Computer Engineering Department Adamson

University

Pawsitive Care: Design and Implementation of an Automatic Dog Feeder Using ESP8266

A Design Project

In Partial Fulfillment of the

Requirements for the Degree

of

Bachelor of Science in Computer Engineering

by

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APPROVAL SHEET

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ABSTRACT

According to the survey the researchers conducted, people tend to leave their pets at home alone. The majority of the respondents answered they were leaving their pets at home when going to school, some were for travel, and only a small percentage when they go to work out of the hundred respondents. Leaving pets at home might cause multiple problems in their physical, emotional, and mental health. There is an abundant quantity of articles online saying that the maximum time a fur parent could leave their pet alone at home is 2 hours. Exceeding the said time limit might cause health problems such as decreased blood pressure and cholesterol levels; might also develop separation anxiety and worst possibly, become distressed. They should not feel such dreadful effects as they feel the pain and suffering people experience as well.

With the application and integration of the concepts of Computer Automation, Embedded Systems, Databases, and Programming, the researchers came up with the idea of developing a smart prototype that would make pets less lonely when their owners are not home. The project consists of hardware components integrated to perform an essential role to both fur parent and pet, with the use of a mobile application, the owner can feed his/her pet while away from home. The smart device also comes with a camera for owners to monitor their pet through mobile applications and automated food dispensing and disposal features based on a food distribution table validated by a veterinarian.

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CHAPTER 1 INTRODUCTION

This chapter introduces the rationale of the research. It discusses the motivation and desired outcomes of the study. This section explains the basis of the conduct of the study, its beneficiaries, and its market potential. Moreover, a solution to the problem is presented and briefly discussed. It consists of the background of the study, conceptual framework, the objectives and contributions of the study, its significance, its scope and delimitations, and operational definition of terms.

A. Background of the Study

This chapter will discuss the origin of the problem and how the group came up with a solution. It will also discuss specific goals, the importance of the study, and its limitations.

1. Motivation

Pet ownership requires a lot of commitments. Along with feeding them on time and properly, this also entails keeping them company and expressing your concerns. Owners may not always be at home on a regular basis, which presents an issue when feeding pets. Owners are constantly troubled by the thought that they still need to take care of a starved young fellow at home while they are preoccupied with personal plans[1].

After deliberating about which area of study should have priority, the group decided to focus on researching Automatic Pet Feeders that will make pet owners feel comfortable even if they leave their pets alone in their homes. The group then searches the market online for products that are already on the market, reading reviews and identifying any shortcomings that led users to request its inclusion in the product. The group then chose to add extra distinctive features that are non-existent in the devices that are currently on the market to provide needs and improvement.

Automatic pet feeders can be programmed to dispense food depending on how many meals per day chosen by the user, which can be especially useful for people who are not home during the day to feed their pets which gives convenience. It can help ensure that pets receive a consistent amount of food each day depending on the pet, which can be important for pets to maintain being healthy. Also provides a safer option for pets that are prone to

begging or scavenging for food, as they can help prevent accidental ingestion of harmful substances.

2. Needs Statement

After reading online reviews of the existing Smart Pet Feeders on the market, the group decided which features to include in the current Smart Pet Feeders based on the problems that were searched on online articles and surveys of dog owners. The group conducted interviews to gather feedback and suggestions for finalizing the features. Additionally, the group collected data through a survey created in Google Forms that covered the extra features that would be included in the pet feeder and acquired positive responses.

Data Acquisition

Interviews for Fur-parents (Google Meet)

The researchers conducted interviews with specific fur parents through Google Meet platform in order to know their side regarding common problems experienced by dogs in everyday living. At first, the group searched for random dog owners that would like to partake in the research. There were in total four respondents convinced by the researchers to answer some following questions about their own experiences of dogs' common problems. Two respondents were also Computer Engineering students who attend the same school as the researchers, and the other two were relatives of one of them. Interviewees were asked the same questions mostly regarding their experiences and knowledge about common dog problems. They were asked if they leave their dogs alone at home, three of them said that they leave their dogs for about 6 hours and more for school and the other interviewee said she leaves her dog for work for about a day at maximum. The researchers also asked the respondents if they are aware of the preferred eating schedule and food amount for dogs depending on their age and breed, three of them said yes, but they were not following it according to them. Afterwards, the group asked the respondents for some advice and suggestions about the features that they would like to see or utilize for their pets' own good. The two computer engineering students suggest that features that would provide light and treats distribution for dogs are good potential features to be added into the system. Another suggestion from one of the interviewees states that the researchers should add some playful music for dogs.

Google Forms Survey

In conducting the survey for the study, the researchers joined several groups of fur-parents/ pet owners in social media platforms and asked politely for answers. The group also conducted a survey within the Adamson University premises, in which they got students/fur-parents to answer the forms. Specifically, the researchers gathered a total of 102 respondents. First and foremost, the respondents were asked for their permission for the researchers to gather some confidential information that would only be used for research purposes.

First question asked was to know how many hours do these pet owners leave their pets alone at home, 51% voted for 3-7 hours, 20.6% for 8-12 hours, 18.6% for 1-2 hours, the other 9.8% were for other options such as 12 hours and above, a week or two, pets are all in province, and never leaving their pets alone at home. They were also asked if they were aware of the preferred eating schedule and amount of food to be served for every dog of unique breed and age; the answers were divided in half as some of them knew about it and some were not at all. Moreover, according to the survey, the majority of 94.1% voted for a feature that showcases a notification system as they were not capable of monitoring their pets while they leave home. According to some online articles found online, water for dogs is very essential as it helps for proper blood circulation and dogs will feel fatigued and weak without it, therefore, the researchers also included a question if a water container would be essential for the to-be-developed project, and 94.1% answered YES that it is required to be added. The very idea of the prototype is to leave pet dogs alone at home for day/s, and thus the researchers asked the respondents if light would be a great addition for the project, 86.1% answered that it is important and the remaining said otherwise. After all the data acquisition, the researchers were able to come up with smart solutions that might help solve the identified problems.

Articles & Charts Online

- *Damaging Pet's Health Through Over Feeding*

Overweight/Obesity. It's crucial to keep a watch out for bothersome indicators that the dog is eating too much because overfeeding can have major health repercussions like heart disease, diabetes, arthritis, and shortened lifespan. The simplest approach to determine if your dog is eating too much is to look at their waist, which may seem obvious. It's crucial to consider your pet's general shape and take a "hands-on" approach to determine whether they are overweight as body weight alone is not the primary indicator. The owner should be able to easily feel a dog's ribs, hips, and spine, and be able to see and feel their waist from above (look for an hourglass shape). When a dog moves, the last few ribs can be seen, which indicates the ideal weight. If the ribs are covered with fat and the owner has to push hard to feel them or if the waist is scarcely noticeable, the dog is probably overweight. There are more health issues related to dogs being overweight than thin, even though owners frequently worry more about seeing their pets' ribs than additional weight. The illustration below shows the different stages of dog body condition. The chart specifically has five stages that show different varieties of dog body fat. The stages were identified with 1 being slim and 5 being plump [54].

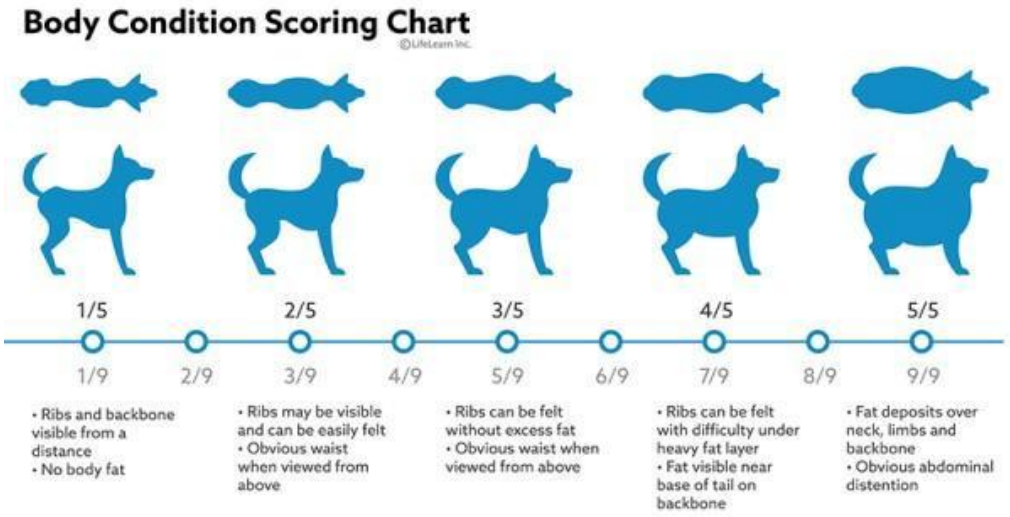

Fig. 1: Body Condition Scoring Chart

Dog Overfeeding. Caring about the dog and want to give him the greatest nourishment to keep him healthy. But the owner is unsure if he/she is giving him too much when it comes to

portion size or how many snacks you share each day. Overfeeding the dog carries numerous health dangers for dogs, just like it does for humans. A startling 54% of dogs in the US are reportedly overweight or obese, according to the Association for Pet Obesity Prevention. Knowing that the pet is eating in a way that keeps him healthy is vital since consuming too much dog food or treats can result in obesity. According to (Hillspet, 2018), the best way to figure out the right amount of dog food and what time the owner should give it to his/her dog is to visit a veterinarian. Feeding the pet more than he should be consuming has many short- and long-term hazards. The 2017 State of Pet Health® report from Banfield Pet Hospital states that overfeeding a dog results in higher vet expenditures for pet owners. According to the study, owners of overweight dogs incur healthcare costs that are 17% higher than those of pets that are at a healthy weight. Additionally, they spend roughly 25% more on prescription drugs. Not the only concerning factor is the amount spent on medical requirements. The health concerns that pets who are overfed confront are even severe. According to the State of Pet Health research, as more dogs gain weight, the prevalence of various disorders has increased, including arthritis and breathing issues. If the dog sustains an injury, such as a shattered limb, the limited mobility caused by excess weight makes healing much more challenging. Last but not least, fat dogs tend to have more sedentary lives, making it more challenging to introduce exercise and increasing their risk for heart disease [55].

- *Essentiality of Water for Pet Dogs*

Dog Dehydration. According to (CampCanine, 2020), Dogs last about 2-3 days without consumption of water. If the dog is dehydrated, it damages all of the processes in their body. Without access to clean water, the dog's vital organs will eventually fail which might lead to serious problems or even death. Dog's water consumption also depends on its status, weather, and activity level. They have also identified the signs of dehydration for dogs such as loss of appetite, excessive panting, dry mouth and gums, sunken eyes, listlessness or lethargy, and lack of skin elasticity. Never depart from home without restocking the dog's water bowl. Make plans to ensure they have access to food and water if the owner will be gone for several hours or even several days. Request someone to visit them, restock their bowls, and perhaps even take them for walks. If not, they can experience health problems that could be fatal as well as loneliness[56

Fig. 2: Dehydrated Dog Signs

- *Dog Food Contamination*

Pet Food Contamination Causes. Pet food should be kept sealed in its original packaging to avoid unwanted contact to air and humidity, which can quickly deteriorate food and raise the risk of bacterial contamination like Salmonella. The best choice is to utilize the original bag and put it in a plastic container if the owner wants to store something in a plastic container. It is advisable to use an airtight, food-grade container if the owner must pour it into one. If the container is empty, it needs to be thoroughly cleaned and dried. When kept in a non-food quality container, the oils and food may lose their flavor and perhaps induce GI upset. After opening the package of dry food, it should be consumed within six weeks. According to (Noblesville Veterinary Clinic, 2020), free feeding is not recommended and food must be offered for just 15-30 minutes. Food containers and bowls must be cleaned regularly to prevent infectious organisms such as Salmonella or Listeria from accumulating on the items. Regardless of what type of food dog owners serve their pets, it must not be allowed to sit out for more than 15 minutes [57].

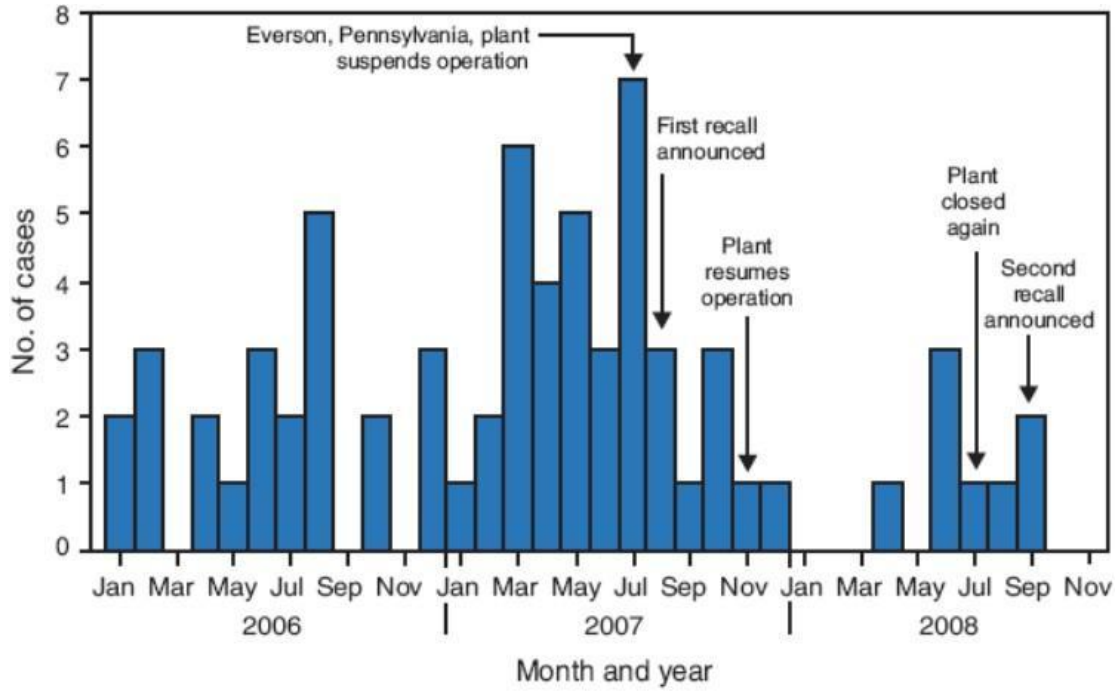

Fig. 3: Dry Dog and Cat Food Contamination associated with Human Salmonella

The illustration above shows the timeline or chart of events that occurred in 2008 in some part of the United States. On May 16, 2008, the CDC released a report on a multistate outbreak of Salmonella enterica serotype Schwarzengrund infections that had been linked to dry dog food in 2006–2007. The final case was discovered on October 1, 2007, and a total of 70 cases had been reported from 19 states at the time of that report. On December 29, 2007, a second case was subsequently discovered. This report updates the previous CDC report, provides additional epidemiologic findings, and describes additional actions taken by public health agencies and the manufacturer. Epidemiologic and environmental investigations have suggested the source of the outbreak was dry pet food produced by one manufacturer, Mars Petcare US. The outbreak now has 79 cases overall after eight further cases were confirmed in 2008. Dry pet food has a shelf life of one year. On September 12, 2008, the business announced a voluntary worldwide recall of all dry dog and cat food products made over a five-month period at one Pennsylvania plant. Recalled products that were contaminated may remain in consumers' homes and pose a health risk. People who own these products should either throw them away or return them to the retailer instead of feeding their pets with them[5].

Some articles online show that pet food contamination is sometimes caused or associated with human infection. Thus making leaving food unattended or uncovered more prone to germs and bacteria. Pet owners must be fully aware of such occurrences in order to promote animal welfare.

- *Irregular Eating Schedule*

General Nutrition. It is harmful for a dog to be overweight, just like it is for humans. Being overweight puts a dog's heart, lungs, and joints at danger and increases their susceptibility to various illnesses. The dog's digestive tract can suffer from chronic digestive issues as a result of an irregular food pattern. A change in diet can typically help with digestive issues. There must be a food distribution chart followed in order to promote dog's health and well being [58].

Animal Welfare Acts (Local & International)

THE ANIMAL WELFARE ACT OF 1998 (Philippines)

By monitoring and regulating the construction and operation of all facilities used for breeding, maintaining, retaining, treating, or teaching all animals as either trade goods or domestic pets, this Act aims to preserve and advance the welfare of all animals in the Philippines. No one may begin an animal business without first obtaining a certificate of registration thereto from the Bureau of Animal Industry (sect. 2). The certificate will only be given following verification that the establishment's animal facilities are sufficient, hygienic, and clean, and that they won't be used in a way that may cause pain or suffering to the animals. The certificate must be in effect for a full year. The responsibility for overseeing the animal business shall fall on the Director of the Bureau of Animal Industry. A Committee on Animal Welfare affiliated with the Department of Agriculture is established herein. The Law deems it unlawful to torture, fail to provide proper care, food, or shelter, or otherwise maltreat any animal (sect. 6). Everyone shall be responsible for preserving the wildlife's natural environment. The destruction of the aforementioned habitat shall be regarded as an act of animal cruelty, and its preservation is a means of animal protection (sect. 7)[6].

THE ANIMAL WELFARE ACT 2006 (UK)

Animal welfare law was essentially reactive prior to the Animal Welfare Act, and action could only be done after an animal had endured needless suffering. For pet owners and those responsible for domestic animals, such as breeders, people who have working animals or farm animals in England and Wales, the 2006 Act introduced an essential and novel idea. According to this act, in order to ensure an individual care for their pets or animals properly, they must provide the following welfare needs[7] :

- need for a suitable environment
- need for a suitable diet
- need to be able to exhibit normal behaviour patterns
- need to be housed with, or apart, from other animals
- need to be protected from pain, suffering, injury and disease.

State And Local Animal Protection Laws (USA)

Companion Animals - the highest level of protection under state regulations, which is typically limited to dogs and cats but occasionally also includes birds, horses, and other animals. However, there have been instances where people have been charged with crimes involving egregiously cruel treatment of wild or domesticated animals. This also applies to aquatic life. For torturing a shark, three Florida teens were charged with animal cruelty in 2017. Additionally, each state has rules covering various facets of "hands-on" animal care. For instance, laws govern how long stray animals must "hold" in animal shelters before being adopted or put to death. Laws also specify how often pets must receive rabies vaccinations. States frequently also have laws governing the breeding of companion animals for sale. "Hot car laws" make it illegal to leave an animal in a moving vehicle during severe weather. In other cases, these animals may be rescued from moving automobiles under specific conditions without the rescuer being subject to civil or criminal penalties. Regulations permitting pets to be included in domestic violence protective orders are becoming more and more prevalent, as are anti-tethering laws that restrict how long pets can be chained or tied outside, especially in inclement weather.

B. Objectives

The main purpose of the system specifically addresses the identified problem that was mentioned in the earlier parts of the document. Based on the past surveys conducted regarding the topic, people, especially pet owners tend to leave their dogs alone at home for some reason that they cannot bring them all the time and everywhere they go. This might lead to horrible results to the pet dogs' overall health. As a result, the researchers decided to go further about this certain topic. Specifically, the study would aim to:

Specific Objectives

- Develop a smart device that has the application of automation and embedded system concepts that has the capability of feeding pet dogs automatically without any human effort;
- Design and integrate mobile application for monitoring through surveillance camera and food weight, notification system; and
- Make unique yet essential features such as automatic night-light and food disposal for contamination prevention.

C. Significance of the Study

Some of us find having a companion is better than being alone, it keeps our minds active and prevents social isolation. Therefore, some people tend to have a pet to fulfill those kinds of feelings. However, fur parents are unable to bring their pets all the time, thus leaving pets alone at home is somehow inevitable, and doing it might have negative effects on pets' health.

The researchers decided to develop a prototype that would be beneficial to both owner and pet, with a smart device controlled through a mobile app, fur parents should worry less as they can still monitor their pets and feed them while being away from home. This study would specifically benefit the following:

- Dog owners/ fur parents
- Dogs' health and well-being
- Future researchers

To be specific, dog owners or the fur parents can just rely on the prototype itself when it comes to attending to their dogs' needs, especially in eating. They will feel at ease leaving home knowing that their dogs can still eat on time. Thus, this would as well, promote the dogs' well being and keep them healthy. Lastly, for the future researchers that would like to embark with the same topic in their research; they will be able to gather some ideas and recommendations by the researchers themselves.

