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IOT based Pet Feeder

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Article Info
Volume 83
Page Number: 269 - 279
Publication Issue:
March - April 2020

Article History

Article Received*: 24 July 2019*
Revised*: 12 September 2019*
Accepted*: 15 February 2020*
Publication*: 12 March 2020*

Abstract
Automation can be done independently by machines, but it can be enhanced with monitoring and controlling features with the help of IoT, as the world becomes increasingly interconnected, the Internet of Things (IoT) creates an extensive network of devices that regularly exchange data. While this interconnection is happening in businesses and throughout organizations on a global level, it's also happening in individual homes. Smart home devices and gadgets are becoming more popular with consumers who enjoy having all their devices interconnected to serve the purpose of increased convince, comfort, energy effeincncy and most importantly personalization which is one of the focus points on this project, with the help of automation of electronics and IoT the experience becomes much more personalized for the user. This research proposed a pet feeder system which is divided into two main sectors including measurements and control unit. System perform periodic measurements of the pet's weight and food level inside the tank. On control unit, the system can operate under smart mode where user can define the energy fact of the food inside the tank and type of the cat. The cat's weight will be, further, measured and the system can compute the right amount of the food to be dispensed to cat. The right amount of food is based on the adequate energy that selected cat shall take per day. The Smart Pet Food Dispensing Algorithm is based on the energy fact of food, type of cat, cat's weight to regulate the flow rate of the feeder. The large outlet is only used in smart mode where its flow rate was calculated as 183.11 cm^3/s while the small outlets allows a flow rate of 8.62 cm^3/s.

Keywords: *IOT, PET FEEDER, Arduino UNO, Smart home.*

1. Introduction

Automation recently has been a technological revolution in demanded in an industrial scale and also in our daily life gadgets, customers are attracted to automatic devices more than anything and that is for the purpose of ease in use and time saving, companies are trying to fulfill the demands and the automation industry is becoming stronger and more developed everyday, to be more descriptive automation is a method of controlling and operating procedures in an automatic manner with the help of electronics and software that can be programmed and implemented with machine learning technologies, automation isn't very new, it has been there in the market since 1960's when the first ATM machine was introduced, with the help of such machinery the process became much easier faster and more convenient for the customer.

Most of the pet owners nowadays want to enjoy the company of their pets, some of the pet owners have the patience and time to feed the pets and some do not have the time to do so. This is where automation and (IoT) comes in handy to develop a system that can fulfil the pet owner without doing any harm to the pets. Therefore, previous and recent projects, will be discussed in the literature review chapter, tremendous projects have been designed and released to the market, these automated pet-feeders are functioning to give a fully personalized experience

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where the pet owner can program the feeding schedule, where the food can be dispensed at specific timings and with specific quantities, previous researches will be taken into consideration, where it will be opening more chances to understand more and learn from previous experiences and finally to combine the ideas of previous researches to reach to a point where the system can be enhanced with the most amount of features to make the pet owner satisfied.Not every pet owner is available to feed their

pets according to their diet schedule, in fact most of the pet owners who are working or studying until late ours of the day are not punctual at feeding their pet, well generally people under estimate the harm of this problem, pet owners usually under look this issue with an un-solving dangerous solution which is over filling the food dish with a very large quantity of food, not only busy pet owners do this but also pet owners that have the impatience of putting food for their pets 3 times a day and doing this process daily is a burden on them.The IoT provides a set of standards and methodologies to associate object in the real world. Internet of Things (IoT) connects all goods with internet through information sensing devices [1].

