the internet, and environmental conditions so that it can be used as a literature with the research title taken. Critical thinking is needed about the function of the tool and how it can solve problems that exist in the real world. Looking at the surrounding environment will help find existing problems so that a tool can be made that can eliminate these problems.

2.1.2 System Requirements Analysis

The next step is to analyze the problems and needs that will be poured into this research so that it becomes a solution. The data that has been collected will be analyzed and described in accordance with the existing problems. The system created will be able to perform several commands with the conditions as below.

1. The tool detects and responds when the cat approaches the food container.
2. Provides food by opening and closing the valve on the shelter hole.
3. Sends a message to the telegram when the sensor detects.

4. All can be controlled via Telegram Bot by sending a predetermined command message.
5. The camera takes a photo when the sensor detects a cat/other object and send it to Telegram Bot.
6. Can take photos manually via Telegram Bot.
7. The housing is simple and flexible.
8. Reads ambient temperature and humidity.
9. Using Telegram as the main controller

2.1.3 System Design

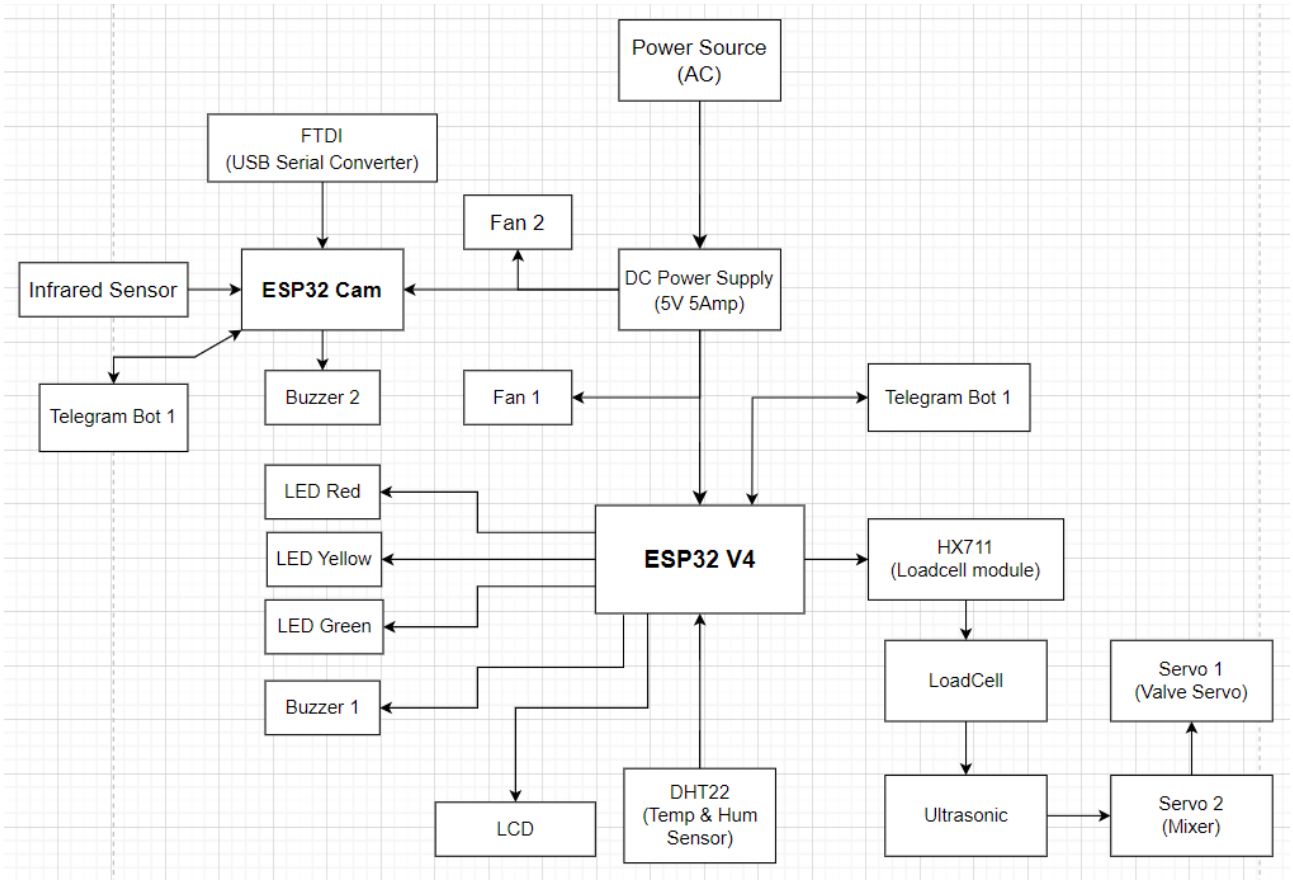

Figure 2. Overall block diagram system

This Block diagram provide all the connection systems. The system uses 2 ESP32 module with 1 power supply unit. ESP32-Cam use as the camera to take a picture and the other ESP32 is the main microcontroller for all sensors and components. ESP32-Cam has Infrared Sensor as the input signal and buzzer 2 as the indicator sound. To program or changing the script code of ESP32-Cam is by using FTDI (USB Serial Converter). And to upload the code, pin GPIO0 and GND of ESP32-Cam must be connected while uploading and press the reset button. When uploading is finished, disconnect GPIO0 and GND pin and press the reset button again. While ESP32 V4 has built-in micro USB port, so it more simple when the user want to change/upload the script code.
Both of ESP

32 needs 5V power supply to work perfectly. And high Amps of supply will be more better because this project has a lot of sensor and mechanic components.
Mini fan is DC type. Each of them needs 5V 100mA to run and both are connected in parallel to the power supply. These fans had a purpose to keep the microcontroller temperature in cool condition. Especially ESP32-Cam, it is faster to increase the temperature because the camera programmed to always in ready mode to take a picture.