Alignment to the Mission and Vision of Adamson University

One of the must-do tasks of a Vincentian student is to be a leader and catalyst of change and attend to those who are in need. As aspiring Computer Engineers, the researchers apply engineering principles and promote excellence considering technical competence in their specific field. By creating smart solutions using the up to date technology, they can prove their involvement in the systemic change addressed in the Mission and Vision of Adamson University; specifically by promoting animal welfare through scientific research and engineering approach.

The Animal Welfare Act of 1998 (Philippines) and The Animal Welfare Act 2006 (UK)

Under the Animal Welfare Act of the Philippines, its purpose is to mainly protect and promote welfare of all animals in the Philippines. It can be done by regulating and supervising all establishments and operations of all facilities for breeding, keeping, training, maintaining, treating of all animals either as household pets or objects of trade[9]. Supplementarily, the Animal Welfare Act of the United Kingdom declared the most 5 welfare needs of pets namely: Health, Behaviour, Companionship, Diet, and Environment. Under these needs and in line with the case study, protection from disease, providing enough and appropriate food as well as access to fresh clean water for the pet's life stage are the considerations a pet owner must know[10].

D. Scope and Delimitations

There are factors and considerations that need to be taken note of, the researchers encountered shortcomings in terms of practical and theoretical constraints. Therefore, the group made decisions of what and what not to be included in the actual development of the prototype.

- **Scope**

Mobile Application (Controller).

- ➢ Buttons for Food Dispensing and Disposal (Manual)
- ➢ Able to feed the dog automatically with the required amount of food
- ➢ Able to monitor food level in the container and receive notifications if it reaches low level (1kg or 33%).
- ➢ Able to receive notifications if the prototype automatically dispenses food.

System Device.

- ➢ Able to Dispense food with accuracy
- ➢ Able to Remove food that has not been taken
- ➢ Stationary Camera using ESP32 Cam

Load Cell. Responsible for measuring the weights of food in the container for notification purposes.

Night-Light Module. Consists of a photoresistor that automatically turns on lights whenever it senses lack of light in the area.

Water Nozzle. Used for dogs' water consumption.

- **Limitations and Delimitations**

Pet Count. The target user must have a limit of one pet since some of the features of the system were specifically designed for a single dog only.

Internet Service Provider (ISP). The mobile application is only accessible through an internet connection provided by local internet service providers.

Food Type. Only small dry food is allowed in this prototype

E. Operational Definition of Terms

Computation Automation - combination and integration of hardware and software to perform a certain task promoting less human effort.

Embedded Systems - pertains to a combination of hardware and software designed for a specific function.

Fur Parent - a person who owns a dog or cat as a pet.

Mobile Application - an application that runs on mobile devices and is used to control the smart pet feeder through internet connection.

Programming - creating a set of instructions and combination of codes in order to perform a particular task.

Smart Device - is an intelligent electronic device that is wirelessly connected to other devices through the internet and can perform interactively.

Smart Pet Feeder - is an electronic device that is capable of feeding pets and can be controlled using a mobile application.

CHAPTER 2 LITERATURE REVIEW

This chapter identifies and enumerates literature, prior art, and existing products related to the study. The purpose of this section is to set the conceptual and theoretical context for the study. This section comprises theory discussions, identification of prior art through technical surveys, and statistics of the current market. Finally, this section summarizes the ideas and features viable for the research.

● Pre-requisite Knowledge

First and foremost, the main goal of the study is to develop a prototype specifically for dog owners who leave their pets alone at home. The said prototype consists of integrated hardware and software and has the capability to feed the pet automatically even without the owner around. It also comes with a mobile application that the owner could utilize for monitoring the pet and receiving notifications whenever the food container needs refilling; there are also features such as a lighting system that automatically turns LEDs on whenever the sensor senses darkness and automatic food disposal that can be controlled through the mobile application.

● Mathematics, Natural Science, an Engineering Fundamentals

Mathematics

Calculating feed portions, building mechanical systems, and determining feeding schedules require a deep understanding of mathematics. Ideas such as metrics, indicators and algorithms are particularly relevant.

Natural Science

By comprehending the fundamentals of life sciences, particularly biology, and animal behavior, one can construct an automatic dog feeder that will satisfy the nutritional needs of many different pets. Dog's weight, digestion, metabolism, and nutritional needs must be considered to determine the proper portion size per serving.

1. Possible Causes of Dog Losing Appetite

The first consideration is how you determine your dog's appetite. Remember that these are only averages if you're worried that your dog isn't eating as much as the

recommendations on the food you buy. Many healthy dogs only consume 60% to 70% of the recommended serving size. It's crucial to get your dog checked out by a veterinarian if you observe any changes in their feeding patterns because lack of appetite in dogs can be a sign of sickness. When a dog who generally eats well refuses to eat, it is especially vital to act quickly. Even while most dogs can go a few days without food without experiencing any serious negative consequences, it is best to deal with the issue as soon as you can [11].

2. Pet Food Contamination

Food can readily create and develop dangerous bacteria when it is exposed to air for a long time. Both people and animals are prone to contracting salmonella, a common and contagious bacterial infection. Salmonella can cause symptoms of food poisoning in cats and dogs, including diarrhea with blood occasionally, vomiting, nausea, fever, and dehydration. In extreme circumstances, the infection may enter your pet's bloodstream and result in sepsis or blood poisoning, both of which pose a serious threat to life. Be aware that your pet is more likely to get an illness if they are young, old, or immunocompromised.

By causing pet food to degrade, improper dog food mixing can lead to dog food contamination. You wouldn't believe it, but giving your pet too much of some vitamins can be bad for them. Unfortunately, low-quality pet food businesses are frequently to blame for their goods having harmful quantities of vitamins. Recently, many different types of dog food were recalled because they included high amounts of vitamin D [12].

3. Water for Pets

Water is essential for pets because it helps with digestion and nutrition absorption by transporting vital nutrients into and out of the body's cells. Additionally, it controls body temperature, lubricates joints, enhances mental performance, and supports the brain and spinal cord. Water is essential for every significant biological process. Pets and humans both struggle when we don't get enough water. We experience fatigue, dizziness, and poor coordination. Dehydration is the excessive loss of water beyond what the body has consumed. Dehydration causes the body to suck water out of the cells, which causes electrolyte imbalance and muscle weakness. If dehydration is not addressed right away, organ failure and death may result [13].

Signs of Pet Dehydration:

- Moving more slowly than normal
- Tiredness
- Loss of appetite
- Sunken eyes
- Panting
- Dry nose and gums

General Rule of Dry Dog Food

It's best to store your dry dog food in a cold, dark place like a pantry or closet and to refrigerate it after opening. Many people believe that dry kibble may remain fresh indefinitely. Consult your veterinarian if you have any concerns about how long you should leave dry dog food out. Depending on the quality of the food and how it is stored, dry dog food can last anywhere from a few months to more than a year. Food spoils more quickly if it is exposed to moisture or bugs. The food will keep a lot longer if it is maintained in a dry, cool environment. Most pet owners prefer to store their dog's food away from the stove in a cabinet or pantry in an airtight container [14].

Table 1: Comparison table of Fresh and Exposed Dog Food

Fresh Dry Dog Food	**Dog food that was left out for too long**
Compared to canned or kibble food, Fresh dry food is often less processed, which means that it keeps more of the vitamins and nutrients that are crucial for your dog's health.	Keep an eye out for symptoms of disease if you believe your dog may have consumed food that was left out for too long. Lethargy, diarrhea, and vomiting are all symptoms of food poisoning.
Fresh dry food is healthier for your dog because it's less likely to have extra additives like fillers or preservatives.	Dry dog food ought to never be left outside for longer than two hours. Your dog can become ill if the food is tainted with bacteria.
Fresh dry food typically has more protein than other commercial dog food varieties, which is essential for preserving your dog's energy and muscular mass.	Bacteria can begin to grow on dry dog food that has been left out.

Engineering Fundamentals

1. **Internet of Things (IoT)**

The Internet of Things is what will make real-world objects into intelligent virtual

objects in the future. The Internet of Things (IoT) promises to bring everything in the environment under a single infrastructure, allowing people to control over the things around and keeping them updated on their status. It is the main instrument of making things such as system prototypes and integration of hardware and software to go online. According to (Patel, 2016), The term "Internet of things" refers to a particular type of network that uses information sensing devices to connect anything to the Internet based on predetermined protocols in order to exchange information and carry out communications in order to achieve intelligent recognition, positioning, tracing, monitoring, and administration.

2. **Automation & Embedded Systems**

Automation is the use of technology to carry out operations with the least amount of human involvement. This comprises commercial applications like business process automation (BPA), IT automation, network automation, automating system integration, robotics in industry, and consumer applications like home automation, among others. According to (Berberian, 2012), automation really makes peoples' lives easier, but it creates complexity and uncertainty.

- **Engineering Specialization**

The system comprises an integration of hardware and software and thoroughly developed through concepts and fundamentals of Computer Engineering. Course subjects under the program such as Computer Automation and Embedded Systems tackled the concepts mostly about the information and usage of various electrical components and how they are being manipulated or controlled by programming. The features of the system mainly revolves in automation and Internet of Things (IoT); doing such a thing requires background knowledge of coding and programming especially in C++ language since Arduino runs through this specific programming language.

- **Codes of Practice, Applicable Laws, and Standards**

Animal Welfare Laws

The Animal Welfare Act of 1998 (Philippines) and The Animal Welfare Act 2006 (UK)

Under the Animal Welfare Act of the Philippines, its purpose is to mainly protect and promote welfare of all animals in the Philippines. It can be done by regulating and

supervising all establishments and operations of all facilities for breeding, keeping, training, maintaining, treating of all animals either as household pets or objects of trade[9]. Supplementarily, the Animal Welfare Act of the United Kingdom declared the most 5 welfare needs of pets namely: Health, Behaviour, Companionship, Diet, and Environment. Under these needs and in line with the case study, protection from disease, providing enough and appropriate food as well as access to fresh clean water for the pet's life stage are the considerations a pet owner must know[10].

Safety Standards

Safety requirements are taken into account, especially since the prototype is an electrical device. The power supply is built to safety standards for electrical, mechanical and physical compatibility.

● Technical Survey

1. Related Researches

How long should I leave the Dog Food out?

It is important to note that dog food can spoil, lose its appeal, and attract pests if left out for more than 15 minutes. Therefore, it is recommended to leave dog food out for as long as it takes your dog to finish it, as long as this timeframe does not exceed 15 minutes. Any remaining food should be promptly removed within a few minutes after your dog walks away from his bowl. This approach encourages your dog to complete his meal, establishes your role as the provider, and ensures that your dog receives fresh and nutritious food. While it is ideal to allow enough time for your dog to finish his food, some dogs may require more time. However, it is advised not to leave the food out indefinitely, as this may lead to your dog becoming selective or picky [46].

Should I leave dog food down all day?

Creating the optimal diet for your dog can be approached in various ways. It is generally advised to avoid providing too much variety in their diet, as this can disrupt their digestion. It is also recommended not to leave food out for extended periods, and any uneaten food should be discarded after 15-20 minutes. However, it is crucial to ensure that your dog always has access to water and their water bowl should never be taken away. Dogs, being scavengers by

nature, have an opportunistic eating behavior, consuming whatever food is available to them. They lack self-regulation when it comes to food intake and can easily overeat. Issues related to eating habits that wouldn't typically occur in the wild can arise in our pet dogs due to the absence of competition for food and reduced exercise compared to their wild counterparts [47].

Best Time to feed dog twice a day: The optimal timing for feeding a dog twice a day is typically advised to have a 12-hour gap between meals. Following this guideline, you can establish a feeding schedule for your dog [48].

Three-Meal Feeding Schedule

Morning Meal: 7:00 a.m.

Afternoon Meal: 12:30 p.m

Evening Meal: 6:30 p.m

Feeding your puppy smaller, frequent meals is beneficial in managing their fast metabolism and ensuring they feel satisfied throughout the day. To determine the optimal puppy feeding times, it is recommended to create a schedule that aligns with your weekday routine and can be consistently followed on weekends as well [49].

Healthy Weight for Dogs

Similar to humans, it is detrimental for a dog's health to be overweight. Excessive weight puts strain on the heart, lungs, and joints, making the dog more vulnerable to various ailments. An irregular feeding schedule can disrupt the dog's digestive system, potentially leading to chronic digestive disorders. By making adjustments to the diet, digestive issues can often be improved. It is not uncommon for a dog to still crave a meal at its old feeding time if the schedule is suddenly changed. Dogs become conditioned to expect food at specific times, resulting in their internal alarm clock triggering hunger. Dogs may have difficulty adjusting to time zone changes or daylight savings time. To acclimate your dog to a time change, it is advisable to gradually adjust its eating schedule over several weeks. Consistency is key, so it is important to keep your dog's water and food bowls in the same location every day. If you have multiple dogs, ensure that each dog has its own designated food and water bowl [50].

Understanding the context for pet cat and dog feeding and exercising behaviour among pet owners in Ireland

According to this study, obesity in cats and dogs increases their risk of developing a number of problems, including diabetes mellitus and cancer. It also makes their orthopedic issues worse and lowers their chances of life. As there is a lack of in-depth knowledge in this area, the goal of this study is to create a better understanding of cat and dog owners' self-reported beliefs and factors that influence owner behavior about feeding and exercising their pet cat or dog. There were a total of 43 pet owners in the seven focus group talks.

The result of this study shows that pet owners frequently expressed a perception of having little control over feeding, which was frequently undermined by other people feeding their pets, the pet's pleading, and the pets' attitudes toward food. In the lack of owner management of pet begging and emotional attachment, treats were employed to modify animal behavior. The majority of participants had favorable opinions toward pet exercise, which may be related to the needs of individual pets, particularly the distinctions between cats and dogs. There have been several stressful situations related to walking dogs and worries about aggressive encounters with other dogs [51].

COMPANION ANIMALS SYMPOSIUM: Obesity in dogs and cats: What is wrong with being fat?

In line with this study, an excess of body fat that impairs health or bodily function is referred to as obesity. This is typically regarded as 20 to 25% above optimal BW in persons. It's necessary for dogs to have this level of excess as well. In a long-term study of dogs, it was discovered that even mildly overweight canines had a higher incidence of morbidity and needed treatment for chronic health issues earlier than their leaner siblings. In general, there was a 25% difference in BW between the groups.

To manage obesity, nutritional and behavioral modifications are important. Exercise, calorie restriction, and a higher protein consumption can all aid in weight loss while preserving lean body mass [52].

Pet Obesity Management Beyond Nutrition

With an estimated 34%-59% of dogs and 25%-63% of cats being overweight or obese, obesity is a major health issue that affects both dogs and cats. Calculating a body condition score (BCS) is the most popular and clinically useful way to diagnose obesity. While MCS is used to measure muscle atrophy, BCS simply measures body fat. Each BCS on a 9-point scale is typically linked to a 10%–15% increase or decrease in optimal body weight and can aid in determining the ideal weight for that pet. Obesity is typically defined as being 10% to 20% over one's ideal body weight (BCS of 6-7 out of 9) and as being obese if it is 20% or higher (BCS of 7-9 out of 9). At every veterinary visit, body weight, BCS, and MCS should be measured as part of the physical examination protocol.

Instead of free feeding, pet owners should be told to weigh and measure the food they give their animals to maintain a healthy physical condition. Puppies of large breeds should have a BCS of 4 to 5 on a scale of 1 to 9. If necessary, a diet with a lower calorie density for puppies or kittens should be chosen. It is vital to have a conversation with pet owners about monitoring their pets' BCS and reducing intake as needed at the time of spaying or neutering. It is best to address BCS and consistently monitor for risk factors at yearly wellness visits with nutritional assessments to promote long-term weight management and obesity prevention. At all phases of life, owners should keep feeding to maintain a healthy physical state [53].

Smart Pet Feeder

Smart Pet Feeders are automated devices that can be connected to your home WiFi network and controlled through an app on your smartphone. They allow you to set feeding schedules, monitor your pet's meals, and portion control the amount of food given [15]. This paper presents a prototype for a pet feeding system controlled by an ATMEGA32 Microcontroller. The system is designed to allow owners to remotely supply food to their pets according to their preferred schedule and in the appropriate quantity. A conical structure made from waste materials is used as a food reservoir, which is connected to a bowl that is monitored by a load cell and a servo motor. A float sensor is also used to monitor the water

level in the container and automatically refill it when needed. This system provides a user-friendly and easy-to-monitor solution for pet owners who are away from home [16].

The Smart Pet Feeder is a device that allows pet owners to feed their pets automatically using a smartphone app. It has a closed-circuit camera so that owners can monitor their pets while they are away from home. The device is designed to be easy to use and can be set to distribute food at specific times and in specific quantities. It uses a bottle that can last for a week and has electrical components such as the Arduino UNO Rev3 and a servo motor. Unlike other pet feeders on the market, the Smart Pet Feeder has internet connectivity and can be operated automatically. This is especially useful for pet owners who are busy or who need to leave their pets alone for extended periods of time. The Smart Pet Feeder is a useful tool for pet owners and has the potential to improve the local mechanical industry [17].

Automated Pet Feeder Called Smart Pakan using 3D Printer with Open Source Control System

This paper presents an automatic pet-feeding machine designed with 3D printing technology and an open-source control system. The machine includes a valve, a servo motor, and a timer to regulate the time of feeding. It utilizes a NodeMCU ESP8266 platform module and ultrasonic sensors, as well as a smartphone with the Blynk application software (IoT). The valve is adjustable in four positions from 10-40 degrees and the distance of the food from the sensor can be monitored up to 9 cm with the attached sensors. The machine is designed to be used continuously and automatically, with owners having control via their smartphones [18].

IOT and Its Benefit in Feeding Domestic Pets

The Internet of Things (IoT) integration into today's society is making it easier to communicate and share data between physical devices equipped with sensors. The researchers in this work use technology to automate the process of feeding pets, providing practical options for pet owners. This system has the ability to fill a pet's food container with an appropriate amount of food at predetermined intervals, regulate the process via a

smartphone app, obtain extra food with a single button press, monitor food intake using a weight sensor, and inform owners when necessary [19].

Monitoring and Feeding System for Pets

This paper discusses a smart pet monitoring and feeding system that uses IoT technology to make pet ownership easier and more convenient. The system includes a pet feeder, controllable through smartphones and computers, that can dispense food and water at set times and in set portions. It also features an IP camera for monitoring the pet and a voice recorder to call the pet for meal time. This system offers pet owners increased comfort and peace of mind, as it can feed pets even when owners are away. Finally, it includes a refill alert and a feeding alert, so owners know when their pet needs more food or water [20].

PetCare: A Smart Pet Care IoT Mobile Application

This paper examines the potential for using an IoT-enabled smart pet system to help enhance pet ownership in the Philippines. The study found that pet owners in the Philippines are highly receptive to the idea of a smart pet system, as they prioritize convenience and safety when choosing a pet feeder. The researchers developed an IoT-enabled smart pet system that includes a remote-activated door, defecation pad, food and water dispenser, music activation with pet-parent voice activation, room temperature sensing, and camera service monitoring. The mobile app was successfully tested and shown to be effective in providing the services promised [21].

Automatic Pet Food Dispenser by using Internet of Things (IoT)

In this research the researchers were able to create an Automatic Pet Food Dispenser with the use of Internet of Things (IoT). This automatic pet feeder is intended for small dogs and cats. It will be very beneficial anytime a pet owner is away from the residence and/or still unable to feed his/her pets regularly. When free feeding is occurring, it would induce obesity

in pets. This device will also be utilized to train pets to eat on schedule by keeping track of their eating habits [22].

Pet Food Dispenser Design using Raspberry Pi

This research shows that the prototype created has a beneficial social impact. Where it benefits the family and also the pets. People's obligations are increasing as a result of globalization, making it harder for them to be with the animal all of the time, resulting in poor nourishment for the animal. That’s why the researchers of this study provide a solution where they created a pet food dispenser using Raspberry Pi [23].

The Study and Application of the IoT in Pet Systems

There is increasing interest in the interaction between humans and physical devices in the real world, and there is a need for natural and intuitive methods to facilitate this interaction. One area where this is particularly relevant is in the care and raising of pets. This study investigates the use of internet of things (IoT) technology to improve the interaction between humans and their pets. The emphasis is on the utilization of location awareness as well as activity and eating regulation via a pet-specific app. The study's findings indicate that the proposed method can greatly enhance the health and symptoms of pets with kidney disease. This solution not only combines fundamental IoT concepts, but it also satisfies the needs of pet owners who are too busy with work to care for their dogs. This system not only incorporates key IoT ideas but also meets the needs of pet owners who are busy with work and may not have time to care for their pets [24].