It is quite obvious that pets require special care and treatment. However, because of the busy routine, it becomes very difficult to care for pets. [2]present a smart system for pets and include system for pet collar, food feeder for pets, and monitoring of pet door.The pet feeder is capable of keeping the water and food clean until the pet wishes to eat. It has a cover for bowl that closes and opens automatically. The presence of pet is detected by the sensor and the cover is opened which enables only the pet to access the food. Moreover, the collar has a GPS tag which is used foridentifying and transmitting the steps of a pet. It has been explained that the present technology is not suitable for providing the best security and indulging delays.[3] explains that humans are exposed to such vast scope of technologies that they couldn't have even imagined it in the past. IoT is an important and rapidly advancing technology.There is a functionality of pet monitoring in the device which will notify the owner about the location of the pet as there are many times when the owner is busy with something else and cannot keep a watch on the pet. Relying on this aspect, even notorious pets can be found. There is yet another feature in the device which is referred as automated calling and it can be beneficial in the cases when there is a threat and the owner wants to be notified about it. Automated pet feeder is basically a new technology for feeding pets.[4]explains that it will help the pet owner in taking care of every pet in the house even when he or she is not present. The device is created for helping pet owners as predetermined amounts of the food are dispensed when the user gives a common using an infrared remote control that is wireless. It is very significant for the owner to realize the diet of pets for ensuring their health. Actually, this system acts in two ways, one is sending information to owners and the other one is feeding pets.The feature concerning the quantity of feed means the quantity of food that the system will be serving in every other feed. In the system, there is a unique feature of refill alert which lets the owner know that the bowl is running empty.[5]used differentautomatic feeder, the components of the automatic feeder include LCD display, Wi-Fi module, T-section of PVC pipe, Acrylic sheets, Arduino UNO, RTC or Real Time Clock, Ky-40 Rotatory Decoder Encoder, and Continuous Servomotor with MG995. Servo motor for continuous rotation is being used with digital modulation. AUGER is rotated by the motor that provides food to dish from food. Arduino UNO sends signals to the motor. It can be said that the shape of AUGER is similar to that of a device used for drilling. Meanwhile, Arduino UNO is actually a board of microcontroller formed on the basis of ATmega328.[6] established the study of Internet of Things and suggested its use for smart feed systems for pets. This system can be connected to a smart phone and the owner can easily watch the activity. Through the communication device, the time and quantity of food can be managed easily. For the purpose of identification of the dog, the RFID smart system is used which can detect the tag of the dog to allow for services. The components used for Smart Dog Feeder are RC522 RFID reader and tag, load cell from gold weighing scale, HX711 weighing module, Arduino UNO, servo motor DF15RSMG, real time clock DS3231, magnetic switch, LM2596, screw shield, ESP8266 Wi-Fi module, and 12V adaptor. This system is installed with 'Appliance Hub

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Application'. Micro-controller controls the JSON objects in this feeding system. ESP8266 Wi-Fi module with Node-MCU firmware programmed in Lua language. The server uses the MQTT protocol, which provides all the information about feeding.[7] explain that as new technologies are being developed, RFID or Radio Frequency Identifier has expanded immensely as a major technology for tracking of things over the globe. The tags of RFID can either be passive or active. RFID in the applications of animal tracking tell about the application of domestic animal tagging by a number of nations that help them in the tracking of animals. The task of tracking is actually carried out using the chip of RFID or radio frequency identification which is related to the tag. This tag can easily be attacked to animals like goats and cows by implantation or clamping on any ear. The authors in this study propose a WOA or web of object architecture that delivers IoT services on the basis of web to animals and humans. Individuals that are more likely to be in contact with animals such as pet owners of veterinarians can keep the track of every animal that they own and can easily diagnose their behavior with the MMS or Mobile monitoring system on the basis of RFID. If an animal is lost then its whereabouts can be identified using the RFID tag. The authors have concluded that with a rising interaction among living things, objects, and humans, there is a critical need to build a strong connection between them.[8] have explained that for providing a feasible solution to the issue of tracking pets, the pet collar must be intelligent and it can be achieved with the addition of a microcontroller unit. GSM technology will be used by the collar for providing updates and monitoring to the phone. The GPS technology will be used by it for the purpose of tracking. The technology of motion sensing will be used by it for the activity of monitoring. Additionally, the program of microcontroller allows various features like environment sensing, feed advisor on the basis of activeness, feeding alarm, sensors etc. The user will be enabled by android application for obtaining the control and updates of real time on a smartphone. Some of the features that the intelligent pet collar delivers are include: tracking of location, virtual leash, interface of smartphone, feeding alarm, voice training, rain sensor, and activity monitor. It has been concluded by the authors that there are various limitations to the proposed system. For instance, when the features in the intelligent pet collar increase, the price increases. Moreover, the system of GPS in the collar is actually bound by the cellular range and the power of battery is limited majorly. However, this technology is finding a rising number of applications as an advanced device in the sector of Pet Care. IoT actually deliver effective technical support for the researchers of zoology and biology fields. [9] explain that for animal tracking and monitoring, IoT is used. The monitoring of animals in remote areas is quite difficult because of the harmful surroundings and anxiety of patterns concerned with the animal movement. Additionally, the limitation of traditional networks of sensors is the energy drawback. It means that delivering the information consistently is practically impossible other than being very costly. It can be said that wildlife monitoring is a trending and attractive application of the IoT in which various heterogeneous sensors are implemented for the monitoring of wild animals. These sensors could be applied as collars for keeping the track of activities of animals.In the presented system, there are 3 applications that have been implemented. These applications include health monitoring, recognition of habitual movement, and location tracking. In the location tracking, the device of tracking is quite useful in keeping a watch on the animal. It will be attached to the animal and a tracker with the receiver of satellite positioning will sent the data location to the center.