Below are the list of all components that used in this project.

Table 1. Components of the project

No.	Components	Description	Quantity
1	ESP32 V4	The Main CPU for drop the food	1
2	ESP32 - Cam	The camera powered ESP32 chip to capture the photo	1
3	Servo MG946R	High torque servo to drop the food.	1
4	Servo SG90	Small torque for mix the food in tank. Usefull to prevent the food stuck in the valve.	1
5	Power Supply Adaptor	Powering all the components.	1
6	Mini Fan	To prevent overheat of the CPU.	2
7	LED	3 LED (Red, Yellow, Green) as the response indicator.	3
8	Ultrasonic Sensor	Detect pets in a distance for giving the food.	1
9	DHT22	Temperature and Humidity sensor.	1
10	Infrared Sensor	Detect pets in a distance for taking a picture.	1
11	Buzzer	As response indicator.	2
12	External Antenna	To receive the WiFi signal stronger and wider distance.	2
13	LCD I2C	Display the status and indicator response.	1
14	MX711 Module	To read the loadcell sensor.	1
15	LoadCell Sensor	Weight sensor for the food in container.	1

The project uses 5V 5Amp power supply that powered by 220V AC outlet. 5A supply is the best choice to power all the components, especially for a project that use more than 1 dc fan.
ESP32 has 32 pins that enough to connect some sensors and other components while ESP32-Cam only has 16 pins.
Another reason why not use ESP32-Cam only as the main CPU is because it takes delay too much to read the sensor. Especially while sending the piture to telegram, all sensors will stop working for a moment until the picture sent to telegram bot. And that is not good pont for time efficiency.

This project use Telegram Bot as the controller by connecting the ESP32 script to telegram bots token. By sending a command that defined from the script, user can control the project.Because the project using 2 module of ESP32, it needs 2 Telegram bot. The 2 Telegram bot has different control setup. The first bot is to giving the food, moving servos, and temp & hum information. While ESP32-Cam is only to take a picture from infrared sensor and send it to telegram bot. These servos (MG946R and SG90) work in food area. SG90 is in the food tank to steer and mix the food to prevent food stuck in the valve hole. While MG946R is a high torque servo that will open the valve and give the food to the container in certain amount. Telegram bot also can be used to take a picture, give the food, receive information from ultrasonic sensor, infrared sensor, loadcell sensor, and temp & hum sensor.