Smart Pet Care System using Internet of Things

This research presents a new smart pet care system that utilizes Internet of Things (IoT) technology. As more people live in single-person households, there is likely to be an increase in pet ownership. This new system allows pet owners to remotely feed their pets and monitor their movements and status while they are away from home using their smartphones. It also

allows owners to control the pet's defecation pad. The proposed system is unique in that it is based on IoT technology and utilizes various sensors and wireless communication capabilities. This means it is not limited by location or time as long as there is a wireless connection. Currently, only two devices have been developed, but the system has the potential to expand and adapt to the needs of pet owners. Another device that can work with existing devices is also in development. The goal is to create whatever pet owners desire [25].

Design of Pet Feeder using Web Server as Internet of Things Application

The Internet of Things (IoT) allows for remote control and monitoring of objects connected to the Internet. The proposed pet feeder is a tool for feeding animals that is equipped with a communication network and can be controlled remotely through a web server. It is distinct from other pet feeders in that it responds to commands given by the owner through a web server. The design of the tool consists of both software and hardware components. The software uses Arduino IDE and ESP8266 Downloader, while the hardware includes an Arduino Uno microcontroller and various other components such as ESP866 modules, ultrasonic sensors, servo motors, an LDR, and a buzzer. The system was successfully implemented on the pet feeder, with the web server displaying information in about four seconds. The availability of food in containers and tanks can also be determined remotely through software and Internet access, even when the controller is in a different location [26].

PetCare: a real-time pet monitoring system with food dispensing using Raspberry Pi

Many people today own pets not just as a means of protecting their home, but also as a source of companionship. However, many pet owners may not have enough time to care for their pets, especially when they have to go on business trips. A pet that stays at home may not have the survival skills to find food on its own and may not be able to survive on its own like stray animals can. As a result, pet owners often ask friends to take care of their pets or look for a real-time food dispensing system that can feed their pet at scheduled times and includes monitoring functions. This paper proposes a monitoring system that includes an automatic food dispenser and several other useful functions to assist pet owners.

The proposed system uses a Raspberry Pi to control and connect with several subsystems, including a real-time monitoring subsystem, a door managing subsystem with software support, and a food dispensing system. The wireless food dispensing system allows the owner to automatically feed their pet according to a schedule or manually according to their preference. The real-time monitoring subsystem allows the owner to monitor their pet and check if any stray pets have tried to enter the cage through a camera. Finally, the door managing subsystem allows the owner to control the door lock/unlock, giving their pet some freedom. This system has the potential to reduce the likelihood of pets being abandoned [27].

Internet of Things

IoT, or the Internet of Things, refers to the interconnected network of everyday objects that have been equipped with intelligence. These objects can communicate with humans and other devices through embedded systems, increasing the ubiquity of the internet. The rapid advancements in technology have allowed for the creation of numerous applications that aim to improve people's lives. IoT has received a lot of attention from researchers and professionals globally [28].

Deep Learning Based Dog Behavioural Monitoring System

This research focused on using image processing and machine learning techniques to track the behavior and activity levels of dogs in order to notify their owners via a mobile app. Breed recognition was done using deep learning on user-submitted videos or photos of the dogs. The research studied the walking, running, resting, and barking patterns of Pomeranian and German Shepherd breeds, using a surveillance camera and sensors to collect data. The audio feature of the surveillance camera was used to identify barking behavior. Transfer learning with ResNet50, Inception V3, and support vector machines were used to recognize and classify the activity patterns of the dogs. The research achieved an accuracy of 89% or higher for breed recognition, 99.5% for walking pattern recognition, 97% for resting pattern recognition, and 60% for barking pattern recognition. This allowed the research to identify unusual behavior in the dogs [29].

Photoresistor

Fig. 4: Photoresistor

Photoresistors, also referred to as dependent resistors (LDRs), are light sensitive devices that are often used to determine the presence or absence of light or to quantify light intensity. LDRs have a very high resistance in the dark, but when exposed to light, their resistance reduces dramatically depending on the strength of the light. LDRs are sensitive to varied wavelengths of light and do not have a linear response. They have been employed in a variety of applications, however their light sensing function can also be fulfilled by other devices such as photodiodes and phototransistors. Because of environmental concerns, some countries have prohibited the use of lead or cadmium-based LDRs [30].

Servo Motor

Fig. 5: Servo motor

A servo motor is a precision motor with the ability to rotate to certain angles or lengths. It comprises a control circuit that delivers feedback on the motor shaft's present position, allowing it to rotate precisely. Servo motors, which are primarily composed of a simple motor and a servo mechanism, are used to rotate things. They can be powered by either DC or AC electricity and are known as DC servo motors or AC servo motors [31].

Smart IoT Surveillance Multi-Camera Monitoring System

In the past 15 years, the market for surveillance digital monitoring systems has evolved significantly. Previously, these systems were used to provide businesses with peace of mind by simply recording footage with cameras. However, modern monitoring systems are often expensive due to the inclusion of proprietary software development kits (SDKs) in the cameras. Some companies offer high-priced custom command centers with multiple screens and specialized detection analysis modules that communicate with multiple cameras. This paper presents a cheaper solution to the surveillance digital monitoring process, using open source image processing methods to create a customizable system that can be used with a variety of camera models. The system also includes a real-time analysis module to make it easier to use for surveillance purposes. The proposed system is significantly more affordable (up to 95%) and user-friendly (90% usability) compared to existing products [32].

An Introduction to Light-emitting Diodes

Light-emitting diodes (LEDs) are electronic devices that emit light when electricity is applied. They produce a narrow range of wavelengths, ranging from UVC to infrared, and can be found in packages with a power output of anywhere from a few milliwatts to over 10 watts. The first LED, which emitted infrared light, was patented in 1961, and the first LED that produced visible light was developed in 1962. It wasn't until the late 1990s that high-power (1-watt) LEDs were developed. Unlike traditional light sources, which use a hot element, ionized gas, or an electric arc to produce light, LEDs generate light through a semiconductor process. The specific wavelength of light produced by an LED depends on the materials used in the semiconductor junction. LEDs are more energy-efficient than incandescent bulbs and can produce more light per watt of electricity. They are also solid-state devices that are more durable than glass-enveloped lamps and do not contain hazardous materials like fluorescent lamps. Additionally, they have a much longer lifespan than incandescent, fluorescent, and high-density discharge lamps. However, when designing an LED-based lighting system, it is important to consider the entire system, not just the LED itself. LEDs do not radiate heat directly, but do produce heat that must be dissipated to ensure optimal performance and lifespan. They also require a constant-current DC power source rather than standard AC line voltage, and may require external optics to produce the desired light distribution, as they are directional light sources. If properly designed, an LED light system can provide performance and a lifespan superior to traditional lighting sources [33].

Automatic Pet Food Dispenser by using Internet of Things (IoT)

The goal of this project is to create a self-operating pet feeding system using the Internet of Things (IoT). They created a feeder to assist in the distribution of dry food diets to small pets such as dogs and cats. It will come in handy if a pet owner is away from home and/or unable to feed his or her pets ordinarily. When pets are given free food, they get obese. This equipment will also be used to monitor pets' eating patterns in order to teach them for planned meals.[34]

IoT and Cloud-based Automated Pet Care System

A specialized system called an automatic pet feeder has been developed to provide care for pets, specifically cats and dogs. This system enables the delivery of food and water to the pets while also monitoring their movements. It incorporates various built-in components that allow for the automated feeding of food and dispensing of water, eliminating the need for human intervention. Many pet owners, overwhelmed by busy schedules and limited time at work, have unfortunately neglected their pets, resulting in hunger and neglect. This project aims to address this issue by providing a solution that saves time and energy for pet owners, ensuring that their pets are fed on schedule and allowing for monitoring through a dedicated application [45].

2. Patent Analysis

The invention relates to an automatic pet feeder with a built-in timer control module and a pie-shaped dish for feeding pets at certain scheduled times. The device has a small number of parts, and in the case of a failure, the consumer can quickly and easily replace the broken parts. The electronics of the device are contained in a single module that can be upgraded and/or changed over time to meet the requirements and wants of the consumer. The components are all composed of plastic, making cleaning, maintaining, and replacing parts simple. According to the present invention, the device will give the pet owner the ability to program the timer module to his or her convenience and have a lock-down feature to prevent the pets from accessing the other compartments of the feeder. The device runs on 3 AA batteries that can be changed without removing or disassembling any part of the machine. To be controlled by a computer, gates, doors, sensors such as infrared, proximity, motion, etc., and other devices, such as a portable remote, the timer module can connect with other devices [35].

Claims:

1. Automated Animal feeder

A programmable, detachable timer module with a microprocessor to manage its operation and a rotating component; a base with a center section where the timer module is to be placed; a bowl positioned on the base with a central piece that serves as the container for the timer module and other compartments for holding food with similar shapes; a cover made to

fit over the bowl, with one aperture in the center for access to the time module and one more opening that is sized and shaped to fit one of the food receiving compartments; a handle for functionally fastening the cover to the time module's rotatable member and for lining up the cover's additional aperture with respect to the bowl and food-receiving compartments; and a locking component that holds the handle and cover to the timer module, allowing the cover to turn in unison with the rotatable part; where the microprocessor can be programmed and controlled via a remote control thanks to the timer module's infrared sensor and radio frequency receiver.

2. The pie-shaped food receiving chambers in the bowl of the automatic pet feeder according to claim 1, wherein there are two or more of them.

3. The automatic pet feeder of claim 1, wherein the bowl is positioned on the base alongside a corresponding number of elevated parts and includes a plurality of notches.

4. The automatic pet feeder of claim 1 with a turn-and-lock mechanism to secure the handle to the lid.

5. The automatic pet feeder described in claim 4, where the handle is a part of the lid.

The automatic pet feeder features a horizontal tray with multiple pairs of food and water bowls that rotate to reveal only one pair at a time. The cover assembly has a clock-controlled mechanism that gradually turns the tray, exposing a fresh set of pre-filled bowls each day during the feeding process [36].

Claims:

1. An automatic pet feeder consists of a tray with pairs of water and food bowls spaced evenly around its edges, a cover plate that sits on the tray and exposes one pair at a time, and a mechanism for rotating the tray to bring the next pair of bowls into position. The tray rests on a base with a journal post, and the tray has a hub at its bottom that sits on the journal post and allows it to rotate. The feeder also has a cover that can be opened and closed, with the cover plate supported inside it and resting on the tops of the bowls when the cover is closed.

2. The mechanism for rotating the tray includes a drive motor within the cover assembly and a rotary coupling member driven by the motor. The tray has a central hub with mechanical coupling that engages the rotary coupling member when the cover is closed over the tray.
3. The feeder has a mechanism for lifting the cover plate off the tray as it rotates.
4. The mechanical coupling means includes a coupling bar within the central hub of the tray and a complementary recess in the rotary coupling member. The coupling bar extends diametrically across the hub.
5. The feeder has a mechanism for lifting the cover plate off the tray as it rotates.

The present invention relates to a smart pet feeder for controlling the feeding of pets. The feeder includes a housing, a bait assembly, a drive assembly, and a throw-out assembly. The drive assembly includes a motor and a belt pulley set and drives the rotation of a transmission gear disc, which rotates a support post and a bait transport rotary disc in synchronization with a cam. This feeds bait from the bait assembly into the dispensing assembly, which dumps the bait for the pet to eat. The feeder is designed to address the problems of poor feeding efficiency and unreasonable structure in existing pet feeder systems [37].

Claims:

1. The automatic pet feeder is composed of several components that work together to provide food and water to a dog or cat. It has a rotating tray with pairs of bowls spaced evenly around its edges, a cover plate that sits on the tray and exposes one pair at a time, and a mechanism for rotating the tray to bring the next pair of bowls into position. The tray rests on a flat base with a journal post, and the tray has a hub at its bottom that sits on the journal post and allows it to rotate. The feeder also has a cover that can be opened and closed, with the cover plate supported inside it and resting on the tops of the bowls when the cover is closed.
2. An automatic pet feeder, as described in claim 1, includes a mechanism for rotating the tray that consists of a drive motor within the cover assembly and a rotary coupling member driven by the motor. The tray has a central hub with mechanical coupling that engages the rotary coupling member when the cover is closed over the tray.
3. An automatic pet feeder, as defined in claim 2, includes a mechanism for lifting the cover plate off the tray as the tray rotates.

4. An automatic pet feeder, as described in claim 2, has mechanical coupling means that include a coupling bar within the central hub of the tray and a complementary recess in the rotary coupling member. The coupling bar extends diametrically across the hub.
5. The mechanism for lifting the cover plate off the tray as it rotates includes a cylindrical sleeve attached to the cover plate and surrounding the rotary coupling member, as well as an upwardly-extending sleeve on the central hub of the tray with a similar diameter. The outer peripherals of the cylindrical sleeve and upwardly-extending sleeve have complementary saw-teeth, the same number as the pairs of water and food bowls.

An animal feeding system consists of a container that houses a microcontroller, one or more applications that are operating on at least one processor of a mobile device, and an access point, all of which are connected by a wireless communications network. Consumable pet food is kept in the container. Consumables are dispensed and flow through an aperture in the container and into a chute. The level of the consumables in the container is monitored by a sensor, which is connected to a microcontroller and sends information about the level to it. The microcontroller then utilizes the information to decide whether the level of the consumables is below a predetermined level. When the level drops below the threshold level, the microcontroller starts communication with a distant vendor over the wireless communications network [38].

Claims:

An animal feeding system, comprising:

A device that includes a microcontroller, one or more applications that are running on at least one processor of a mobile device, at least one application from a remote vendor that is running on at least one processor of a remote server, and an access point, all of which are set up to communicate with one another through a communications network; the container that stores consumables and has an opening through which the system dispenses the consumables; a chute for catching the consumables when they enter the container through the entrance;

The animal feeding system of claim 1, where ordering more consumables for the animal feeding system is part of starting communication with at least one application of the remote vendor.

The animal feeding system of claim 1, where the wireless local area network serves as the communications network (WLAN).

The system for feeding animals described in claim 3, where the WLAN employs the WiFi communications standard.

The animal feeding system of claim 1, where the wireless personal area network serves as the communications network (WPAN).

Table 2: Patent analysis

Citation	US7650855 B2 [35]	US4248175 A [36]	US11006614 B2 [37]	US10743517 B2 [38]	Proposed Solution
Software Application			Mobile Application	Mobile Application	Mobile Application (MIT App Inventor)
Alert Notification				Mobile App Notification (Food Dispense)	Mobile App Notification (Food level, Food Dispensing and Food Disposal)
System Functionality	Timing Mechanism	Timing Mechanism Rotating Tray	Timing Mechanism Rotating Tray	Timing Mechanism Rotating Tray	Timing Mechanism (Food dispensing and disposal) Rotating Food Disposal Tray Night-Light Module Load Cell
Power Source	Battery	Battery	Battery	Battery	Wall Outlet powered
Embedded			Camera	Camera	Camera

Container	Food	Food and Water	Food	Food	Food and Water

Table 2 indicates a gap analysis of patents and utility models related to the proposed solution, comparing the features of the proposed solution with those of existing solutions. The features considered in the comparison include the software application, alert notification, system functionality, power source, embedded components, and container used. As mentioned, some existing solutions do not use software applications, while others use mobile apps. One existing solution employs an alert notification system to inform users that food has been dispensed. All existing solutions use timing mechanisms for system functionality, and most include a rotating tray. All existing solutions use batteries as the power source, and some include cameras as embedded components. However, most existing solutions only focus on food distribution and do not include water.

3. Competition Intelligence

Crabtek Wifi Smart Pet Feeder is an existing product on the market that is similar to our study. This product is available from online stores such as Shopee and Lazada.

Fig. 6: Crabtek Wifi Smart Pet Feeder

This product includes an HD camera, feeding plan, video and photo capture, timer, schedule, moisture-proof, two-way audio, and is controllable via a mobile app even when the pet owner or fur parent is away as long as it has an internet connection. When it comes to its price, this product costs ₱5,149.

Fig. 7: Cherry Home Smart Pet Feeder

Cherry Home Smart Pet Feeder is an available product on the online market, such as Shopee and Lazada. The model name of this product is CPFEED01 Smart Pet Feeder with a camera. The main features of this product are Smart WIFI App control, power bank slot, meal scheduler, two-way audio, infrared night vision, and photo and video capture. This product has a feeder capacity of 1.5kgs with a weight of 2.2 kg, a power input of 5V2A, wifi 802.11 b/g/n, 2.4GHz, and a 720p camera with a distance range of up to 20m. The price of this product is P5,049.

Fig. 8: Smart Feed Dog and Cat Feeder 3L

This product can be seen in the online market/stores such as lazada and shopee. It has a feature of feeding at a regular time and manual feeding with a mobile app available on IOS and android. It has a 3-liter hopper for dry food with a maximum diameter of 15mm. This smart pet feeder also has an automatic turning mechanism to solve the problem of food jams. The feeding method is only manual and automatic, the food size is up to 15mm, the hopper capacity is 3L, and it is only used for dry dog food. The price of this product is P4.060.

Fig. 9: Rojeco Smart Pet Feeder

The Rojeco Smart Pet Feeder is available in their store and online markets such as lazada and shopee. This product has the feature of feeding the pets using the smartphone whenever and wherever the customer wants. It has both Wifi and a button version available where the owner can set up a feeding schedule through the app using the wifi, and a button version setting on the built-in timer in the product without using wifi or the app. Once set up, the schedule will be recorded in the feeder's local memory. Even on the WIFI it will still feed automatically, but no notification will be received via the APP if the feeder is not connected to WIFI. The product is suitable for cats and dogs, and the price of this product in the online market is P3,149.

- **Conceptual Framework**

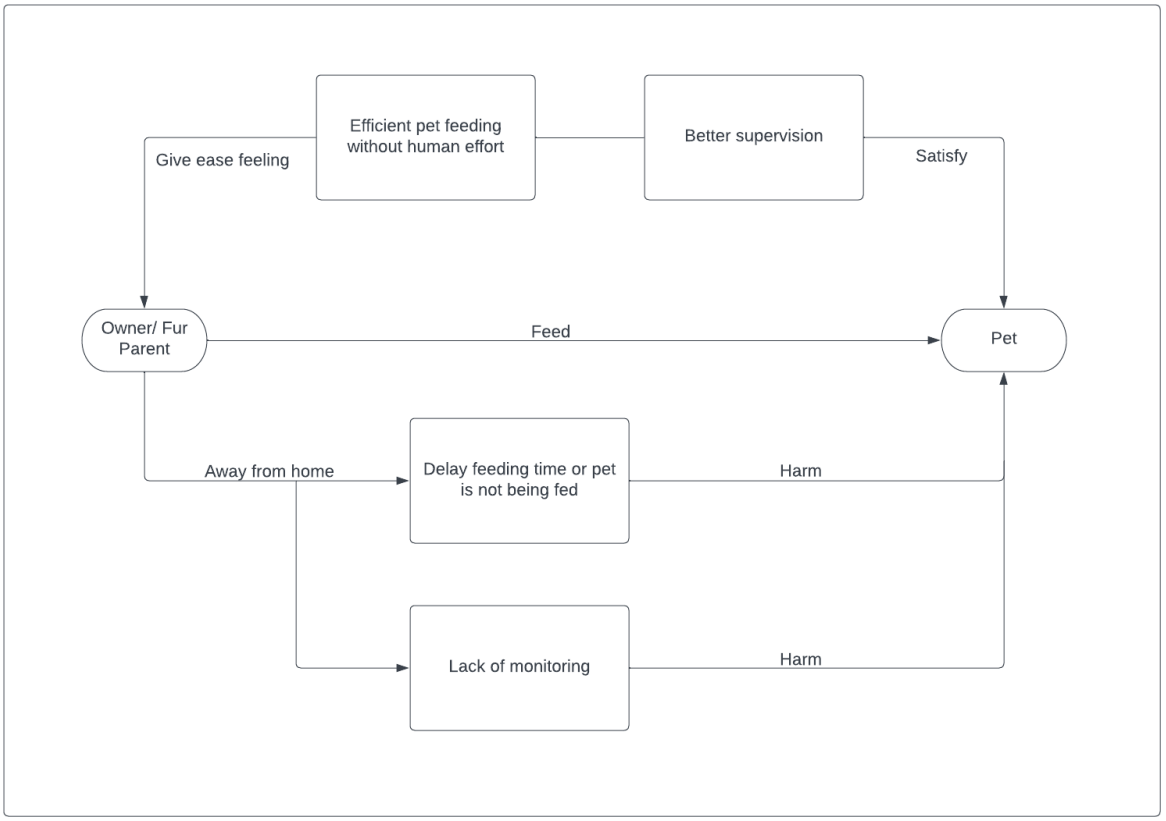

Fig. 10: Conceptual Framework of the Study

The image above illustrates the problem and its factors as well as the proposed solution of the researchers in a block diagram manner. The researchers first identified the root of the problem being the inevitable leaving of dogs alone at home. As a result, owners would be unable to feed their pets manually which might cause horrible outcomes in terms of the dogs' health.