2. Proposed System Methodology

The proposed system runsbased periodic measurements of the pet's weight and food level inside the tank. The system can be set to:

1) Smart Mode: User can define the energy fact of the food inside the tank and type of the cat. The cat's weight will be, further, measured and the system can compute the right amount of the food to be dispensed to cat. The right amount of food is based on the adequate energy that selected cat shall take per day. This section will be further explained in detail. The Proposed block diagram of the system is show in Figure 1.

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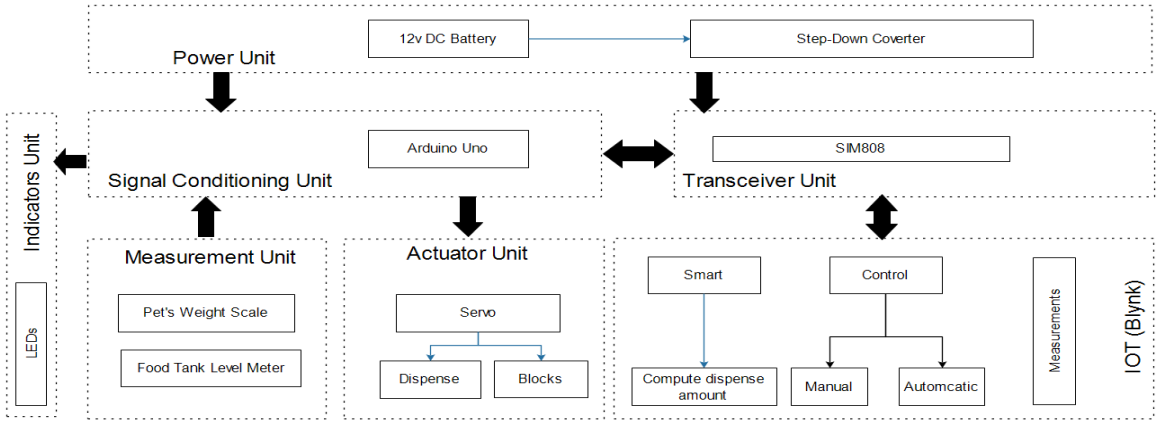

Figure1: Bock Diagram of the Smart automated pet feeding system

2) Control Mode: The system can be set to control mode. Control mode allows user to dispense food with two different methods. The control mode can be run as:
   a. Automatic: Under the automatic control mode, the system can be scheduled for certain time to dispense the food with adjustable dispensing time.
   b. Manual: Under manual control mode, user can dispense food at any time for certain duration defined as adjustable dispensing time.

The measurements are taken from load cell and ultrasonic sensor at period manner. The duration can be set by user. For example, taking measurements at each 10 seconds. The measurements are effective in the process of system. The measurement of:

1) Load cell (weight sensor) is used in smart food as one of the crucial elements to define the right amount of food to be dispensed; and,
2) Ultrasonic sensor (food level meter) can prevent dispensing process and notify user about emptiness status of food tank.