2.1.4 Hardware Design

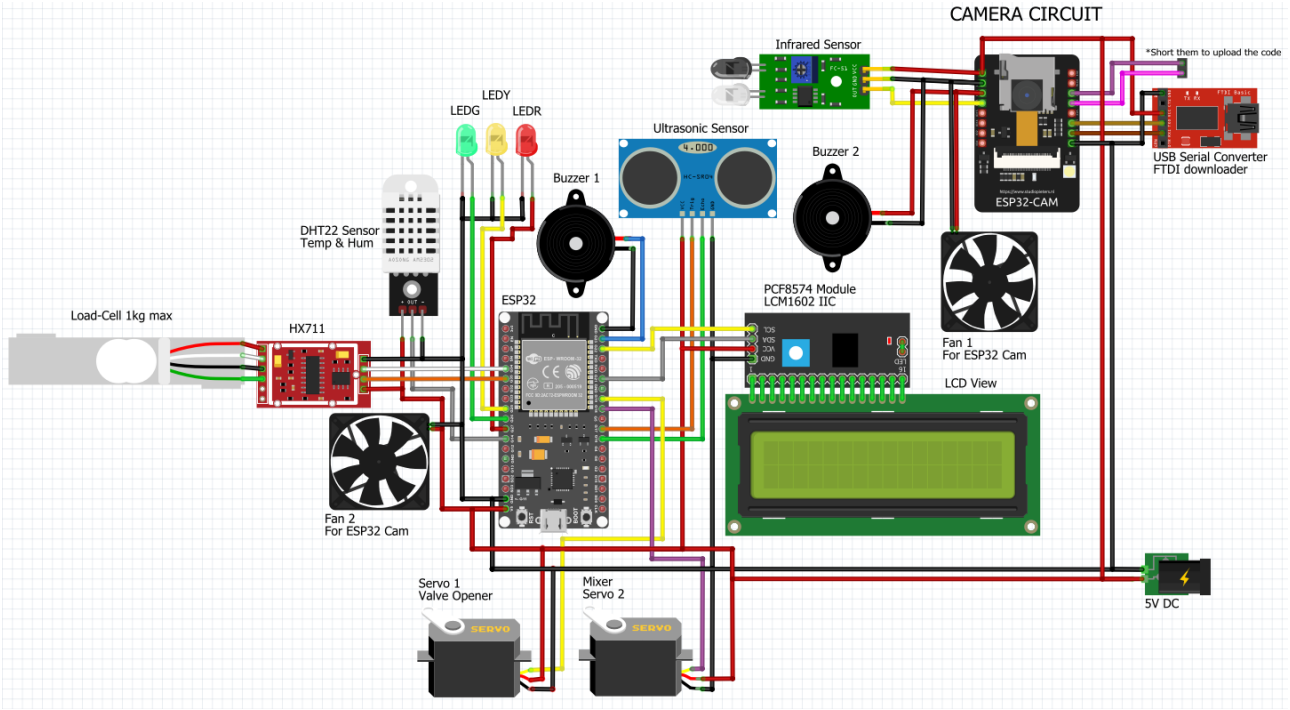

Figure 3. Overall Schematic Diagram

This is the complete schematic diagram of the project. The project contain 2 different circuits. There are ESP32 V4 and ESP32-Cam microcontroller that are not connected each other, but still use one power supply. Sensor and other components will work according to their microcontroller and not affecting other schematic circuit.

DISTANCE SENSOR

Ultrasonic is the main sensor in this project. This sensor uses ultrasonic sound that works above 20kHz. The sound of 20kHz and above is the range of sound that humans and cats cannot hear. So

this frequency is very safe to use especially for pet cats. Ultrasonic sensor has 4 pins to operate, there are VCC, GND, Echo and Trig. Echo and Trig are connected to GPIO16 & GPIO17 of ESP32 V4. These 2 pins are for receiving the signal of the sensor that will send to the microcontroller. VCC & GND are the power input to turn on the ultrasonic sensor module. Buzzer and LED are the indicator of the ultrasonic sensor when detects any object or cat in range <15 in front, then the buzzer and LED will blink 2 times at the same time. The test is completely done to measure distance on the ultrasonic sensor. This test has 3 trial to get an average for finding the percentage of errors were made. The formula to calculate the error percentage is below.

$$e = \frac{a-d}{d}\ 100\% \qquad (1)$$

a = Average of the data

d = Real distance

e = Error percentage

WEIGHT SENSOR

Load-Cell sensor in this project can measure to 1kg max of the weight. The HX711 is 24-bit analog-to-digital converter (ADC) that is designed for weighing scales and industrial control applications to interface directly with a bridge sensor. It is specially made for amplifying signals from cells and reporting them to another microcontroller. HX711 has 10 pins, 6 for the sensor, 2 for signal out, and 2 others as the power input. This project only use 4 pins for sensor instead of 6. DOUT & SCK is the pin to output the signal. DOUT pin connected to GPIO34 and SCK to GPIO35 in ESP32. While the power for this Module is 5V DC. To make the weight measurements close to precise, any object of load must removed from the container before turning on the project. This will make the weight measurement start from zero when the project is on. The unit of this measurement is in gram.