On the other hand, the diagram also shows possible harmful experiences such as lack of monitoring and delay of feeding. In contrast, the proposed solutions of the case study such as better supervision and efficient automatic feeding were also included to showcase the capabilities and functionalities of the proposed system.

● Literature Synthesis

The process of research development underwent many stages of planning, consulting, and theorizing all the possible implementations of Engineering concepts to develop the features of the study. Yet beforehand, the researchers also considered the feasibility of the development of the proposed features. In the figure above, it shows all the proceedings and actions that the researchers go through which led the group to conduct research about the identified topic.

Synthesis of Nearest Prior Art

Table 3: Related Literature Gap Analysis

Citation	S.Koley, S.Srimani, D.Nandy, P.Pal [16]	B.Saputro, F.Dandha, L.Rusdiyana [18]	V. Kirbac, L. Kouhalvandi [19]	Devika [20]	Proposed Solution
Software Application		Blynk Application Software	Blynk Application Software	Blynk Application Software	MIT App Inventor
Alert Notification			Mobile App Notification (Food Decrease)	Mobile and Computer App (Refill and Feeding Alert)	Mobile App Notification (Food level, Food Dispensing and Food Disposal)
System Functionality	Timing Mechanism	Timing Mechanism	Timing Mechanism	Timing Mechanism Voice Recording	Timing Mechanism (Food dispensing and disposal) Rotating Food Disposal Tray Night-Light Module

	Load Cell				Load Cell
Power Source	Battery	Wall Outlet Powered	Battery	Battery	Wall Outlet powered
Embedded				Camera	Camera
Container	Food	Food	Food	Food and Water	Food and Water

The table presents 4 related studies and literature on the use of automatic pet feeders, some of which utilize a software application called Blynk. Two of these feeders have alert notification systems, one of which is triggered when the food level decreases and the other for refilling and feeding alerts. The system functionalities of the 4 related studies vary, including timing mechanisms, automatic food dispensers, voice recorders, and load cells. While some of the feeders are powered by batteries and wall outlets, most rely on batteries. Only one of the related literatures includes a camera for monitoring purposes, and the feeders have either one container for food or separate containers for water and food. The proposed solution for an automatic pet feeder utilizes a mobile application to access the camera on the prototype and also includes a load cell to know when the food level is low. The feeder has an automatic food disposal and a photoresistor or night sensor that turns on the light in low lighting conditions. The prototype is powered by a wall outlet and has separate containers for food and water. The camera is included in the prototype to allow the user to monitor their pet remotely.

CHAPTER 3 METHODOLOGY

This chapter discusses the research methodology and procedures used in the study. This section comprises detailed research methods, research requirements, deliverables, the development pipeline, the research specifications, and research metrics. details on different processes that would be used to develop the design project. Furthermore, physical designs and experimental designs are specified in this section.

A. Research Design

The methodology used in gathering and analyzing the data is a quantitative method, and the tool that researchers will use is google forms for data collection. The researchers use quantitative methods since the requirement for survey respondents for the case study is 100 respondents and above. The quantitative method is suitable for analyzing and evaluating survey results that use a vast population. Google forms will produce graphs and charts for the survey result. Using google forms has a good advantage for the researchers since it already makes charts and graphs of the survey results. The survey result must have at least 90% and above respondents agreeing will use the product when it is done.

The researchers used the Agile Method for developing the prototype. The project was initially divided into parts or per feature, and improvements were continuously applied after a task. Each researcher has its own task in developing the project, tasks were divided per feature, then all were combined into a one system or a prototype.

B. Feature Specification

The researchers aim to create an automatic pet feeder that will help the fur parents or pet owners not to worry about leaving their pet/s at home alone. There are already existing smart/automatic pet feeders in the market, but the researchers seek to improve and add features to this existing product. The researchers browsed the internet and looked for markets that sell smart/automatic pet feeders, such as lazada and shopee. The researchers listed the functionalities and features available in the market, and getting product and customer reviews is necessary. These will give the researchers an idea of the possible features and functionalities to add by differentiating the existing product from the product the group seeks to create. The researchers do an interview first before conducting a survey to ensure that

some fur parents are willing to use this kind of product and to know if there are functionality and features they would like to see on the pet feeder that is not available in the market.

The researchers gathered data from 102 respondents, and in the results, out of 102 respondents, 96.1% of the respondents answered “YES” that they would use a smart/automatic pet feeder. These results show that most respondents are willing to use this product. The survey results showed good responses for the functional features of the product. The product will have an application that will help owners monitor their pets while away from home. The product will also have an application that will send a notification when the food container needs a refill. The smart pet feeder will also have a camera that will help the fur parents to monitor their pet/s via the app when they are not home.The researchers will also add a feature with a light sensor that automatically turns on the light when it senses darkness. Lastly, a wall outlet will power the smart pet feeder.

1. Identified Market Opportunities

The researchers aim to create a smart pet feeder that will help fur parents or pet owners not to worry about leaving their pets at home alone. Many fur parents leave their pet/s home alone, and the reason/s for it is work, school or travel. The product researchers seek to create has an application that will help owners monitor their pets while away from home. With the help of the product, fur parents or pet owners would not have to worry about feeding their pet/s when they are not home. It increases the demand for pet feeders, mainly for smart/automatic pet feeders that are easy to use. The identified product market will be online stores such as lazada and shopee, since there are already smart/automatic pet feeder products in the online market.

There are already existing smart/automatic pet feeders, but the researchers seek to improve this product. The researchers look for the product reviews of the existing product in the market to get more ideas and information on the possible functionalities and features to add to the current or existing smart/automatic pet feeder. The researchers do an interview first before conducting a survey to ensure that some fur parents are willing to use this kind of product and to know if there are functionality and features they would like to see on the pet feeder that is not available in the market. The researchers gathered data from 102 respondents, and in the results, 99% of the respondents have pet/s in their household, and

95.1% consider themselves fur parents. In the graph, 93.1% of the respondents do not own a smart/automatic pet feeder, but 52.9% heard about this kind of product. Out of 102 respondents, 96.1% of the respondents answered “YES” that they would use a smart/automatic pet feeder. These results show that most respondents are willing to use this product.

2. Requirement Specification

After conducting surveys, several consultations, informal interviews, and group discussions, the researchers came up with unique ideas that could be added as features to the prototype while also considering the possibility of it being created. As much as possible, the researchers wanted to add specifications that are easy to be made yet unique and essential. After weeks of gathering data, the researchers figured out what features to add and what not, and considered the amount of time given to develop the actual project itself.

Based on group discussions and consultations with the thesis adviser, who is a fur parent as well, the automatic refilling feature of food and water is not recommended as it promotes more exposure to germs and contamination. Lights were also suggested by the respondents from the conducted survey, the group thought likewise that it will be essential, especially for pet owners that will be away from home for 24 hours or more. Notifications were also considered an essential feature of the project, as it reminds the owner through the mobile application if the pet food needs refilling.

3. Feasibility Analysis

Evaluating all the key factors pertinent to the project is essential so that the researchers can determine the cons and pros of implementing the project. The feasibility study discusses the operation, technical and financial feasibility that will help the group give a clear picture in the budget required in creating the project.

Operational Feasibility

The researchers aim to create an automatic pet feeder that will help the fur parents or pet owners not to worry about leaving their pet/s at home alone. To fulfill the study's objective,

the group does a planning process to make a successful implementation of the project. The researchers surveyed 102 respondents that are located in NCR and 4-A Calabarzon. The researchers are planning for deployment testing from those places. Out of 102 respondents, 96.1% are willing to use the product. That would be a massive help for us the researchers if they would take part in using our product for the deployment testing.

Technical Feasibility

There are no problems with the availability of equipment or tools for conducting and implementing the project; all the components needed in creating the hardware are not hard to find since there are stores and online stores the researchers can visit. In making the software, there are downloadable applications such as android studio for developing the mobile application. All the group members have their laptops for coding purposes.

Financial Feasibility

The researchers browsed the internet to look for the markets selling smart/automatic pet feeders since it is the competitors. That gives an idea of the total costs of creating the product. Many electronic components will be used in making this product, but all of it is financially viable. The researchers planned to visit the stores selling electronic components needed in creating the hardware to do a price canvassing of the components or materials and the same with online stores such as lazada and shopee. After the price canvassing, the researchers can determine the possible cost of developing the product.

Table 4: Components Summary Table

Components	Estimated Cost	Quantity	Estimated Final Cost
ESP 8266	₱150	1	₱150.00
High Torque DC Motor MG-996R	₱275.00	2	₱550.00
ESP32-CAM Camera Module ESP32-S OV 2640 2MP	₱ 800.00	1	₱800.00
Photoresistor 5mm Light Sensitive	₱35.00	5	₱35.00
LED	₱50.00	3	₱150.00

Servo 360	₱250.00	1	₱250.00
Servo 180	₱150.00	1	₱150.00
Jumper wires	₱60.00	3	₱180.00
Power supply (3v - 12Ω)	₱650.00	1	₱650.00
Load Cell (10kg)	₱100.00	1	₱100.00
HX711 Module	₱750.00	1	₱750.00

4. Functional Requirements

In determining the system requirements, the researchers surveyed 102 fur parents or pet owners to get their opinions on whether the product's functionalities and features are essential. The product that the researchers seek to create already exists, the automatic pet feeder, but the researchers want to improve and add features to this existing product.

The survey results showed good responses for the functional features of the product. The product will have an application that will help owners monitor their pets while away from home, and 94.1% of the respondents answered “YES” that it is essential. The smart pet feeder will also give a camera that will help the fur parents monitor their pet/s via the app when they are not home, and 95% answered “YES” that it is an essential feature. The product will also have a water container feature, and 94.1% answered “YES” that it is an important feature. 86.1% of the respondents answered “YES” that it is an essential feature for a smart/automatic pet feeder to have a light sensor that automatically turns on the light when it senses darkness.

This study focuses on seven functionalities/features requirements which are the following:

- Mobile Application

This feature allows the fur parents or pet owners to receive a notification when the food needs to be refilled. It also grants the user the capability to monitor their pets while away from their respective residences.

- Camera

The product consists of a camera for seeing the pet; this will help the owner if they want to check or see their pet/s.

- Rotatable Food Container

The container for food can be rotated and is connected to a servo for automatic food disposal.

- Light Sensor/ Photoresistor

This type of sensor will automatically turn on the lights when it senses darkness since the owner might put or place the product where it is dark at night.

- Automatic Food Disposal

The product also comes with automatic food disposal to prevent contamination. The user can manually dispose of the food on the container using the mobile app, and also, it has an automatic feature in which it disposes food 15 minutes before the scheduled food distribution.

- Automatic and Manual Feeding

The system consists of two varieties for the user to feed his/her dog. Through the mobile app, the user can send treats to his/her dog using manual feeding. There are also instances where the user is unable to attend to his/her dog, this is where automatic feeding can be used. Automatic feeding depends on how the user wants his/her dog to be fed, there is also a table verified by a professional veterinarian that shows the amount of food and how many meals per day to serve the dog according to his/her age and breed.

- Pet Water Nozzle

This feature was already an existing technology which was added to the prototype. It is attached at the left side of the prototype.

C. Design Constraints

In this section, the researchers will elaborate on the limitations of developing every feature in each constraint criterion. Moreover, included here are the factors considered by the group in developing the actual prototype.

1. Technical

- Automatic Lighting System - automatically turns on lights if senses darkness using a photoresistor.
- Surveillance Camera and Notification System (Mobile Application) - monitor pet dog with camera and receive notifications if food reaches a certain low level (1kg or 33%). The system will also send a pop-up alert if the prototype automatically dispenses food based on the time schedule.
- Time Scheduling - distributes food at a certain time depending on how many meals per day. For twice a day, there is an interval of 12 hours which makes the first dispense at 8 am and the second at 8 pm. On the other hand, for thrice a day, there is an interval of 5 hours, first meal will dispense at 7 am, second time at 12 pm. and for the last is at 5 pm.
- Automatic Food Disposal Tray - automatically dispose of food every 15 minutes after food is dispensed. This feature can also be controlled manually.

After multiple deliberations and group discussions, all the features will be included. Time scheduling for choosing how many meals per day will be based on the documentation provided by the researchers showing the possible or most appropriate time of giving food for the pet dog.

2. Health and Safety

Animal welfare is a must on creating this prototype, the feeder should be designed to ensure the health and well-being of the pet. This includes ensuring that the pet has access to a sufficient and appropriate amount of food and water and that the feeder is safe and easy to use.

3. Ethical

There are various ethical constraints and ethical considerations that should be considered when constructing this prototype, and these are the product cost, and privacy. Because the

researchers are concerned about the possible end user's financial status, one of the ethical constraints is product cost. That's why the researchers must ensure that the prototype is affordable in the market. The next consideration is privacy; because the prototype includes a surveillance camera, the user's privacy must be protected. The ethical considerations here include the end user's or individual's privacy and home privacy.

4. Cultural

When creating an automatic dog feeder, the researchers must consider cultural constraints to make sure that the prototype is aligned with cultural practices and beliefs. There are some cultural constraints to be considered:

- Noise level - since there are some cultures that are very sensitive to noise, it is important that the product or prototype can operate silently to avoid distraction or disturbance to others.
- Feeding rituals - there are different cultures that have different types of feeding rituals or practices when it comes to how they feed their dogs. Some fur parents, for example, prefer to hand feed their dogs and give food on a certain schedule. With this, make sure that the automatic dog feeder will respect this kind of feeding practice since this is the one that they used to.
- Technology acceptance - the product must be user-friendly or easy to use because there are some fur parents who are not familiar with the new technologies.

5. Social

Social constraints are the factors that may appear while the researchers are doing the project. There will be opposition and wider interest in the project coming from people. The researchers must determine the public concern pressure that may become a critical observation. The project that researchers are planning to do is for dog owners or fur parents. The observations and opinions of the dog owners are necessary for the project and it may cause a major alteration to the plan of the research. These kinds of constraints are part of the public concern and are labeled as “nimbyism” or “not in my backyard”.

6. Environmental

When it comes to environmental constraints, there are some factors that must be remembered or practiced. These are:

- Materials - make sure that the materials used are eco-friendly so that they will not have a negative impact on the environment.
- Casing - the casing must be made of sustainable materials and come from a renewable

source, such as plywood and many more.

7. Sustainability

The prototype should be sustainable. The feeder should be designed with sustainability in mind, using materials and practices that are environmentally friendly and minimize waste. Additionally, food portioning is important; the prototype must be able to control the amount of food to dispense to ensure that it will help reduce waste.

8. Economic

The economic constraints are related to the project budget and the allocation of resources that the researchers will use while doing the project. The researchers must allocate appropriately or adequately to make sure that there will be no problem in terms of the project budget. The economic constraints are not only about the overall budget that the researchers needed but also about the cash flow through the supply chain. There will be bankruptcy if the cash flow is not being determined. There will be a lot of considerations that the researchers must determine when it comes to the wider economic constraints.

9. Legal

The legal constraints are the many regulations that the researchers must follow while doing the activities needed to do the research. The research must follow the law, safety requirements, planning and any regulation in doing the research. There are a lot of penalties and even possible criminal proceedings if the laws and regulations are not being followed. The project that the researchers are planning to develop is for household pets such as dogs, meaning there will be a dog that is needed in the experiment of the product. The researchers must follow the laws that protect and promote the welfare of all animals in the Philippines such as Republic Act 8485 Section 1 and Republic Act 10631 Section 7. The most important legal considerations that the researchers must not forget are related to the respondents or research participants. The researchers must maintain the privacy and protection of the information of the research participant.

10. Physical

The electronic components that were used actually depend on the features that will be included in the project. For the night-light module, components such as photoresistor, led lights, and resistors were used. For the dispensing and disposing servo modules, components such as servo motors were used. And for the overall functionality of the system, components such as step-down module, load cell, decoder (Hx711), power supply, jumping wires, ESP32 Cam for camera, and ESP8266 for the microcontroller.

D. System Architecture

The system comprises features that would help the fur parents or pet owners not to worry about leaving their pet/s at home alone. For software, the tool that the researchers will use in creating the software or mobile application is MIT Application. That will help the researchers build a mobile application that connects to the hardware or product. For hardware, the microcontroller that the researcher will use is ESP8266 which is needed in the coding or programming. The researchers will use various electronic components such as servo, cables/wires, relay, load cell, decoder (HX711 module), LED strip, photoresistor, camera (ESP32Cam), microcontrollers, power supply, and USB step-down module.

1. System Workflow

Pet Owner/ Fur Parent - This user is the one expected to set up the automatic pet feeder in case of leaving the pet alone at home. The user can also access the camera installed on the device through a mobile application. There will be a notification sent to the mobile application of the user if the pet food in the prototype is at a low level (1kg or 33%). There is also a feature which enables the user to manually dispense and dispose of food with the use of the mobile application. A pop-up message will also appear when the prototype automatically dispensed food with a timestamp.

2. Functional Design

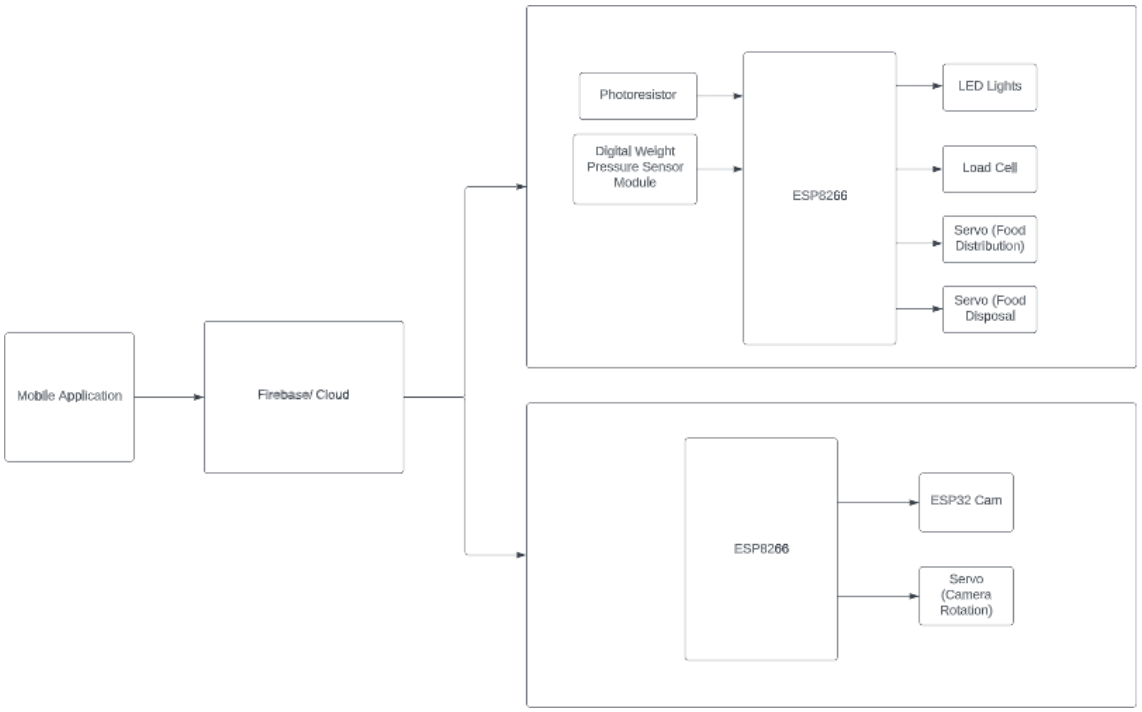

Fig. 11: Block Diagram of the System

The figure above illustrates the features of the system from a block diagram perspective. Firstly, the photoresistor that is included in the automatic lighting system of the prototype; detects the lackness of light in a certain area and triggers the LED lights to turn on automatically. Next are the camera and load cell or the weight sensor, both features are connected and accessible through the mobile application. The user can access the camera installed in the smart device even while being away from home, the load cell is to detect the weights of the container for food of the pet, and it sends a notification to the user's mobile app if it reaches a certain level (1kg or 33%). All components function according to the input data it receives from the mobile application to firebase cloud.