The servo motor dispenses the food based on the modes defined by user. Servo can dispenses the food with large and small outlet.

The whole system is powered up by an external 12v DC battery. SIM808 is connected to the battery through step-down or buck converter to obtain 9v DC consistently.

Indicators are connected and controlled by Arduino Uno. Once the system is powered up, the Red LED turns ON. Green LED turns ON once the communication with IOT is successful.

The flowchart of the system portrayed the mechanism for the proposed system under both smart and control mode. The straightforward flow of the system is as:

1) Calibrate the weight sensor
2) block the flow by keeping the servo at angle of 90
3) Establish communication with IOT by initializing the SIM808
4) obtain the commands from blynk app
5) If updating time is reached, check the measurements
   a. Read 30 samples from ultrasonic sensor; store them in an array; find the mode of the readings as the capacity of food in tank
   b. Read 5 measurements from load cell sensor; apply mean value over the readings
   c. Update the readings on Blynk app
6) Continuously check smart mode condition and
   a. If the smart plan is selected, wait for first schedule to activate
   b. If the control mode is selected:
      i. If the automatic mode is selected, wait for schedule timer to activate and dispense the food via large outlet for given dispensing timer.
      ii. If the manual mode is selected, continuously check for permission from user; once the permission is granted, dispense the food with respect to the selected outlet and dispensing timer.
7) If smart feeding amount is activated:
   a. Get the type of cat from blynk

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b. Obtain the last measurement for cat's weight
c. Obtain the energy fact from blynk
d. Compute the right feeding amount based on Smart Pet Food Dispensing Algorithm.

3. Dispensing mechanism (Outlets)

The dispensing mechanism is provided by a half circle wood material connected at under beneath of the food tank outlet. This half circle plate with diameter of 22 cm has two outlets on sides; one is large with diameter of 5cm and another is small with diameter of 2 cm. The half circle plate blocks the flow of the food if it is not set to either outlets. The selected servo motor can rotate from 0 to 180 degrees.

Once the system is powered up, the servo is set to angle of 90 degrees to normally block the dispense flow; therefore, the dispensing mechanism is set to normally close. The servo can be set to angles of 10 and 150 to respectively permit small and large outlet interface with food tank outlet.