FOOD DROP SYSTEM

There are 2 servo used in this system. Servo 1 for Valve Opener and Servo 2 is for Mixer.
Servo 1 will allow food to flow from the tank to container. The servo is MG946R which is high torque servo. The purpose is to open and close the tank hole that contains high pressure of food. This high pressure is because the tank hole is 5.8cm. It is so big that small servo will get hard to work.
Servo 1 will open for about 40° for 2 loops and back to 0° position (0°- 40°- 0°- 40°- 0°).
User can change how many food will drop by changing the value of the servo angle.
The second servo is SG90. This is the most servo that can be found in market . This servo is to steer or mix the food in the tank to prevent the food stuck when the valve is opened. The servo will do the

80° of movement for 2 loops and back to 0° position (0°- 80°- 0°- 80°- 0°) when before the food and after the food drops.

Servo 1 (Valve Opener) connected to pin GPIO19 and servo 2 (Mixer) to pin GPIO18. Both servo use 5V power supply

The workflow of this schematic is Servo 2 – Servo 1 – LED Green.

Servo 2 (mixer) will do 80° of swing for 2 loops, after that the Servo 1 (Valve Opener) will do 40° of movement for 2 loops to drop the food. When the food was dropped and the servo 2 back to 0°, the LED green will blink for 10 times indicating that the process of the work is finished.

TEMPERATURE & HUMIDITY SENSOR

DHT22 is a Temperature & Humidity sensor. This sensor is more accurate than DHT11 version. DHT22 sensor will send the signal to the ESP32 through pin OUT to GPIO14. The sensor will read temperature in Celcius and Farenheit while humidity in percentage. When telegram bot send a command to read the temp & hum, the ESP32 will receive the massages and take the signal from DHT22 sensor and send the result back to telegram bot. In telegram will receive the temperature in celcius and farenheit, and humidity in percentage.

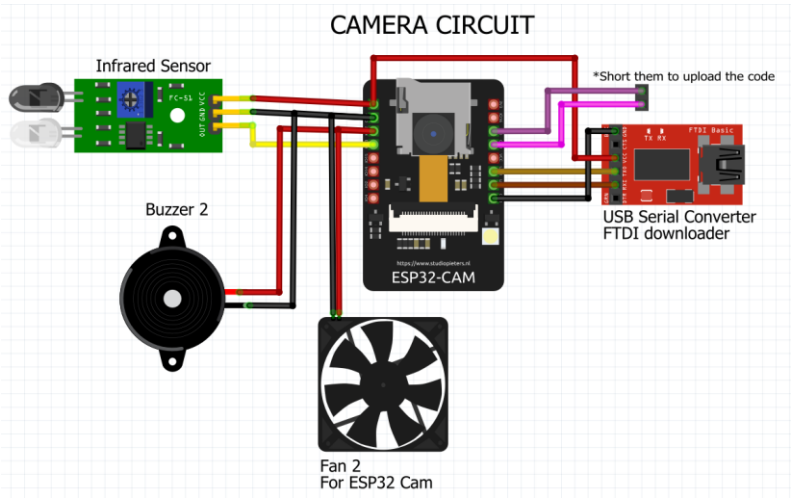

Figure 8. Camera Schematic

ESP32-Cam has pin, 8 pins are GPIO and the rest are power supply, ground, and RX & TX. Fan 2 has function to keep the microcontroller camera in low temperature. While FTDI is the downloader for ESP32-Cam. FTDI allows user to upload the script code when it needs to be change. Connect GPIO0 to ground and press enter while uploading the script code. When upload finished, disconnect GPIO0 and GND, then press reset button, and the camera will start. The RX and TX pin of camera to FTDI are cross-connected. RX pin is receiver pin and TX pin is transmitter pin.

The main work of this microcontroller is when infrared detects any object in a certain distance (in this project is 3.5cm), the camera will take a picture and send it to telegram bot. It will take delays to capture the photo and send to telegram. The buzzer 2 is the indicator of the sensor when sensor detects an object. Buzzer will beep 2 times when sensor detects an object . To change the sensor range, adjust the trimpot on the infrared sensor. The minus of this sensor is it cannot adjust the range more than 10cm, and very high impedance when contact with sun light. Means the sensor will high when receive sun light.