3. Software Design

In this section, the system's software design is presented and also discusses the software specification, system pipeline, and algorithm design. To make the system easier to understand, this section provides several illustrations of diagrams.

Software Specification

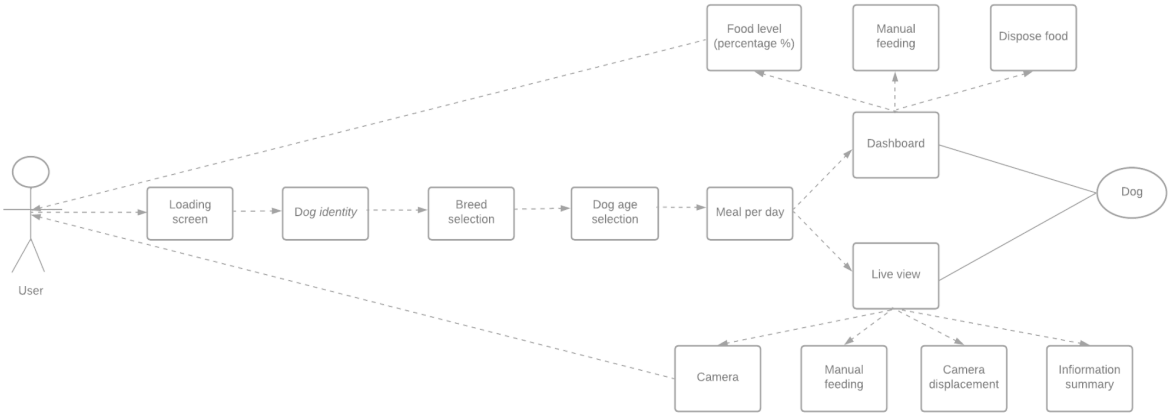

Fig. 12: Software Specification of the System

The case diagram () depicts the user and the dog as the actors. The user's initial step is to enter the dog's name. Following that, the user must select a dog breed: toy (0.5 kg-6.9 kg), small (7 kg-13.9 kg), medium (14 kg-22.9 kg), or large (23 kg-41 kg). The user will then pick its dog's age range from 0 to 1 year old, 1 to 10 years old, and 11 and above. The next step is to choose the number of meals per day, whether it is two or three meals per day. It also indicates the number of meals necessary each day based on the breed. After entering all of the necessary information, the user proceeds to the dashboard, where he or she may view the food level % and manually regulate the food dispensing and disposal. Finally, the live view is where the viewer may observe the dog using a camera. The live view screen also includes a manual feeding button and a dog information summary.

System Pipeline

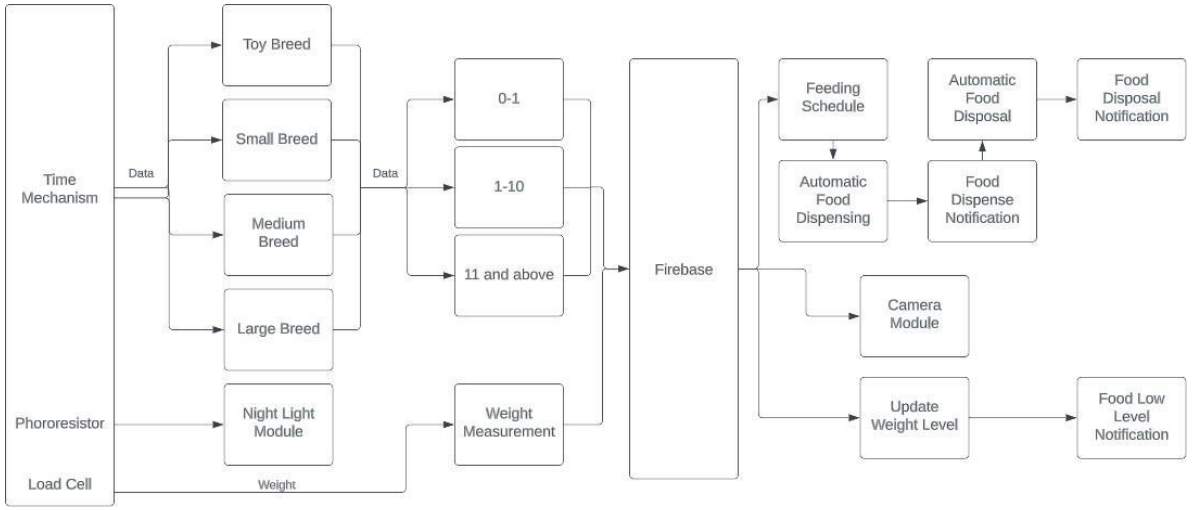

Fig. 13: System Pipeline of the System

The figure above shows the system pipeline of the system that the study will use. As shown there will be three (3) input data in the system. The timing mechanism will provide the feeding schedule depending on data that the user will be choosing from breeds to age. The data will be processed in Firebase to provide the scheduling per day and the amount of food to be dispensed. After the food is dispensed, the automatic food disposal will prompt and a notification will pop up as well. The photoresistor is used for the night light module to provide light in the absence of light so the user will be able to monitor their dog through a mobile application. The load cell is used to measure the weight of the dog food that is currently in the container, if the measured weight becomes one (1) kilogram or lower, a notification will pop up that the food level is low.

Algorithm Designs

Fig 14: Data Elicitation Diagram of the System

The figure above shows the data elicitation diagram of the system wherein the user will provide relevant details about their pet such as breed, age, and meal per day. The system will provide recommendations based on the validated dog food distribution table. The sensor data such as the weight sensor will collect data on the current weight of the food in the feeder to notify the user if the feeder needs to be refilled. Also, the camera will capture images per frame so the user can monitor their dog from time to time. The timing mechanism can be modified through the system setting which will be determined by the feeding schedule and food portion. The food dispenser will provide food portions depending on the inputted data of the user and will prompt a notification during the dispensing process, and also automatically dispose of food after fifteen (15) minutes and the load cell continuously updates the remaining amount of food and provides notification if the food level is low.

4. Data Management Design

The data management design explains and shows the life cycle of the data, including its sources, storage, processing, and analysis, in this section. In this step, the data value chain should be taken into consideration.

Data Flow Diagram

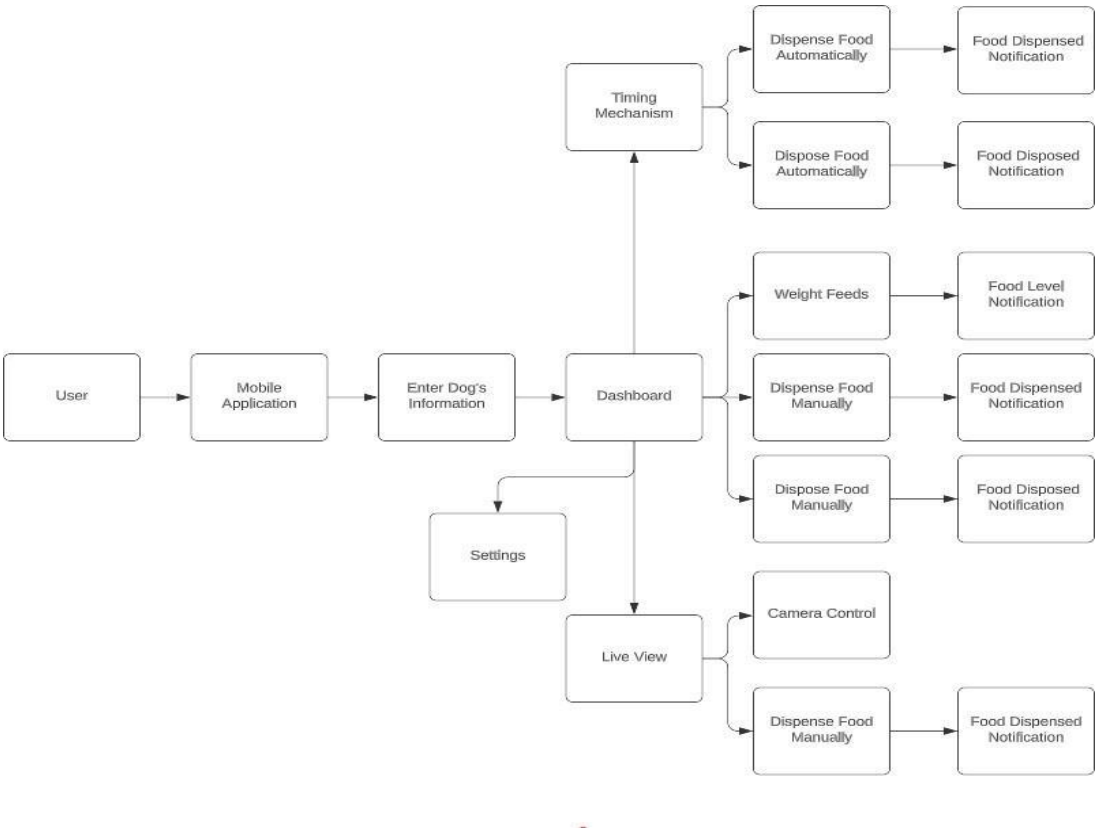

Fig. 15: Data Flow Diagram

The figure above shows the data flow diagram where it shows the flow of the system. In this data flow the user is the fur parent. After opening the mobile application, the user will ask to enter his/her dog information such as name, breed, age, and meal per day. After that, the user will direct to the dashboard where it shows the weight of feeds, dispense and disposed button for manual feeding and disposal. Upon clicking the buttons, a notification will pop up once successfully dispense and dispose. Next is the live view button, where the user can see a video showing the bowl and its surroundings. Also, it has a dispense food button for manual feeding. Lastly the settings, where the user can view the dog's information and also the user can modify or change the information inputted.

Entity Relationship Diagram

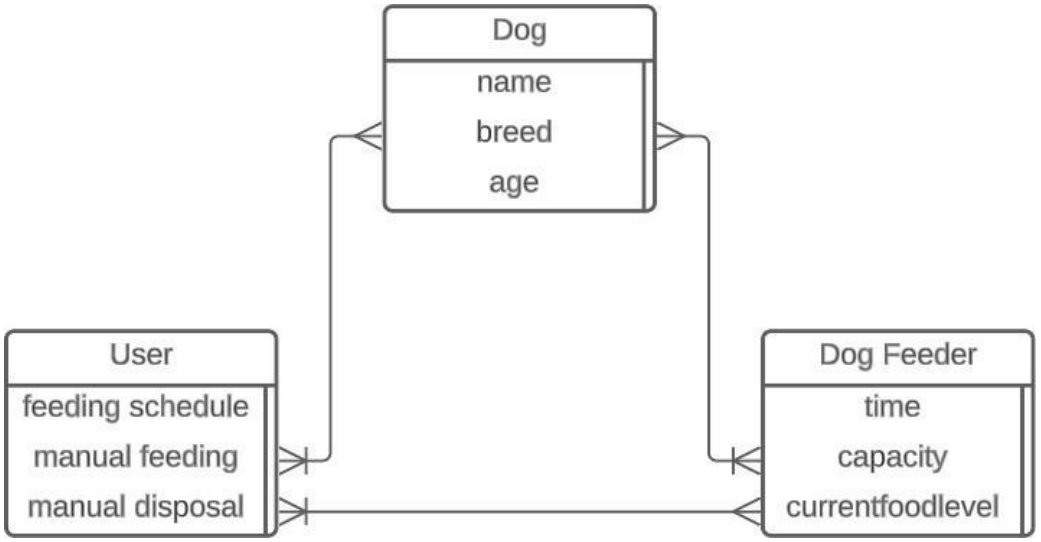

Fig. 16: Entity Relationship Diagram of the System

The figure above shows the entity relationship diagram (ERD) of the study. The ERD shows the relationship of one object to another entity. There are three tables in the ERD of the system which are the user, dog and dog feeder. The first table consists of a feeding schedule, manual feeding and manual disposal. It is connected to the other entity or table which is the dog or the second table. The 1st table is connected to the second table since the dog table will be based on the information inputted by the user. The 3rd table which is the dog feeder consists of time, capacity, and current food level. The 3rd table is connected to the 1st table since the information of the dog feeder table will be based on the user input data.

Network Diagram

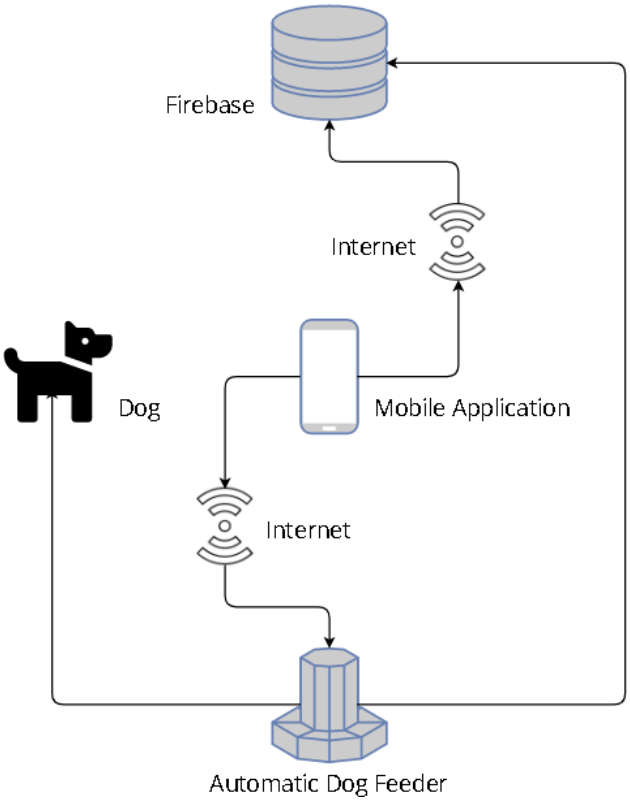

Figure 17: Network Diagram of the System

The figure above shows the network diagram of Pawsitive Care. Starting from the mobile application, data needs to be transferred through the internet to the automatic dog feeder connected to the firebase. The process of inputting data from the mobile application will automatically prompt the user to be connected to the real-time firebase and the control to the automatic dog feeder, after getting the data needed, the real-time firebase will provide necessary information to the mobile application that will help monitor live updates in the system such as notifications. After acquiring the necessary data, the timing mechanism will be updated and the system will provide an automatic feeding system for the dog.

5. Hardware Design

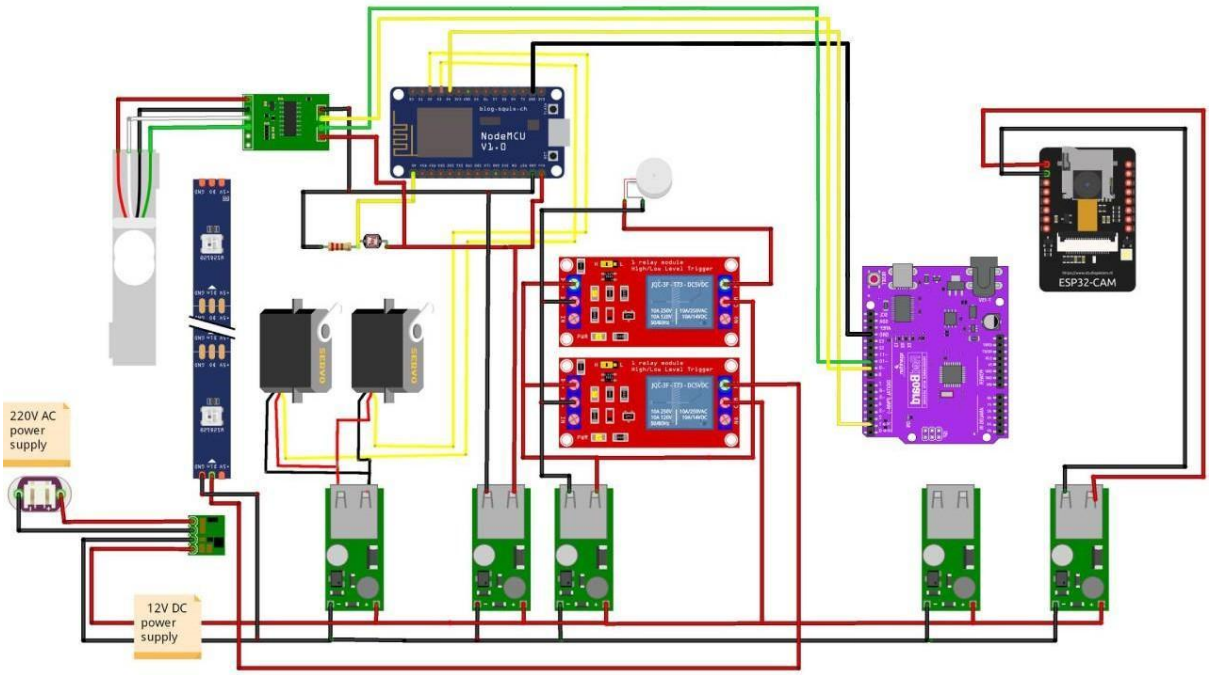

Fig. 18: Hardware/Circuit Design

The image shown above is the circuit diagram of the prototype consisting of different components such as power supply, decoder (hx711), load cell, strip light, servo, step-down module, esp8266, photoresistor, resistor, gizDuino UNO-SE, and an esp32 cam. Overall, the circuit is composed of three microcontrollers, but only two of them were mainly used for configuration. The first ESP8266 was used for the timing mechanism of servos, load cell & hx711 functionality, night-light, and relay module. The gizDuino UNO-SE was used to save data from the load cell so that every time it resets automatically, the previous data will still be recorded. Step-down converter modules were used to regulate the voltage output from the main source of 12V.

For the main ESP8266 used, the following pins were used: D2, D3. D4, A0, GND, and Vin. D2 and D3 were used for the signal of two servos used for the Dispensing and Disposing Servo module. A0 was used for the photoresistor, GND and Vin were used for the ground and power input for the microcontroller. All other components were directly connected to the power supply, thus 3v3 pin were not used. RX and TX pins were not used as it cannot be used for normal I/O or sending/receival serial data. D0, D1, D5, D6, D7, and D8 were not used as there are enough I/O pins for the electric components that are supposed to be

connected directly to the microcontroller. EN and RST pins were not used as there was no use for the functionality of the system. Moreover, SD pins, CMD, and CLK were also not used as they are used for SD card configuration. For the gizDuino Uno-SE, pin 1, pin 9, pin 10, and ground were only used. Pin 1 was used as TX/Transmitter to send data to the ESP8266's D4 which served as RX/Receiver, Pin 9 and 10 were directly connected to the HX711 module for the load cell.

6. Industrial Design

This section illustrates and explains the physical design of the prototype that is possible to be filed as industrial designs.