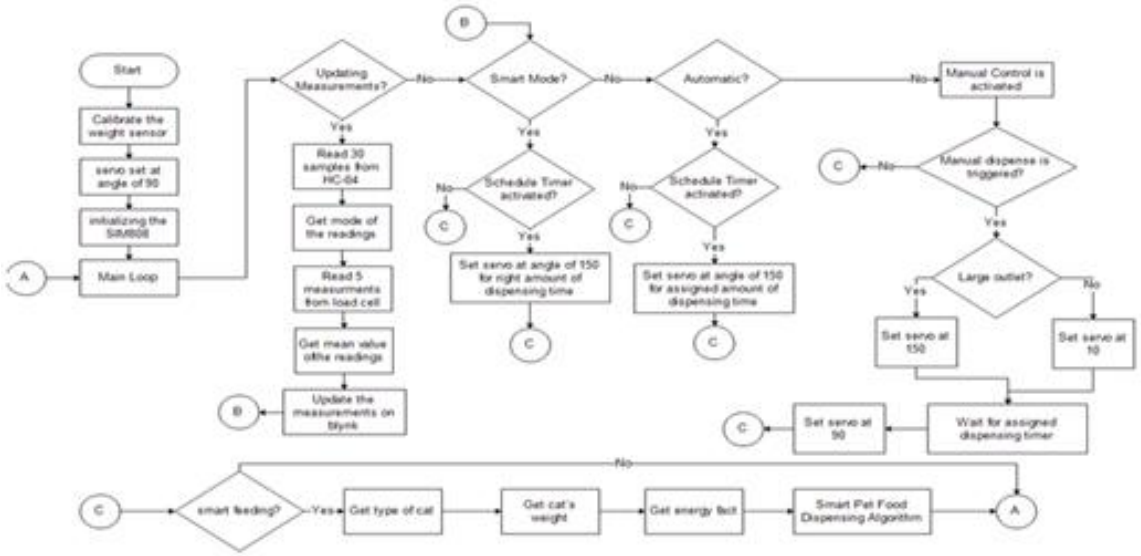

Figure 2: Flowchart of the Engine lock system

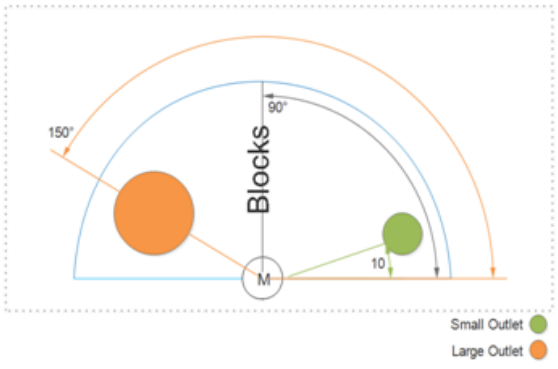

Figure 3: Dispensing Mechanism (half circle plate)

B. Volumetric Flow Rate

In order to find the amount of food being dispensed from the food tank into the feeding area, Volumetric Flow Rate shall be calculated via below formula:

Q = A * V

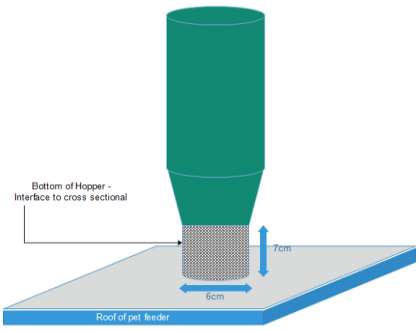

Figure 4: Side view of the food tanker and cross sectional area

The cross sectional area depends on the outlets interfaced with bottom of the hopper. Therefore, the A can be found for small and large outlets as:

$A_s = \pi * r_s^2$ .....(4.1)

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knowing that r_s = 1cm;

$A_s = \pi * 1^2 = 3.14\ cm^2$

and for large outlet;

$A_l = \pi * r_l{}^2$

knowing that r_l = 2.5cm;

$A_l = \pi * 2.5^2 = 19.63\ cm^2$

However, the motive behind this flow is the gravity; in another word, Gravitational flow rate. Gravitational flow rate is calculated using Manning's Equation, which applies to the uniform flow rate in an open channel system that is not affected by pressure. The Manning's Equation for flow rate is:

$Q = A * V = A * (\frac{1}{n} * R^{\frac{2}{3}} * \sqrt{s})$.....(4.2)

Where:

Q = Flow Rate,

v = Velocity,

A = Flow Area,

n = Manning's Roughness Coefficient

R = Hydraulic Radius, and

S = Channel Slope

The surface of the food tank at the outlet is made of steel and the cross-sectional outlets are made of wood. The Manning's Roughness Coefficient for steel and wood is 0.012. The slop channel in the food tank is near closed to 0.012 cm.

The hydraulic radius can be calculated by below formula:

$R = \frac{A}{P}$.....(4.3)

Where P is the wetted perimeter and it is equal to the sides and bottoms of the bottom of hopper. The *P* is almost equal for both the outlets. Therefore, the P is 19 cm.

Therefore, the Hydraulic Radius for small and large outlets are as 0.165 cm and 1.033 cm respectively.Therefore, the flow rate for small and large outlets is 8.62 cm^3/s and 183.11 cm^3/s respectively.

C. Smart Pet Food Dispensing Algorithm

The smart dispensing mode is designed to obtain required information from pet and define adequate amount of pet's food. Below information are required to be obtained for pet including:

1) Pet Type: Different types of cat consume different amount of energy; thus, they require variant amount of food to consume. For example, kitten usually need 200 kilocalories per day which can be split into two meals; each meal contains 100 kilocalories. The proposed system considers 5 types of cats as tabulated in table 1.