TELEGRAM BOT

When the tool has been made, the system implementation will be carried out, namely all controls and tool performance can be seen via Telegram. The Telegram in question is Telegram Bot. Telegram bot is a feature provided by Telegram to users so that they can use it in any case including controllers and other projects. So that the tool can connect to the Telegram bot, it must enter the Telegram bot token into the programming script.

(a) (b)

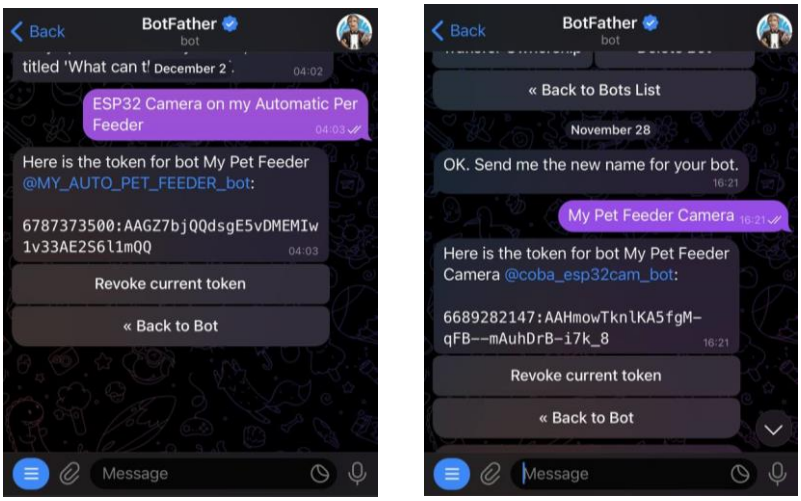

Figure 10. (a) The Token for My Auto Pet Feeder;
(b) The Token for Camera bot

The telegram bots used totaled 2 bots, namely for pet feeders and cameras. Each is set with a separate program script. The My Pet Feeder bot can manually feed, read the temperature sensor, read the weight of leftover food, detect objects from ultrasonic, and open the valve fully for the purpose of draining the food tank.