Prototype Design

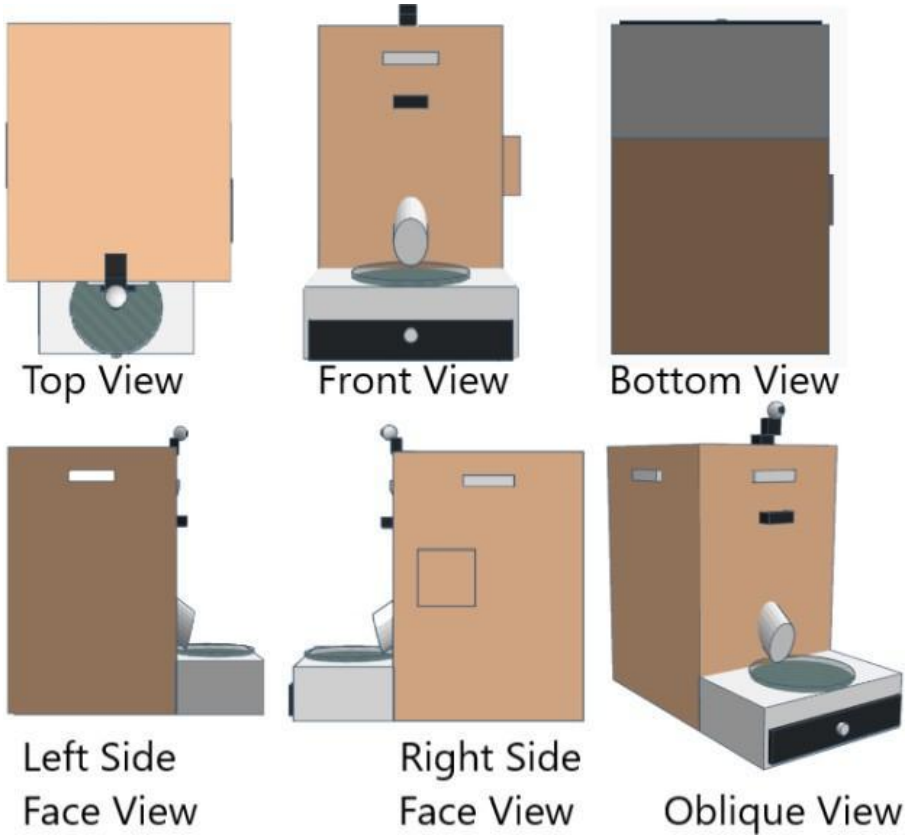

Fig. 19: Prototype Design

The 3D Computer-Aided Design for the prototype has been made using Tinkercad web application. Figure 4 shows the prototype design of the system, it includes the top view, front view, bottom view, left side face view, oblique view, and right side face view of the initial prototype design.

Graphical User Interface

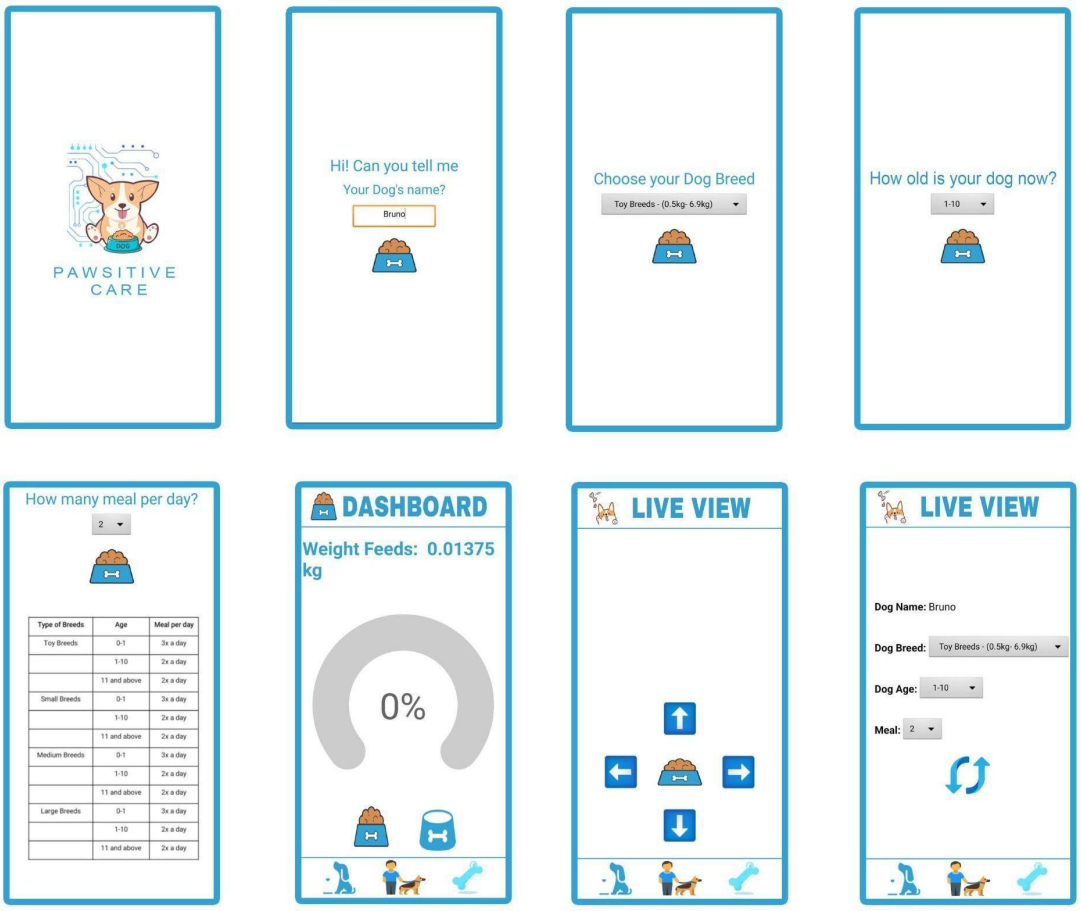

Fig. 20 : Automatic Dog Feeder Graphical User Interface Design

The automatic dog pet feeder will have an application that will help owners monitor their pets while away from home. The purpose of the product, other than being able to monitor their pet/s while being far away from home, and also to receive a notification when the food level is at critical level (1kg or 33%). To start using the application, clicking its icon will automatically redirect the user to the graphical user interface of the mobile application. The app will ask the user for its dog's name, breed, age, and how many meals to serve per day. Then after the information gathering, the user will now be redirected to an interface in which he/she can access the Dashboard and Live View. In the Dashboard part, the user can see how much food is left in the container (in Percentage%), there are also buttons for manual feeding and food disposal. In the Live View portion, the user can access the camera and move it using the arrows, there is also a button for manual feeding. Also included in Live

View, the user can see the recorded information of his/her dog and lets the user edit every information on the spot.

E. Experiment Design

In this specific part of the case study, the tests and metrics that will be used to determine the efficiency of the prototype will be identified.

1. Performance Measurement

There are several ways in order to test the functionality of the prototype as a whole. And there are three factors that will test the system's whole functionality effectiveness: accuracy, timing mechanism, and actual testing.

Accuracy Testing

Timing Mechanism

Type of Breeds	Weight	Age	Food Weight	Meal per day
Toy Breeds	0.5-6.9 kg	0-1	75 grams	3x a day
		1-10	225 grams	2x a day
		11 and above	170 grams	2x a day
Small Breeds	7-13.9 kg	0-1	75 grams	3x a day
		1-10	300 grams	2x a day
		11 and above	225 grams	2x a day
Medium Breeds	14-22.9 kg	0-1	300 grams	3x a day
		1-10	450 grams	2x a day
		11 and above	375 grams	2x a day
Large Breeds	23-41 kg	0-1	450 grams	3x a day
		1-10	675 grams	2x a day
		11 and above	525 grams	2x a day

Fig. 21: Dog Food Distribution Table

The illustration shown above is the food distribution table for dogs according to their age and breed. The most important part of this table to be considered is the food weight or food serving depending on what type of dog it will be used for. The delay or the time of servo turning is the most crucial part for this test. The servo designated for food distribution must be on point and dispenses food with correct measurements based on the table.

Timing Mechanism

Type of Breeds	Age	Meal per day
Toy Breeds	0-1	3x a day
	1-10	2x a day
	11 and above	2x a day
Small Breeds	0-1	3x a day
	1-10	2x a day
	11 and above	2x a day
Medium Breeds	0-1	3x a day
	1-10	2x a day
	11 and above	2x a day
Large Breeds	0-1	3x a day
	1-10	2x a day
	11 and above	2x a day

Fig. 22: Meals per day according to age and breed table

There are two options for choosing how many meals per day for dogs based on the table: it is either 2 times or 3 times a day. The distribution is based on the actual timezone inputted in its code. According to Dogsee (2022), dogs eating 2 times a day must have 12 hours apart from eating another meal, they also recommended a time which is 8AM in the morning and 8PM in the evening. For 3 times a day, the recommended time is 7am in the morning, 12pm and 5pm in the afternoon. The food dispensing feature must function automatically based on the said certain timeframes.

Actual Testing

In the actual testing, the prototype must be tested out with the actual user of the prototype, which is the pet dog. In this process, the dog must be seen eating through the use of the prototype. The placement of every component and features will be tested out if an actual dog can easily identify where to eat the food and where to get water for consumption.

Key Performance Indicators

Table 5: Key Performance Indicator for each objective

Objectives	**Task**	**KPI**	**Threshold**
Develop a smart device that has the application of automation and embedded system concepts that has the capability of feeding pet dogs automatically without any human effort;	Automatic Dispense	Accuracy of Automatic Feeding (Margin of Error)	≤ 15 grams of excess or inadequate from exact value
Design and integrate mobile application for monitoring and notification system; and	Live View Camera	Latency	≤ 100 ms [42]
	Notification System	Alert Speed (Seconds)	≤ 2 seconds
Add unique yet essential features such as automatic night-light and food disposal for contamination prevention.	Night-Light Feature	LDR (Light dependent resistor)	≤ 1000 LDR Value
	Food Disposal Feature	Response Time (Seconds)	≤ 5 seconds

2. Test Cases

This section of the study discusses each test performed on the system before the actual deployment. It will ensure that the system or one of its features is working as it should. There will be three types of tests in the test cases which are the unit test, integration test and system test to make sure that all the features are working based on what was proposed.

Unit Testing

The developer creates and runs unit test cases to make sure that individual units function as intended [39]. Unit testing ensures that every component or unit is working properly before doing the integration of the units.

Table 6: Unit Testing

Test ID	Tests	Test Results
UT_ESP	ESP8266	The ESP8266 will start once the power is being applied.
UT_SM	Servo motors	The servo motors will work or start moving once the code is uploaded.
UT_LC	Load cell	Can measure the weight accurately.
UT_ESP32CAM	ESP32-Cam	The ESP32 Cam will start once the power is being applied.
		Can show live video.
UT_PR	Photoresistor	Can detect the absence of light.
UT_PS	Power Supply	Can be used as a power source once connected to an electrical socket.
UT_T	Relay	Can perform on and off function when connected with a microcontroller.
UT_LC	Decoder	Can convert signals into data.

UT_SDM	USB Step-down Module	Can be used as a medium for power supply for USB .
UT_LED	LED Strips	Lightens up when connected to a power source.

Table 6 shows the unit testing summary, there are 12 different unit tests meaning the researchers test the 12 components to ensure that each component is working properly, even a tiny detail of how it is being tested will be shown in the table. Ensuring each unit of the system is working properly is very necessary before proceeding with the next step which is integrating the units. The test results displayed in the table are the desired output for the functionality of each unit or component.

Integration Testing

The Integration testing stage is used to identify flaws that arise through the interaction of integrated parts or units [40]. The Integration testing is the 2nd stage of testing after ensuring that each unit is working or functioning properly.

Table 7: Integration Testing

Test ID	**Tests**	**Test Results**
IT_NLM	Night-Light Module	Lightens up when the sensor senses lackness of light in a certain area.
IT_DSM	Dispensing Servo Module	Servo turns automatically according to the schedule set, given by food distribution table
IT_DISM	Disposing Servo Module	The servo connected to a bowl rotates simultaneously causing food to be disposed of.
IT_CAM	Camera Module	Camera is functioning properly.

Table 7 shows the summary of the integration testing of each module. There are five different integration tests which are the night-light module, food dispensing module,

food disposal module, relay module and camera module. The test results displayed in the table are the expected results of the functionality of each module.

System Testing

Testing a system as a whole is known as system testing. The system's functionality is tested by integrating all of the modules and components to see if it performs as intended [41]. The system test is the third stage of testing after ensuring the integration of each module is working properly.

Table 8: System Testing

Test ID	Tests	Test Results
ST_MA	Mobile Application	Consists of all the buttons for hardware functionalities
ST_FB	Firebase	Able to send data from mobile application to hardware.
ST_TM	Timing Mechanism	Able to choose how many meal per day based on the given food distribution table
		Able to dispense food automatically on a fixed schedule.
ST_AN	Alert Notification	Able to receive notification when the amount of food is low.
ST_LC	Live Camera	The camera will show the live video to monitor the pet.
		Controllable using mobile application

Table 8 shows the summary of the system testing after the integration. There are six system tests that the researchers will do which are the mobile application, network, timing mechanism, alert notification, live camera and night light. The expected results show that all the systems are functioning properly as intended.

CHAPTER 4 DATA AND RESULTS

This chapter discusses the research the collected data and analyzed results from the experimentations done by the researchers. Relevant data analyses are made using visual, statistical, or numerical techniques to get relevant interpretations. Data related to the set metrics and KPIs are also shown in this chapter together with the adherence of the made system with the quality model presented in ISO/IEC 25010.

A. Experimental Results

This section will show the experiment results or the experiment that is generated by or on behalf of the person who experimented, it can be called an experimenter. The Pawsitive Care Dog Feeder is a device that is designed to automatically and manually dispense and dispose of food. It is programmed or coded using a software application such as Arduino IDE, MIT App Inventor and Firebase for saving the data. The dog owner can monitor the dog using the camera feature of the product. There is also a water container or pet water nozzle for the dog when it feels thirsty. The dog food container can contain a maximum of 3 kilograms of food. There is a circular progress in the mobile application where the user can check the current amount of food in the container. The dog owner will be able to feed the dog while being far away at home, it will lessen the uncomfortable feeling of not being able to feed the dog at the right time.

Food Dispensing and Disposal Schedule Test

The Pawsitive Care Dog Feeder has a feature for scheduling feeding and it is automatically and manually disposing and dispensing food. Timing Mechanism is one of the features of the product, the user will be able to choose a meal per day for their dog based on the recommended table. The actual schedule for 2x a day is 8:00 am to 8:00 pm, and for 3x a day is 7:00 am for the morning and 12:00 pm for lunch and 5:00 pm for dinner. The researchers also do several experiments of manually and automatically disposing and dispensing food.

Test ID Number	Time	Results
ADD2xv1	12:00 pm	The food is successfully automatically dispensed at the desired time.
	12:05 pm	The food is successfully automatically disposed of at the desired time.
	12:10 pm	The food is successfully automatically dispensed at the desired time
	12:15 pm	The food is successfully automatically disposed of at the desired time.

Table 9: Experiment of Automatic Dispensing and Disposing (2x a day) Version 1

Table 9 shows the experiment Test ID Number ADD2xv1 of automatically feeding and disposing of twice a day. The researchers choose a 5 minutes interval time for automatic dispensing and disposal. The researchers did 2 experiments for dispense and also for disposal. The results of the experiment show that all the time that is being tested is successfully disposed of and dispensed at the desired time.

Test ID Number	Time	Results
ADD2xv2	1:00 pm	The food is successfully automatically dispensed at the desired time.
	1:05 pm	The food is successfully automatically disposed of at the desired time.
	1:10 pm	The food is successfully automatically disposed of at the desired time.
	1:10 pm	The food is successfully automatically disposed of at the desired time.

Table 10: Experiment of Automatic Dispensing and Disposing (2x a day) Version 2

Table 10 shows the experiment Test ID Number ADD2xv2 of automatically feeding and disposing of twice a day. Same with Table 10, the researchers do 2 experiments with a 5 minutes interval for dispensing and disposing. The results of the experiment shows that all the time that is being tested is successfully disposed of and dispensed at the desired time.

Test ID Number	Time	Results
ADD3xv1	1:30 pm	The food is successfully automatically dispensed at the desired time.
	1:35 pm	The food is successfully automatically disposed of at the desired time.
	1:40 pm	The food is successfully automatically dispensed at the desired time.
	1:45 pm	The food is successfully automatically disposed of at the desired time.
	1:50 pm	The food is successfully automatically dispensed at the desired time.
	1:55 pm	The food is successfully automatically disposed of at the desired time.

Table 11: Experiment of Automatic Dispensing and Disposing (3x a day) Version 1

Table 11 shows the experiment Test ID Number ADD3xv1 of automatically feeding and disposing of thrice a day. The researchers do 3 experiments with a 5 minutes interval for food dispensing and disposal. The results of the experiment show that all the time that is being tested is successfully disposed of and dispensed at the desired time.

The automatic dispensing and disposing is one of the main features of the product but there is also a manual dispensing and disposing feature in the mobile application, where the user can click the button for manual dispensing and disposing. If the user wants a treat for the dog or if the user thinks that the amount of food being dispensed is not enough, there is a manual button

for dispensing. If the user thinks that the amount being dispensed is more than the dog needs, there is a manual button for the disposal. The automatic dispensing and disposal that is already inputted or set by the user will not be overwritten or changed if the user clicks the manual button for dispense and dispose of. Meaning the user does not need to worry if the automatic dispense and dispose of will be affected by the manual button for dispense and dispose of.

Manual Dispensing

Test ID Number	Time	Results
MDPEv1	2:00 pm	The food is successfully automatically dispensed at the desired time.
	2:05 pm	The food is successfully automatically disposed of at the desired time.

Table 12: Experiment of Manual Dispensing Version 1

Table 12 shows the experiment Test ID Number MDPEv1 of manual feeding. The researchers did 2 experiments for manual dispensing. The results show that all the time that is being tested is successfully dispensed.

Manual Disposing

Test ID Number	Time	Results
MDPOv1	2:10 pm	The food is successfully automatically dispensed at the desired time.
	2:15 pm	The food is successfully automatically disposed of at the desired time.

Table 13: Experiment of Manual Disposing Version 1

Table 13 shows the experiment Test ID Number MDPOv1 of manual feeding. The researchers did 2 experiments for manual disposing. The results show that all the time that is being tested is successfully disposed of.

Food Weight Accuracy Test

There is a dog feeding table that the group needs to follow and this table is already validated by a professional veterinarian or veterinary doctor. The table was also in the mobile application to make sure that the user of the application will be able to see the recommended table that the group provided. The group did an accuracy test experiment on the distributed food weight for every breed. This will help to know if the results of distributed food are accurate to the expected food weight based on the dog feeding table.

Toy Breeds

Test ID Number	Age	Expected Food Weight	Results
TBATv1	0-1	75 grams	81 grams
	1-10	225 grams	235 grams
	11 and above	175 grams	175 grams

Table 14: Accuracy Test Experiment for Toy Breeds Version 1

Table 14 shows experiment Test ID Number TBATv1 of the accuracy test experiment for toy breeds. It shows that the distribution results and expected food weight are somehow accurate, meaning there are times that the distribution is very accurate and sometimes slightly. There is only a 6-10 grams gap, and for the ages 11 and above the food distribution is very accurate to the recommended table.

Test ID Number	Age	Expected Food Weight	Results
TBATv2	0-1	75 grams	75 grams
	1-10	225 grams	232 grams
	11 and above	175 grams	175 grams

Table 15: Accuracy Test Experiment for Toy Breeds Version 2

Table 15 shows experiment Test ID Number TBATv2 of the accuracy test experiment for toy breeds. It shows that the distribution results and expected food weight are mostly accurate and 7 grams gap or difference for the ages 1-1.

Small Breeds

Test ID Number	Age	Expected Food Weight	Results
SMATv1	0-1	75 grams	80 grams
	1-10	300 grams	307 grams
	11 and above	225 grams	235 grams

Table 16: Accuracy Test Experiment for Small Breeds Version 1

Table 16 shows experiment Test ID Number SMATv1 of the accuracy test experiment for small breeds. There is only a 5-10 grams gap in food distribution with the expected output. The food distribution and expected food weight are not always the same but as long as there is a small gap it is still an acceptable result.

Test ID Number	Age	Expected Food Weight	Results
SMATv2	0-1	75 grams	84 grams
	1-10	300 grams	298 grams
	11 and above	225 grams	231 grams

Table 17: Accuracy Test Experiment for Small Breeds Version 2

Table 17 shows experiment Testing ID Number SMATv2 of the accuracy test experiment for small breeds. There is only a 2-9 grams gap in food distribution from the expected output.

Medium Breeds

Test ID Number	Age	Expected Food Weight	Results
MBATv1	0-1	300 grams	308 grams
	1-10	450 grams	455 grams
	11 and above	375 grams	375 grams

Table 18: Accuracy Test Experiment for Medium Breeds Version 1

Table 18 shows experiment Test ID Number MBATv1 of the accuracy test experiment for medium breeds. There is only a 5-8 grams gap in food distribution, and for the ages 11 and above the food distribution is very accurate to the recommended table.