Table 1: Type of cats and their energy consumption

Type of Cat	Average energy consumption per day (Kcal)	Weight (kg)	Average energy consumption per day for each kg (Kcal)
Kittens	200	2.25	88.49
Lean Domestic Cat	440	9	48.88
Overweight Domestic Cat	310	9	34.44
Exotic (Wild) Cat	780	9	86.66
Pregnant Cat	1091	9	121.22

2) Pet's weight: Cat's weight will be measured by load cell once the cat stands on the scale plate. The cat weight cannot be less than 1kg. The cat's weight will be used to determine the total energy to feed the cat. For example, if the cat is under pregnancy condition with weight of 12kg, the total calories required for the cat per day would be calculated as: *Total calories requires per day for pregnant cat: 121.22 * 12 = 1454.64 kilocalories.*

3) Energy fact of the food: There are various types of pet's food with different nutrition resulting in variant energy per serving. The standard way to understand the energy of food is to get the energy amount per 100 grams for the selected food

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which can be obtained from nutrition fact. For example, if the energy amount in 100 gram of a certain food is 300 kilocalories; considering above example, the amount of food to be dispensed to cat would be:

Total food amount to dispense = (*1454.64* 100) / 300*

Total food amount to dispense = 484.88 grams

As there are two schedule in system, the amount of food to be dispensed per each schedule would be 242.44 grams. This amount is controlled by adjusting the dispensing time for the servo motor per flow rate for large outlet. The smart mode only runs by the large outlet.As there are two schedule in system, the amount of food to be dispensed per each schedule would be 242.44 grams. This amount is controlled by adjusting the dispensing time for the servo motor per flow rate for large outlet. The smart mode only runs by the large outlet.

4. Simulation and hardware result

D. Graphical User Interface (Blynk)

The GUI of the system is based on Blynk application. The app contains three tabs including:

1)Measurements: To allow user adjust the updating time for measurements, monitor updates measurements (load cell and food amount in tank), and monitor the status of the dispenser (either it is blocks, large, or small outlet).
2)Control Unit: User can consider smart or controlled mode, adjust the schedule timers, adjust the energy in the selected food, or manually control the dispensing mechanism.
3)History: A live chart shows and store the behaviour of system in terms of dispensing food to pet.

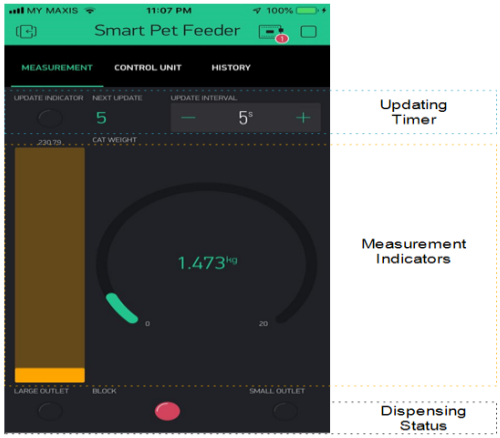

Figure 5: Measurement window of the smart pet feeder system

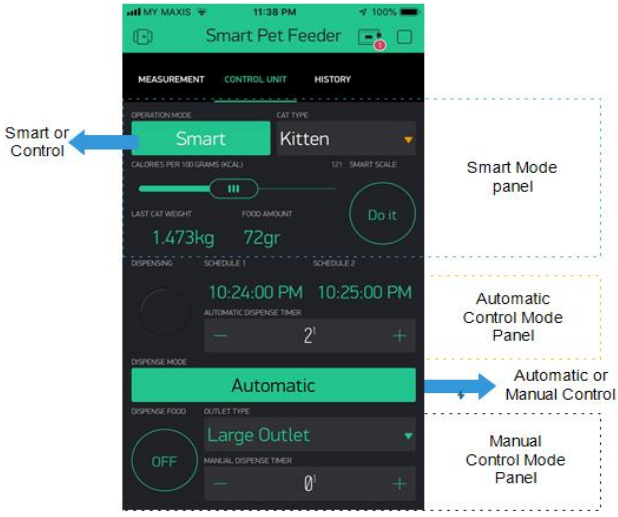

Figure 6: Control unit tab

E. Prototype (Hardware simulation)

Figure 7: Front and back view of the smart pet feeding prototype

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The prototype of the system is showcased in figures 7. The system is built on a wooden frame with dimension of 60 * 35 * 35 cm (length * width * height). The height mentioned in the dimension is the frame of the system. The height of the feed tank which is mounted on top of the frame will add up 31 cm to the entire prototype height. Therefore, the height of the prototype in presence of the feed tank is 66 cm.