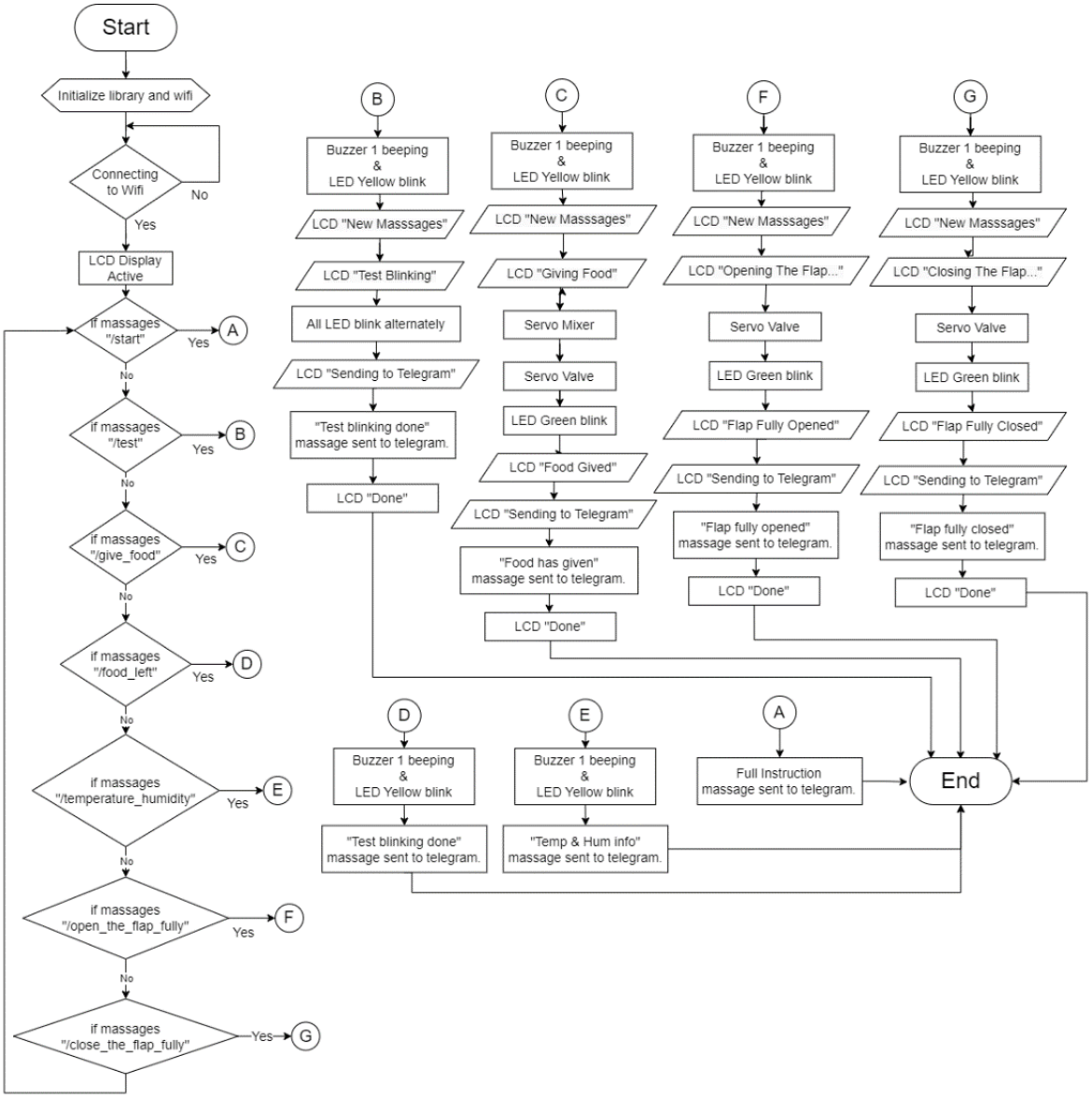

Figure 12. Pet Feeder flowchart

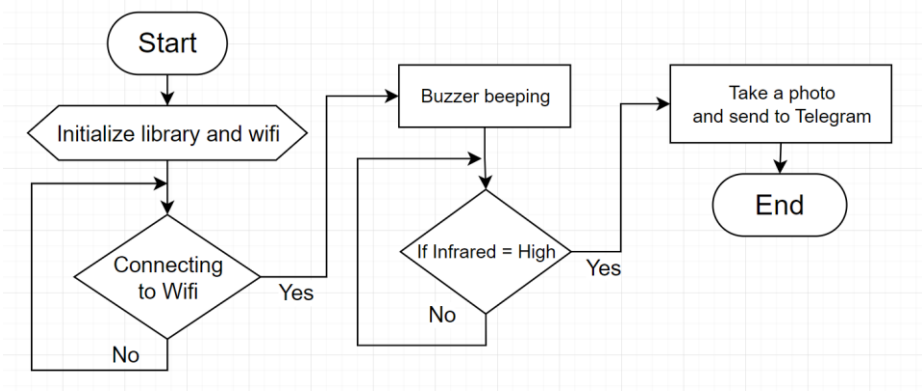

Figure 13. Camera Flowchart

3. RESULTS AND DISCUSSION

This discussion will lead to a tool that has been designed, namely the Automatic Cat Feeding Tool Using Telegram. At this time, researchers have conducted research and experiments on building designs, characteristics of various sensors used, mechanical systems, Load-Cell sensor readings, Infrared sensors, camera performance taking pictures when cats approach the sensor, and the flexibility of telegrams as full remote control.

(a) (b)