Test ID Number	Age	Expected Food Weight	Results
MBATv2	0-1	300 grams	290 grams
	1-10	450 grams	460 grams
	11 and above	375 grams	375 grams

Table 19: Accuracy Test Experiment for Medium Breeds Version 2

Table 19 shows experiment Testing ID Number MBATv2 of the accuracy test experiment for medium breeds. There is only a 10 grams gap in food distribution, and for the ages 11 and above the food distribution is very accurate to the recommended table.

Large Breeds

Test ID Number	Age	Expected Food Weight	Results
LBATv1	0-1	450 grams	463 grams
	1-10	675 grams	638 grams
	11 and above	525 grams	521 grams

Table 20: Accuracy Test Experiment for Large Breeds Version 1

Table 20 shows experiment Test ID Number LBATv1 of the accuracy test experiment for large breeds. There are more than 10 grams of difference in food distribution. The gap is not that very big for the ages 0-1 and 11 and above but slightly big difference for the 1-10 years old.

Test ID Number	Age	Expected Food Weight	Results
LBATv2	0-1	450 grams	472 grams
	1-10	675 grams	633 grams

	11 and above	525 grams	514 grams

Table 21: Accuracy Test Experiment for Large Breeds Version 2

Table 21 shows experiment Test ID Number LBATv2 of the accuracy test experiment for large breeds. Same with the test no.13 results, there are more than 10 grams of difference in food distribution. The gap is not that very big for the ages 0-1 and 11 and above but a slightly big difference for the 1-10 years old.

Manually and Automatically Dispense Equivalency Test

The researchers did an equivalency experiment test of manually dispensed and automatically dispensed to prove that both were equally dispensed. There will be a mobile application to input the necessary information about the dog. The application will ask for the dog's name, breed, age, and meals to serve per day. When the user already inputs the dog's information, especially the dog breed, the prototype will automatically set a meal schedule and food weight based on the recommended table provided. There is a button in the dashboard if the user wants to manually feed the dog, and this feature will be based on the user's input that's why the manual and automatic dispense must have an equal dispense of food. The equivalency test will prove if both have equally dispensed and are slightly equal.

Toy Breeds

Test ID Numbe	Expected Food Weight	Manually Dispensed Results	Automatically Dispensed Results
TBMADEv1	75 grams	79 grams	77 grams
	225 grams	226 grams	230 grams
	175 grams	180 grams	1176 grams

Table 22: Equivalency Test for Toy Breeds Version 1

Table 22 shows the equivalency test of manually dispensed and automatically dispensed food for toy breeds. The results show that the amount of food being dispensed is almost equal. There is only a 4-6 grams difference between each other and both are almost equal to the expected output.

Small Breeds

Test ID Number	Expected Food Weight	Manually Dispensed Results	Automatically Dispensed Results
SBMADEv1	75 grams	78 grams	80 grams
	300 grams	295 grams	296 grams
	225 grams	228 grams	231 grams

Table 23: Equivalency Test for Small Breeds Version 1

Table 23 shows the equivalency test of manually dispensed and automatically dispensed food for small breeds. The results show a 2-3 grams difference between each other and both are almost equal to the expected output. Meaning the amount of food that is being manually and automatically dispensed is almost equal.

Medium Breeds

Test ID Number	Expected Food Weight	Manually Dispensed Results	Automatically Dispensed Results
MBMADEv1	300 grams	295 grams	301 grams
	450 grams	447 grams	452 grams
	375 grams	374 grams	375 grams

Table 24: Equivalency Test for Medium Breeds Version 1

Table 24 shows the equivalency test of manually dispensed and automatically dispensed food for medium breeds. Both automatically and manually dispensed results are almost the same, there is only a small difference like 1-6 grams.

Large Breeds

Test ID Number	Expected Food	Manually Dispensed	Automatically Dispensed
	Weight	Results	Results
LBMADEv1	450 grams	445 grams	453 grams
	675 grams	645 grams	650 grams
	525 grams	523 grams	520 grams

Table 25: Equivalency Test for Large Breeds Version 1

Table 25 shows the equivalency test of manually dispensed and automatically dispensed food for large breeds. The results are the same with the other experiment tests where the amount of food that is being dispensed automatically and manually is nearly equal. There is only a small amount of grams difference and both of them are also nearly equal to the expected food weight.

Reliability and Accuracy Test

The reliability and accuracy will show the similarity or closeness of the repeated measurements to each other. Measuring the reliability and accuracy needs consistent testing to improve the reliability since getting the same or similar results over and over again will give reliable results. Testing through repetition or more similar repeated testing is the more reliable the results.

Dog Breeds	**Age**	**Expected Output**	**Trials**				
			1st	**2nd**	**3rd**	**4th**	**5th**
Toy	0-1	75g	75g	71g	74g	73g	71g
Small	0-1	75g	73	78g	69g	72g	69g
Medium	0-1	300g	300g	297g	283g	289g	301g
Large	0-1	450g	445g	459g	427g	438g	424g
Toy	1-10	225g	228g	230g	265g	224g	214g
Small	1-10	300g	297g	304g	286g	302g	294g
Medium	1-10	450g	441g	462g	437g	418g	426g
Large	1-10	525g	530g	516g	530g	510g	531g
Total:		2,400g	2,389 g	2,417g	2,371g	2,326g	2,330g

Table 26 : Reliability and Accuracy Experiment

The table 26 shows the reliability and accuracy test, the researchers repeatedly test every breed with a specific age to get reliable results. The expected output will be the base of

every trial, and the results of the trials must be close to the expected output to be considered accurate. In the reliability test, the researchers did a repetition of trials or testing to make sure that the data results will be reliable since one trial cannot be considered a reliable result and it must be 2 or more than 2 trials. The researchers did 4 similar trials of food dispensing to check if the total output is close to each other. The trial result for every breed shows that there is no big difference to each other and the results are almost the same as the expected output. The results show that all the total results are close or almost similar to each other, meaning there is only a small amount of difference. The total results of every trial show that it is close to the expected total output which is 2,400 grams. The most important thing is that all of the trial results are almost similar to the expected output.

B. System Quality Assessment

This part of the paper shows the process of evaluating the quality and performance of the software and hardware system of the product. The group created an evaluation survey form to get data from the respondents. The respondents of the evaluation survey are the future users of the software and hardware system which are the pet owners. The evaluation survey form that the group created is based on the model of ISO/IEC 25010 which comprises the eight quality characteristics. The group chose four suitable metrics or characteristics that can be seen in the system which are the features of the system, functionality sustainability, usability and missing features of the system.

Features of the System

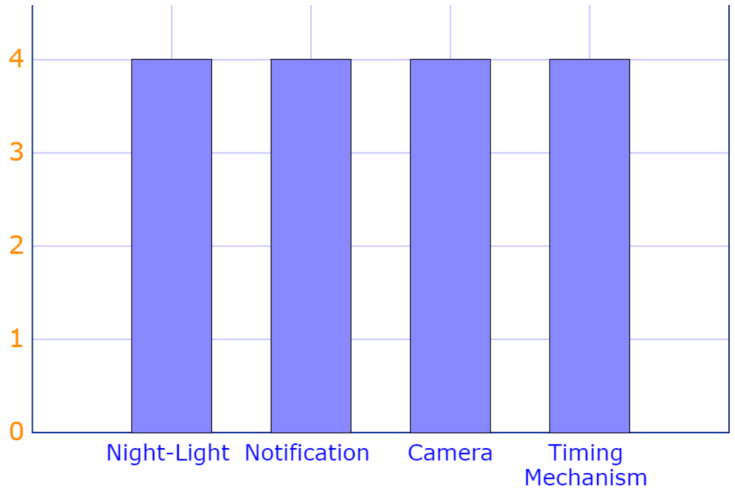

Fig. 23: Features of the System

The figure 33 shows the graphical representation of the answers of the respondents about the features of the system of the Pawsitive Care Dog Feeder. There were five dog owners/pet owners that answered the evaluation survey form that the group provided. All of them answered or rated the product with the number 4 or I expect it with all the features of the system. The Pawsitive Care Dog Feeder successfully disposed and dispensed food automatically and manually for the dog. The live camera successfully sees or monitors the dog while eating, and the night-light feature automatically lightens up when it senses darkness.

Functionality Sustainability

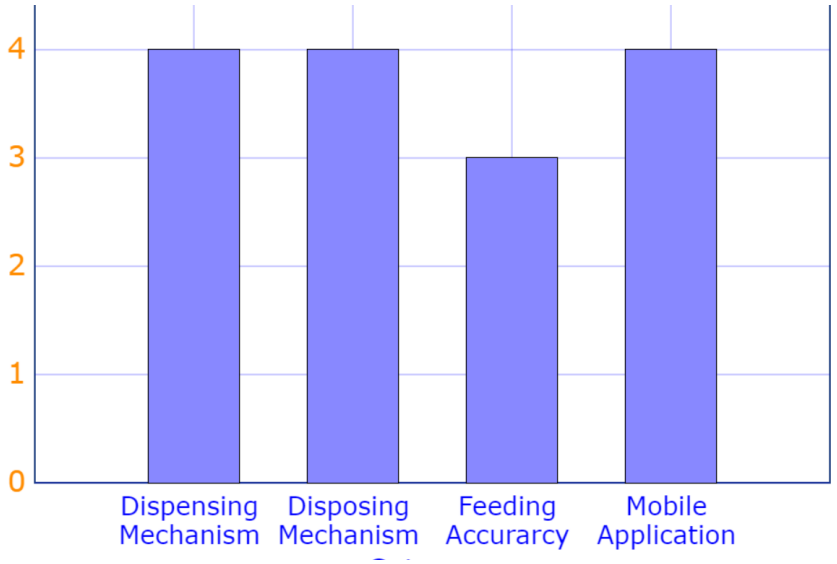

Fig. 24: Functionality Sustainability

The figure 34 shows the graphical representation of the answers of the respondents about the functionality sustainability of the Pawsitive Care Dog Feeder. All of the users or pet owners answered number 4 or strongly agree with all of the characteristics or features of the product except for one. The Pawsitive Care Dog Feeder successfully fed and disposed of the food at the exact time. The product can store a typical amount of food in the container and shows the remaining food level inside of it. The Pawsitive Care Dog Feeder User Interface is a user-friendly application. The only feature that the users rate 3 or agree with is the product has accurately fed the dog based on the recommended feeding table since sometimes it does not accurately dispense the desired amount of food.

Usability

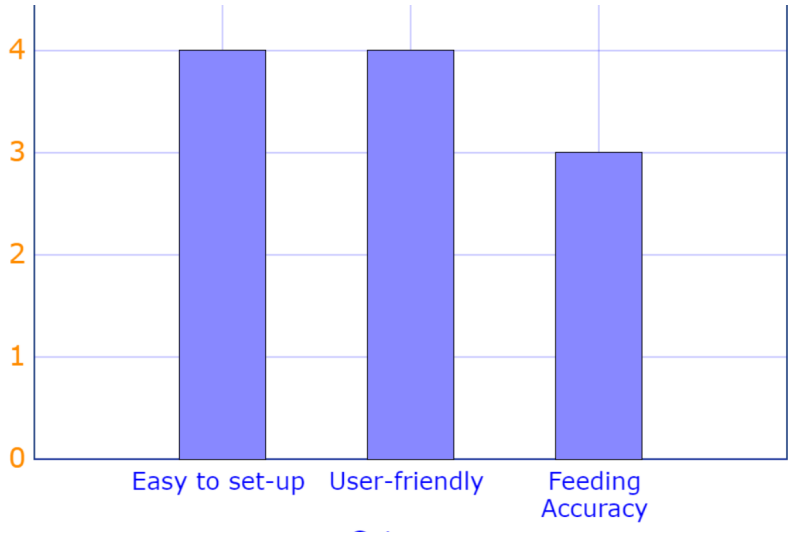

Fig. 25: Usability

The figure 35 shows the graphical representation of answers of the respondents about the usability of the Pawsitive Care Dog Feeder. The pet owners or users answered or rate number 4 or strongly agree with all the characteristics of the usability of the product. The Pawsitive Care Dog Feeder is easy to set-up, and the mobile application is easy to use since it is user-friendly. In terms of feeding accuracy, the pet owners answered 3 or agree since sometimes the product does not dispense the food with the desired amount of food.

Missing Features of the System

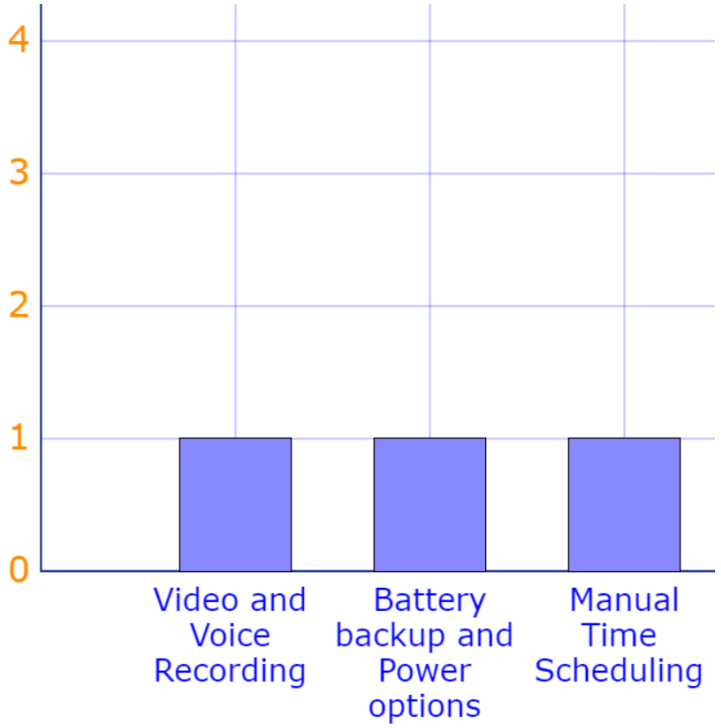

Fig. 26: Missing Features of the System

The figure 36 shows the graphical representation of answers of the respondents about the missing of the system of the Pawsitive Care Dog Feeder. All of the users or the pet owners answered it number 1 which strongly disagreed with all the characteristics of missing features of the product. There is a camera in the product but there are no video and voice recording and playback features. The Pawsitive Care Dog Feeder is wall outlet powered so there are no battery backup and power options for it. There is no feature of manually setting the timer or schedule of food dispensing since it is already automatically set meal per day.

C. Functional Testing Results

This section includes a summary of the unit test findings to determine whether the components to be used are functional without any sort of defects or errors. Researchers can use functional testing to detect faults, inconsistencies, or inaccuracies in the system's intended behavior.

Table 27: UNIT TEST SUMMARY RESULTS TABLE

Unit Tests	**Results**
ESP8266 Unit Test v1	The ESP8266 starts once power is applied. The program or code uploaded without any errors and it functions properly.
Servo Motors Unit Test v1	The servo motors start once the power is applied. The servo motor sample code was uploaded successfully without error.
Load Cell Unit Test v1	Load Cell can measure the weight accurately. The load cell sample code was uploaded successfully without error.
ESP32 CAM Unit Test v1	The ESP32 cam starts once the power is applied. The ESP32 cam sample code was uploaded successfully without error.
Photoresistor Unit Test v1	The photoresistor sample code was uploaded successfully without error. Able to detect light and dark.
Power Supply Unit Test v1	The power supply was able to deliver power with 12 volts.
Relay Unit Test v1	The relay was able to measure the correct value of the resistance.
Step-Down Module Unit Test v1	The step-down module was able to convert and regulate voltage.
LED Strips Unit Test v1	The LED strip was turned ON once power source applied.

Table 28: INTEGRATION TEST SUMMARY RESULTS TABLE

Integration Tests	Results
Night-Light Module v1	The Night-Light Module started once the power applied. The Night-Light module sample code was not uploaded successfully and there is an error. The Night-Light Module didn’t work properly.
Night-Light Module v2	The Night-Light Module started once the power applied. The Night-Light Module sample code was uploaded successfully without error. The Night-Light Module works properly and is able to sense light and dark.
Dispensing Servo Module v1	The Dispensing Servo Module started once the power applied. The Dispensing Servo Module sample code was not uploaded successfully and there is an error. The Dispensing Servo Module didn’t work properly.
Dispensing Servo Module v2	The Dispensing Servo Module started once the power applied. The Dispensing Servo Module sample code was not uploaded successfully and there is an error. The Dispensing Servo Module didn’t work properly.
Dispensing Servo Module v3	The Dispensing Servo Module started once the power applied. The Dispensing Servo Module sample code was uploaded successfully without error. The Dispensing Servo Module didn’t work properly.
Dispensing Servo Module v4	The Dispensing Servo Module started once the power applied. The Dispensing Servo Module sample code was uploaded successfully without error. The Dispensing Servo Module works properly according to the given scheduled time. Also works for manual feeding.

Disposing Servo Module v1	The Disposing Servo Module started once the power applied. The Disposing Servo Module sample code was not uploaded successfully and there is an error. The Disposing Servo Module didn't work properly.
Disposing Servo Module v2	The Dispensing Servo Module started once the power applied. The Disposing Servo Module sample code was uploaded successfully without error. The Disposing Servo Module works properly according to the given scheduled time. Also works for manual disposal.
Camera Module v1	The Camera Module started once the power applied. The Camera Module sample code was not uploaded successfully and there is an error. The Camera Module didn't work properly.
Camera Module v2	The Camera Module started once the power applied. The Camera Module sample code was uploaded successfully without error. The Camera Module didn't work properly.
Camera Module v3	The Camera Module started once the power applied. The Camera Module sample code was uploaded successfully without error. The Camera is accessible through the mobile application and works real-time.

Table 29: SYSTEM TEST SUMMARY RESULTS TABLE

System Test	Results
Mobile Application v1	The Mobile Application buttons work as expected. The Mobile Application functionality buttons cannot send data to firebase. The Mobile Application able to save data set by the user
Mobile Application v2	The Mobile Application buttons work as expected. The Mobile Application functionality buttons are able to send data to firebase and then hardware. The Mobile Application able to save data set by the user
Firebase v1	The functionality buttons are able to send data to firebase and then hardware. The app was able to save data set by the user.
Timing Mechanism v1	The module for dispensing and disposing food is able to dispense and dispose of food on the scheduled time. The timing for servo rotation was not giving the recommended amount of food based on the table.
Time Mechanism v2	The module for dispensing and disposing food is able to dispense and dispose of food on the scheduled time. The Time Mechanism was enough to dispense an exact amount of food.
Alert Notification v1	The Load Cell was not able to measure the amount of food inside the container. The alert notification was not able to notify if food level is at 1kg or 33%. The notification for automatic dispensing and disposing was able to notify once the prototype successfully dispensed and disposed of food.
Alert Notification v2	The Load Cell was not able to measure the amount of food inside the container. The alert notification was able to notify if

	food level is at 1kg or 33%. The notification for automatic dispensing and disposing was able to notify once the prototype successfully dispensed and disposed of food.
Alert Notification v3	The Load Cell was able to measure the amount of food inside the container. The alert notification was able to notify if food level is at 1kg or 33%. The notification for automatic dispensing and disposing was able to notify once the prototype successfully dispensed and disposed of food
Live Camera v1	The camera was able to be accessed through a mobile application.

CHAPTER 5 CONCLUSION AND RECOMMENDATIONS

This chapter discusses the imperatives of the analyzed data from the previous chapter. For the concluding statements, the researchers should detail the contributions of this work along with the justifications to the objectives, hypotheses, and its alignment to the needs statement of the potential users. Furthermore, the researchers can also discuss the further implications of the study, its sustainability, and its possible developments.

A. Contributions

There are several automatic pet feeders existing in the market as of now, they do all have one in common as a feature, automatic and manual feeding. The created system and prototype has the same features as well, but all information about the serving of food for dogs were all verified by an actual vet doctor; and that's what makes it unique and reliable. Its automatic and manual feeding feature both have a notification system in which it pops up messages when the prototype dispenses and disposes food manually and automatically. The prototype also has a load cell in it to measure the weight of food inside the container, it also notifies the user through mobile application if the food level reaches its critical low level (1kg or 33%). It also has a night-light module made out from LED lights and a photoresistor which automatically turns on light when the sensor detects lackness of light in a certain area. The camera installed can be accessed through mobile application, and shows live view of the bowl and its surroundings. The pet water nozzle already exists in the market and was also included in the prototype for water dogs' water consumption.