5. Testing and results

F. Flow rate (small and large outlets)

This tests aims to determine the flow rate of the small and large outlets. This was calculated that flow rate of large and small outlets are respectively 183.11 cm^3/s and 8.62 cm^3/s. This tests requires to keep the system in manual mode and test the large and small outlet flow rate at first. The amount of food dispensed in the serving plate will be collected and pour into a Glass Beakers. The beaker is a cylindrical with dimension of 40 into 7 cm (height and diameter).

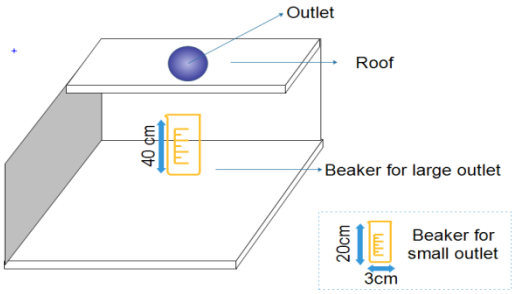

Figure 8: Setup for testing the flow rate with presence of beaker

The test conducted for flow rate of both large and small outlets indicates that there is small discrepancy between the calculated flow rates and the measured flow rate. This should be noted that the amount of food dispensed into the beakers are based on 1 second; therefore, the volume dispensed is measured on cubic centimeter per second. This was observed that the average flow rate of the large and small outlets are 179.96 and 7.85cm^3/s. This indicate that the large outlet is 98.27% accurate while the small outlet's accuracy is 91.06%. The error in dispensing the food for large and small outlet is ± 3.15 and $\pm$ 0.77 cm^3/s.

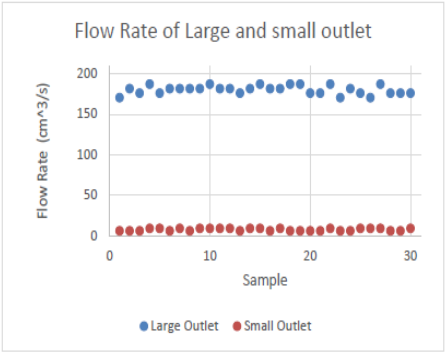

Figure 9: Flow Rate of Large and small outlet

G. Power Consumption

This test aims to find out the total power consumption of system. In order to find out the power consumption of system, the voltage and current drawn from the power course are essential. The voltage is known in this test as the power source of system is a 12v DC rechargeable acid battery. Therefore, the current shall be measured from the battery to the rest of components.

Table 2: Data collected for power consumption of system

Second/ Reading	Current measurement (mA)	Event	Power Consumption (w)
1	40		0.48
2	41		0.492
3	40		0.48
4	42		0.504
5	121	Communication with IOT	1.452
6	43		0.516
7	69	Servo Motor	0.828
8	40		0.48
9	43		0.516
10	123	Communication with IOT	1.476
11	42		0.504
12	40		0.48
13	41		0.492
14	43		0.516
15	121	Communication with IOT	1.452
16	43		0.516
17	42		0.504
18	70	Servo Motor	0.84

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19	40		0.48
20	123	Communication with IOT	1.476
21	41		0.492
22	40		0.48
23	41		0.492
24	41		0.492
25	121	Communication with IOT	1.452
26	42		0.504
27	40		0.48
28	42		0.504
29	42		0.504
30	122	Communication with IOT	1.464
31	41		0.492
32	40		0.48
33	41		0.492
34	40		0.48
35	120	Communication with IOT	1.44
36	41		0.492
37	68	Servo Motor	0.816
38	41		0.492
39	40		0.48
40	120	Communication with IOT	1.44
41	43		0.516
42	43		0.516
43	43		0.516
44	40		0.48
45	122	Communication with IOT	1.464
46	42		0.504
47	42		0.504
48	40		0.48
49	40		0.48
50	120	Communication with IOT	1.44
51	40		0.48
52	41		0.492
53	67	Servo Motor	0.804
54	40		0.48
55	121	Communication with IOT	1.452
56	40		0.48
57	41		0.492
58	43		0.516
59	43		0.516
60	123	Communication with IOT	1.476