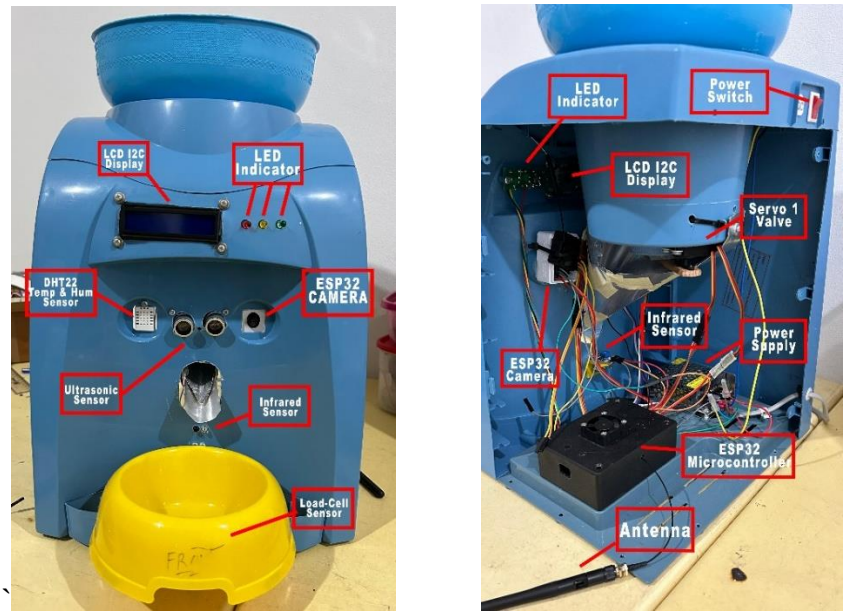

Figure 14. (a) Anatomy project from outside

(b) Anatomy project from inside

This tool has been tested in each part of the sensor module and other components to calculate the percentage of success of this tool. Some modules that are tested are Ultrasonic sesnsor, Load-Cell, Infrared sensor, ESP32-Cam, and how much food comes out when the servo moves.

3.1 Ultrasonic Sensor

Ultrasonic sensors detect objects in front of them at a certain distance.In this project, the distance has been determined and several experiments have been done so as to get the value below. The experiments were done 5 times so that it is enough to see the average working value.

Table 2. Ultrasonic Sensor Reading

Range (cm)	Experiment 1	Experiment 2	Experiment 3	Average	Error (%)
10	10 cm	9 cm	10 cm	9.6	4
15	14 cm	14 cm	14 cm	14	6.6
20	19 cm	20 cm	20 cm	19.6	2
25	24 cm	25 cm	24 cm	24.3	2.8

3.2 Main Sesnsor & Servo Testing

To drop the food, there are 2 main sensor that will work here. They are Load-Cell and Ultrasonic sensors. The Ultrasonic Sensor will detect the object/cat in front of it, while the Load-Cell will read and calculate the weight on the food plate. Food will come out only when the ultrasonic sensor detects an object with a distance of ≤15cm and the weight on the plate ≤1 gram. After that the servo will move and drop the food onto the plate with a predetermined portion. Food will not come out if the Load-Cell sensor value is >1 gram. Likewise for the ultrasonic sensor. Food does not come out when the ultrasonic value is >15cm and the Load-Cell sensor is >1 gram.

Table 3. Main Sensor and Servo Testing

Exp.	Ultrasonic (cm)	Load-Cell (gram)	Servo for dropping the food
1	>15	>1	not active
2	>15	<1	not active
3	<15	>1	not active
4	≤15	≤1	active

3.3 Feeding Data Testing

Table 4. Real Feeding Test

Exp.	Ultrasonic (cm)	Load-Cell before (gram)	Food dropped (gram)	Load-Cell after (gram)	Portion Target	Error (%)
1	<15	-0.14	1.08	1.22	1 gram	8
2		-0.10	1.03	1.13		3
3		-0.12	1.67	1.79		67
4		-0.02	1.39	1.41		39
5		-0.05	1.67	1.72		67

This section describes data on feeding under actual conditions. The data describes the value of the Load-Cell sensor and the amount of food dropped. The desired target portion of food is 1 gram. However, because the food pile is in a different position every time, especially the shape of the food pile.

3.4 Camera and Infrared Sensor

Table 5. Taking a photo

No.	Infrared (cm)	Take a photo
1	>7	No
2	<7	Yes

In this experiment, the camera and infrared will provide output in the form of taking pictures and sending them to a telegram. Because infrared sensors cannot measure distance, manual measurements are taken using a ruler between the object and the infrared sensor. Infrared sensors are

set to a detection distance of <7 cm so that they can take pictures. But this distance will not always be constant because infrared light can be easily affected by sunlight / ultraviolet light.

3.5 Telegram Send and Receive Delay

This data provides information about the time when the telegram sent the command message and the time when Esp received the message, as well as the duration of the delay between the two. So it can be seen how long it takes when the device is controlled via IoT. This delay is highly dependent on the speed of the internet/wifi connected between these two devices. The faster the internet/wifi, the more responsive the device works.

Table 6. Telegram Send and Response Delay to Drop The Food

Exp.	Telegram Send Time	Esp32 Receive Time	Delay Duration
1	01:21:15	01:21:21	6 sec
2	01:22:10	01:22:12	2 sec
3	01:23:00	01:23:01	1 sec
4	01:28:40	01:28:44	4 sec
5	01:31:30	01:31:36	6 sec
6	01:33:50	01:33:57	7 sec

Table 7. Telegram Send and Response Delay for Camera

Exp.	Telegram Send Time	Esp32-Cam Receive Time	Photo Received in Telegram	Total Delay
1	01:12:10	01:12:16	01:12:22	12 sec
2	01:13:20	01:12:21	01:12:26	6 sec
3	01:14:30	01:14:33	01:14:37	7 sec
4	01:15:35	01:15:35	01:15:40	5 sec
5	01:16:40	01:16:40	01:16:47	7 sec

The data shows how much delay it takes to send a command message to take a photo via Telegram until the photo is received by the Telegram user. In some of these experiments, it can be concluded that the time distance from sending a message until the photo is received is> 5 seconds, and it depends on the internet / wifi speed used between the 2 devices.

3.6 The Output

(a) (b) (c)

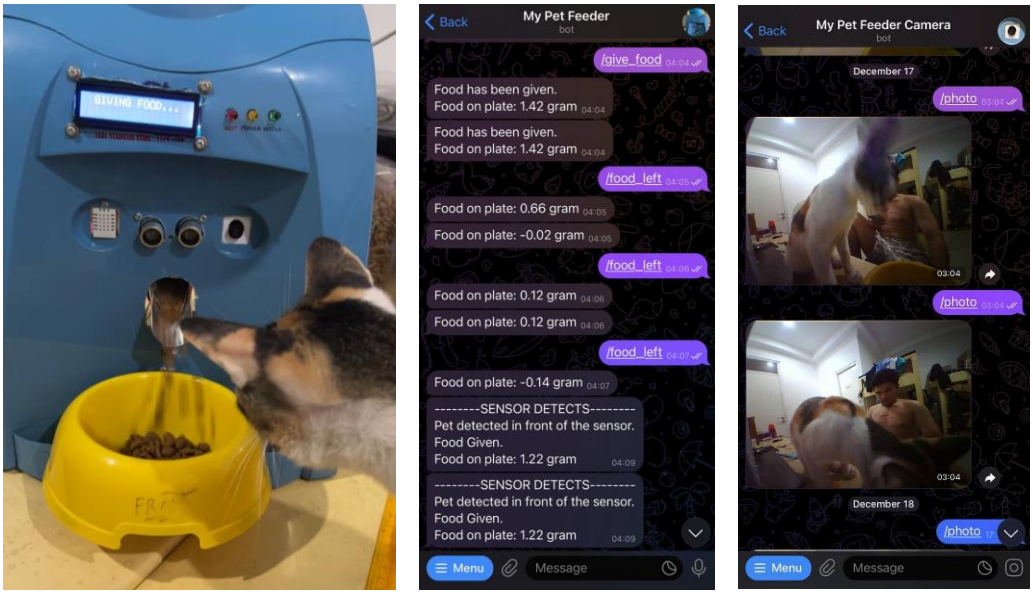

Figure 14. (a) POV project with a cat

(b) Pet Feeder Telegram bot chat

(c) Camera Telegram bot chat

There are 2 different telegram bots mean that there are 2 esp32 microprocessors used in this project. The first image shows the real situation and conditions with a cat waiting for food to be given from the project. The second image shows the contents of the Telegram bot chat which contains information about feeding and others. And the third image shows the contents of the Telegram bot chat for the Camera in the form of a photo of the cat.

4. CLOSING

Simple and flexible are inside this project. By using an used dispenser as its housing to make it easier to assemble and install components. The mechanical part to drop the food are using 2 servo.

There are irregular delay in sending and receiving command messages from Telegram. Program of the script is made to check the incoming message to the telegram and read the sensor offline alternately every 3 seconds, and it is also not constant. This delay instability makes the sensor, especially the ultrasonic, sometimes not read because it is still changing its turn to check the incoming message to the telegram. The size of the food selected is important to the smooth working system of the project.Food dosing is also quite stable because the shape of cat food is quite large and irregular in position when in the tank. In order to make the wifi used esp32 stable, an additional antenna is used so that the performance of the device is not stuck due to weak wifi signals.

5V 5Amp power supply is the main voltage supply in this project. Because it uses 2 fans and also many other components, it is highly recommended to use this supply.

LITERATURE

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