Power consumption of system is stable at approximate 0.5w while there is no communication between the IOT and Servo motor. The servo motor can consume significant amount of current resulting in a boost on – 0.4w- to the normal power consumption of system. SIM808 consumes the most of the power of system – 0.9w. Communication with IOT can raise the power consumption of system to 1.45w with current consumption of 123 mA.

Therefore, the power consumption of the system under no command is 0.1428 mWh. By adding the total power consumption (excluding extra 0.4w consumption of servo motor), the total power consumption of the system would be 40.92 mW in one minute. By converting this value to milli watt per hour (1/60 = 0.016); the power consumption of system under communication with IOT with 5 seconds measurement update time is 0.682 mWh.

H. Efficiency of dispending food under smart mode

This test aims to investigate the accuracy of the dispensing dispending food under smart mode.There is no any specification for setup in this test. System will be set to different weights, different type of cats, and constant energy fact (considering same food is being dispensed). The amount of food dispensed on the serving plate will be collected and weighted. This can show the accuracy of system in dispensing the required amount of food in grams. The type of cat is addressed as 1 to 5 with respect to the table 3.

Table 3: Type of cat and their energy consumption

No.	Type of Cat	Average energy consumption per day for each kg (Kcal)
1	Kittens	88.49
2	Lean Domestic Cat	48.88
3	Overweight Domestic Cat	34.44
4	Exotic (Wild) Cat	86.66
5	Pregnant Cat	121.22

The data are collected from 100 readings. The energy fact of the food is constant throughout this test as only this food is used in this test. The food used in this test contains 285 kilocalories per 100 grams.

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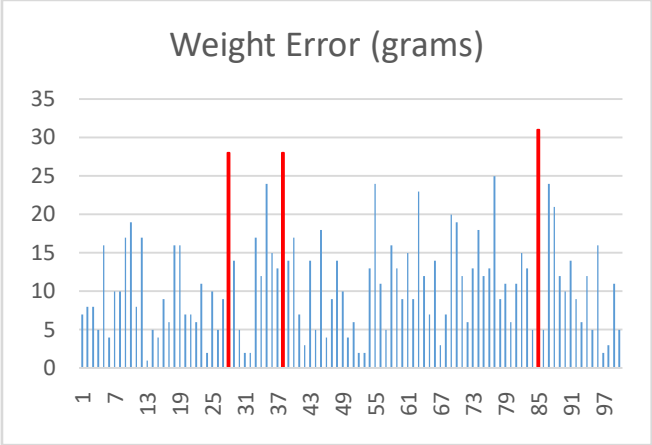

Figure 10: Weight Error in grams for dispensing under smart mode

6. Conclusion

The proposed system is divided into two main sectors including measurements and control unit. System perform periodic measurements of the pet's weight and food level inside the tank. On control unit, the system can operate under smart mode where user can define the energy fact of the food inside the tank and type of the cat. The cat's weight will be, further, measured and the system can compute the right amount of the food to be dispensed to cat. The right amount of food is based on the adequate energy that selected cat shall take per day. The result of flow rate indicated that the average flow rate of the large and small outlets are 179.96 and 7.85 cm^3/s. This indicate that the large outlet is 98.27% accurate while the small outlet's accuracy is 91.06% with respect to the calculated flow rate for the large and small outlets. The error in dispensing the food for large and small outlet is ± 3.15 and $\pm$ 0.77 cm^3/s. The proposed system consumed fraction of energy to operate. The power consumption test revealed that the power consumption of the system under no command is 0.1428 mW per hour; and under communication with IOT with 5 seconds measurement update time is 0.682 mW per hour.

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