B. Conclusion

One of the main objectives of developing the prototype is to apply the concepts of Embedded Systems and Computer Automation to create a system capable of feeding pet dogs with less effort. It is specifically addressed through the manual and automatic feeding feature of the prototype. With just a press of buttons, the user can ensure the food consumption of his/her pet dog is still being followed and attended to. The next objective is to design and integrate a mobile application for monitoring and notification system; it is addressed through the use of a load cell, the user can be able to know the level of food inside the container through the mobile app, it also sends notification whenever it reaches a certain low level. It also sends notifications for automatic dispensing feature, it shows the time stamp and a short message saying that it already dispenses food. Moreover, it also comes up with a camera for

monitoring purposes, and also accessible through the mobile application. Lastly, add unique features such as night-light module and food disposal. The researchers added a feature to the prototype using LED lights and a photoresistor, being connected together and with the right code and calibration, it adds up a feature which automatically turns on lights whenever the amount of light is lacking. They also connected a servo to the bowl itself for food disposal, with just a push of a button through the mobile application, the system will dispose of the food and will be stored in a drawer-like container specifically designated for storage of disposed food.

C. Recommendations

This particular section is for future researchers that would like to pursue developing the same or similar prototype like the one discussed in this case study. Embarking through this study requires consideration of different aspects and constraints that are related to the welfare of animals especially for dogs. If this technology will be developed for future research, the researchers recommend creating a system suited for both dogs and cats. Water sanitation could also work considering food and water contamination are most likely to happen most of the time. Water level monitoring and automatic dispense could also be added up since automation can increase the efficiency of mostly everything. Adding up a vibration motor can smoothen up the dispensing of food from the container to the bowl, it is also recommended to be added with of course considering the noise it might cause everytime it functions. For the surveillance feature, cameras that could capture a wide range of view could be used for better monitoring, or 360 degrees rotatable camera if possible. Additionally, in creating this type of surveillance camera using an ESP32 cam, make sure to use the right libraries, such as FirebaseESP32.h for interacting with Firebase, WIFI.h for wifi connectivity, and base64.h, which is used to convert captured photos into base64 format. Furthermore, future researchers may use AI cameras and computer vision to detect and identify dog breeds. Future researchers may use various types of camera, such as Raspberry Pi camera for higher image or video quality or USB webcam for affordable yet high-quality resolution. For the mobile application that shows the amount of dog food inside the container, the circular progress must limit to only 100 percent or 3 kilograms.

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APPENDIX A

Additional Images and Discussions

APPENDIX B

Project Development Plan

WBS NO.	Task Name	Status	Assigned to	Start Date	End Date	Duration in Day	Comments
1	**Document Revision**						
1.1	Chapter 1	In Progress	All	Apr-15	May-20	35	
1.2	Chapter 2	In Progress	All	Apr-15	May-20	35	
1.3	Chapter 3	In Progress	All	Apr-15	May-20	35	
1.4	Chapter 4	In Progress	All	Apr-25	May-31	36	
1.5	Chapter 5	In Progress	All	Apr-25	May-31	36	
2	**Project Planning**						
2.1	Component Selection	Complete	All	Feb-01	Feb-04	3	
2.2	Price Checking	Complete	All	Feb-15	Feb-16	1	
2.3	Budgeting	Complete	All	Feb-18	Feb-20	2	
3	**Project Execution / Testing**						
3.1	Software Design						
3.1.1	Mit App	Complete	Jaycion Ray H. Manicio	Mar-10	May-14	65	
3.1.2	Firebase	Complete	Jaycion Ray H. Manicio	Mar-15	May-16	62	
3.2	Hardware						
3.2.1	ESP-32 Cam	Complete	Christian Dave C. Codilla	Mar-05	May-27	83	
3.2.2	Loadcell	Complete	Sunny A. Dy	Mar-05	May-15	71	
3.2.3	Photoresistor	Complete	Sunny A. Dy	Mar-05	Apr-10	36	
3.2.4	Servo 360	Complete	Christian S. Manong	Mar-05	May-18	74	
4	**Features**						
4.1	Mobile Application	Complete	Jaycion / Sunny	May-04	May-14	10	
4.2	Live Camera	Complete	Christian Dave C. Codilla	May-17	May-27	10	
4.3	Notification	Complete	Sunny / Jaycion	May-05	May-15	10	
4.4	Night-Light	Complete	Sunny A. Dy	Apr-01	Apr-10	10	
4.5	Dispense and Dispose						
4.5.1	Automatic	Complete	Christian S. Manong	May-08	May-18	10	
4.5.2	Manual	Complete	Christian S. Manong	May-08	May-18	10	
5	**Project Performance**						
5.1	Project Objectives	Complete	All	May-15	May-25	10	
5.2	Document	Complete	All	May-20	Jun-18	29	
5.3	Cost Tracking	Complete	All	May-20	May-30	10	
5.4	Overall Project Performance	Complete	All	May-20	May-30	10	

APPENDIX C

Survey Forms Used

Section 1 of 5

Research Idea Survey: Automatic Pet Feeder

CONSENT FORM

In compliance to RA 10173 or the Data Protection Act of 2012 (DPA of 2012) and its Implementing Rules and Regulations, we are detailing here the processing of the data you will provide to us.

Purpose: This is to gather data about the experiences of at least 100 fur parents or pet owners who have dogs or cats in their household, as our requirement in the course CPE Practice and Design 1 LAB of this school year, 2022-2023.

Personal Data. The following are the personal data that we may need to collect:
a) Full Name
b) Email
c) GCash Number

Storage, retention, disposal. Personal data collected shall be stored in Adamson University's google drive for a period of until May 21, 2023 (end of semestral period). Upon expiration of such period, all personal data shall be disposed of in a secure manner that will forbid further processing, unauthorized disclosure and editing.

Data Protection. The University shall implement reasonable and appropriate organizational, physical, and technical security measures to protect your personal data. Only the student researchers shall have access to the data collected and processed.

Data Subject Rights. Under RA 10173, the following are some of the rights the data subject may exercise, (for the full list of rights see https://www.privacy.gov.ph/know-your-rights/):

1. Right to be informed on the collection and processing of personal data through this consent form;
2. Right to object on the processing of personal data or to restrict the processing of personal data upon request;
3. Right to access the personal data collected and processed upon request;
4. Right to request for rectification of personal data; and
5. Right to withdraw his or her consent.

To exercise data subjects right and for data privacy concerns or inquiries, please communicate with us through:
christian.dave.codilla@adamson.edu.ph
christian.manong@adamson.edu.ph
jaycion.ray.manicio@adamson.edu.ph
sunny.dy@adamson.edu.ph

Permission to collect and process personal data

☐ Yes, I give consent to the collection and processing of my personal data for the said purpose.

Permission to store personal data

☐ Yes, I give consent to the retention of my personal data.

Permission to use my personal data

☐ Yes, I give consent to use of my personal data for the said purpose

Section 2 of 5

Personal Information

Description (optional)

Full Name (FirstName MI. LastName)

Short answer text

Email *

Short answer text

GCash No.

Get a chance to win ₱200

Short answer text

Section 3 of 5

Survey Questions

Description (optional)

Do you have pet/s in your household? *

- Yes
- No

What type of pet/s you currently have? *

- Dog
- Cat
- Both
- Other...

How many pet do you have? *

Short answer text

Do you consider yourself a fur parent? *

- Yes
- No

How many times a day would you need to feed your pet/s? *

- ◯ 2 times a day
- ◯ 3 times a day
- ◯ More than 3 times a day

Do you ever accidentally forget to feed your pet/s? *

- ◯ All the time
- ◯ Sometimes
- ◯ Rarely
- ◯ Never

When you travel, do you take your pet/s with you? *

- ◯ Yes
- ◯ Sometimes
- ◯ No

How often do you leave your pet/s at home alone? *

- ◯ All the time
- ◯ Sometimes
- ◯ Rarely
- ◯ Never

How long do you leave your pet/s at home alone? *

- ◯ 1 - 2 hours
- ◯ 3 - 7 hours
- ◯ 8 - 12 hours
- ◯ 13 hours and above

How long do you leave your pet/s at home alone? *

- ◯ 1 - 2 hours
- ◯ 3 - 7 hours
- ◯ 8 - 12 hours
- ◯ 13 hours and above
- ◯ Other...

What are the reason/s you left your pet/s alone in your house? *

- ◯ Work
- ◯ Travel
- ◯ School

Have you heard of smart/automatic pet feeders? *

- ◯ Yes
- ◯ No

Do you own a smart/automatic pet feeder? *

- ◯ Yes
- ◯ No

Would you use a smart/automatic pet feeder? *

- ◯ Yes
- ◯ No

Section 4 of 5

Functional Features

In this section, the group aims to enumerate the features that fur parents or pet owners may think are essential or not about the product the group seeks to create.

The group aims to create a smart/automatic pet feeder with an application. The project aims to help fur parents or pet owners not to worry about leaving their pets at home alone. The application will help you talk to and monitor your pets while you are away from home.

Do you think receiving a notification about the level of food and water via an app is essential? *

- ◯ Yes
- ◯ No

Would you like a smart/automatic pet feeder with a camera so you can monitor pet/s via the app? *

- ◯ Yes
- ◯ No

Do you think it's essential to have a automatic opening/closing lid mechanism for food and water bowl? *

- ◯ Yes
- ◯ No

Do you think it's essential to have a feature that will allow the owner to record your voice for a message to remind your pet/s that it's time to eat? *

- ◯ Yes
- ◯ No

Would you like a smart/automatic pet feeder with a built-in speaker and microphone that will allow you to call and talk to your pet/s through your phone? *

- ◯ Yes
- ◯ No

Do you think it's essential to have a feature that will allow the owner to record your voice for a message to remind your pet/s that it's time to eat? *

- ◯ Yes
- ◯ No

Would you like a smart/automatic pet feeder with a built-in speaker and microphone that will allow you to call and talk to your pet/s through your phone? *

- ◯ Yes
- ◯ No

Do you think having a water container feature is also essential in the smart/automatic pet feeder? *

- ◯ Yes
- ◯ No

Do you think it would be an important feature for a smart/automatic pet feeder to have a light sensor that automatically turns on the light when it senses darkness? *

- ◯ Yes
- ◯ No

How would you like the smart/automatic pet feeder to be powered? *

- ◯ Battery powered
- ◯ Wall outlet powered
- ◯ Both

Is there functionality, feature, and material you would like to see on the smart/automatic pet feeder that's not available?

Short answer text

Evaluation Form

The automatic dog pet feeder has an application that will help owners monitor their dogs while away from home. The product has a mobile application where the user needs to input the dog's information and then choose or set a meal for the dog. It also has a manual button for food disposal and dispensing and also a live camera to monitor or see the dog. It also has a pop-up notification when the container reaches a 3 kilogram and a notification when the dog food is being manually and automatically disposed of and dispensed. This will solve the problem for pet owners when leaving their dogs at home alone.

Please answer the following questions by rating them from 1 to 4

4 - I expect it

3 - I like it

2 - I don't like it

1 - I don't expect it

Features of the System

I like it when the night light feature automatically lights up when it senses darkness.

1 2 3 4

I like it when the mobile application alerts me with a pop-up notification when the dog food reaches 1 kilogram in the container and also a notification when the dog food is manually and automatically disposed of and dispensed.

1 2 3 4

I like it when the camera helps me to monitor or see my dog.

1 2 3 4

I like it when the bowl automatically disposes of the dog food after 15 minutes of eating the meal.

1 2 3 4

The following statement describes the Pawsitive Care Dog Feeder. Indicate your agreement or disagreement by encircling the appropriate number that corresponds to your answers:

Please answer the following questions by rating them from 1 to 4

4 - Strongly Agree

3 - Agree

2 - Disagree

1 - Strongly Disagree

Functionality Sustainability

The Dispensing Mechanism of the Pawsitive Care Dog Feeder successfully fed the dog at the exact time.

1 2 3 4

The Disposing Mechanism of Pawsitive Care Dog Feeder successfully disposed of the dog food at the exact time.

1 2 3 4

The Meal Programming of Pawsitive Care Dog Feeder fed the dog an accurate amount of dog food based on the recommended feeding table

1 2 3 4

The Pawsitive Care Dog Feeder can store a typical amount of dog food in storage or a container

1 2 3 4

The Pawsitive Care Dog Feeder User Interface is a user-friendly mobile application that allows you to easily input the dog information, set the meal-per-day, check the remaining food level and monitor your dog

1 2 3 4

Usability

The Pawsitive Care Dog Feeder is easy to set-up

1 2 3 4

The Mobile Application of Pawsitive Care Dog Feeder is user-friendly or easy to use

1 2 3 4

In terms of Feeding Accuracy, the Pawsitive Care Dog Feeder dispenses the desired amount of dog food

1 2 3 4

Missing Features of the System

There is a Video and Voice Recording and Playback in the mobile application of the automatic dog feeder

1 2 3 4

There are Battery backup and Power options for the automatic pet feeder

1 2 3 4

The Mobile Application has a feature for setting the timer or schedule of food dispensing

1 2 3 4

APPENDIX D

Test Forms Used

TABLE 30 RESULTS OF UNIT TESTING OF ESP8266 V1

Test Writer:						
Test Case Name:	ESP8266 Unit Test		**Test ID # :**	UT_ESPv1		
Description:	Unit test to know if the ESP8266 is working properly		**Type:**	☐ white box ☐ black box		
Tester Information						
Name of Tester:	Jaycion Ray H. Manicio		**Date:**	March 05, 2023		
Hardware Version:	PC ESPv1 Hardware		**Time :**	3:00 PM		
Setup :	The ESP8266 is connected to the power source.					
Step	**Action**	**Expected Result**	**Pass**	**Fail**	**N/A**	**Comments**
1	Power Test	The component will start once the power is being applied.	✓			There is no problem regarding the power test.
2	Uploading Test	The program or code will be uploaded without any error and will function properly.	✓			The code is successfully uploaded.
Overall Test Result: Pass						

TABLE 31 RESULTS OF UNIT TESTING OF SERVO MOTORS V1

Test Writer:						
Test Case Name:	Servo Motors Unit Test		**Test ID # :**	UT_SMv1		
Description:	Unit test to know if the servo motors are working properly		**Type:**	☐ white box ☐ black box		
Tester Information						
Name of Tester:	Christian Dave C. Codilla		**Date:**	March 05, 2023		
Hardware Version:	PC SMv1 Hardware		**Time :**	4:30 PM		
Setup :	The servo motor is connected to the power source.					
Step	**Action**	**Expected Result**	**Pass**	**Fail**	**N/A**	**Comments**
1	Power Test	The component will start once the power is being applied.	✓			There is no problem regarding the power test.
2	Uploading Test	The program or code will be uploaded without any error and will function properly.	✓			The code is successfully uploaded. The servo is successfully working.
Overall Test Result: Pass						

TABLE 32 RESULTS OF UNIT TESTING OF LOAD CELL V1

Test Writer:						
Test Case Name:	load Cell and Decoder Unit Test		**Test ID # :**	UT_LCv1		
Description:	Unit test to know if the load cell and decoder are working properly		**Type:**	☐ white box ☐ black box		
Tester Information						
Name of Tester:	Jaycion Ray H. Manicio		**Date:**	March 05, 2023		
Hardware Version:	PC LCv1 Hardware		**Time :**	3:30 PM		
Setup :	The load cell will be tested using the multimeter.					
Step	**Action**	**Expected Result**	**Pass**	**Fail**	**N/A**	**Comments**
1	Accuracy Test	Can measure the weight accurately.	✓			The load cell is working properly.
2	Uploading Test	The program or code will be uploaded without any error and will function properly.	✓			There is no problem with the uploading test.
Overall Test Result: Pass						

TABLE 33 RESULTS OF UNIT TESTING OF ESP32 CAM V1

Test Writer:						
Test Case Name:	ESP32 CAM Unit Test		**Test ID # :**	UT_ESP32CAMv1		
Description:	Unit test to know if the servo motors are working properly		**Type:**	☐ white box ☐ black box		
Tester Information						
Name of Tester:	Christian Dave C. Codilla		**Date:**	March 05, 2023		
Hardware Version:	PC _ESP32CAMv1 Hardware		**Time :**	4:50 PM		
Setup :	The ESP32 CAM is connected to the power source.					
Step	**Action**	**Expected Result**	**Pass**	**Fail**	**N/A**	**Comments**
1	Power Test	The component will start once the power is being applied.	✓			The ESP Cam is working properly when the power supply is applied.
2	Uploading Test	The program or code will be uploaded without any error and will function properly.	✓			The code is successfully uploaded.
Overall Test Result: Pass						

TABLE 34 RESULTS OF UNIT TESTING OF PHOTORESISTOR V1

Test Writer:						
Test Case Name:	Photoresistor Unit Test		**Test ID # :**	UT_PRv1		
Description:	Unit test to know if the photoresistor is working properly		**Type:**	☐ white box ☐ black box		
Tester Information						
Name of Tester:	Christian Dave C. Codilla		**Date:**	March 05, 2023		
Hardware Version:	PC _PRv1 Hardware		**Time :**	6:00 PM		
Setup :	The photoresistor is connected to the power source.					
Step	**Action**	**Expected Result**	**Pass**	**Fail**	**N/A**	**Comments**
1	Uploading Test	The program or code will be uploaded without any error and will function properly.	✓			There is no problem with the code that is being uploaded.
2	Wirings and Connections	Able to detect light and dark.	✓			There is no problem with connection.
Overall Test Result: Pass						

TABLE 35 RESULTS OF UNIT TESTING OF POWER SUPPLY V1

Test Writer:						
Test Case Name:	Power Supply			**Test ID # :**	UT_PSv1	
Description:	Unit test to know if the power supply is working properly.			**Type:**	☐ white box ☐ black box	
Tester Information						
Name of Tester:	Jaycion Ray H. Manicio			**Date:**	March 06, 2023	
Hardware Version:	PC_Sv1 Hardware			**Time :**	1:30 PM	
Setup :	The power supply will be test using the multimeter					
Step	**Action**	**Expected Result**	**Pass**	**Fail**	**N/A**	**Comments**
1	Voltage Test	The voltage value or output in the power supply is 12v.	✓			The voltage value of the power supply is correct.
Overall Test Result: Pass						

TABLE 36 RESULTS OF UNIT TESTING OF RELAY V1

Test Writer:						
Test Case Name:	Relay Unit Test			**Test ID # :**	UT_Rv1	
Description:	Unit test to know if the relay is working properly and has the correct value of the resistance.			**Type:**	☐ white box ☐ black box	
Tester Information						
Name of Tester:	Jaycion Ray H. Manicio			**Date:**	March 06, 2023	
Hardware Version:	PC Rv1 Hardware			**Time :**	1:50 PM	
Setup :	The relay will be tested using the multimeter.					
Step	**Action**	**Expected Result**	**Pass**	**Fail**	**N/A**	**Comments**
1	Resistance Value Test	The expected output or resistance value will be measured.	✓			The expected output or value is measured correctly.
Overall Test Result: Pass						

TABLE 37 RESULTS OF UNIT TESTING OF USB STEP-DOWN MODULE V1

Test Writer:						
Test Case Name:	Step-down Module Unit Test			**Test ID # :**	UT_SDMv1	
Description:	Unit test to know if the Step-down Module is working properly			**Type:**	☐ white box ☐ black box	
Tester Information						
Name of Tester:	Jaycion Ray H. Manicio			**Date:**	March 06, 2023	
Hardware Version:	PC SDMv1 Hardware			**Time :**	2:30 PM	
Setup :	The step-down module will be tested using a multimeter.					
Step	**Action**	**Expected Result**	**Pass**	**Fail**	**N/A**	**Comments**
1	Power Test	The component will be able to convert or regulate voltage.	✓			
Overall Test Result: Pass						

TABLE 38 RESULTS OF UNIT TESTING OF LED STRIPS/LIGHTS V1

Test Writer:						
Test Case Name:	Step-down Module Unit Test			**Test ID # :**	UT_LEDv1	
Description:	Unit test to know if the LED Lights are working.			**Type:**	☐ white box ☐ black box	
Tester Information						
Name of Tester:	Jaycion Ray H. Manicio			**Date:**	March 06, 2023	
Hardware Version:	PC LEDv1 Hardware			**Time :**	3:00 PM	
Setup :	The LED Lights will be tested by connecting it to a power source					
Step	**Action**	**Expected Result**	**Pass**	**Fail**	**N/A**	**Comments**
1	Power Test	The component lightens up when connected to a power source.	✓			The LED strips are working properly.
Overall Test Result: Pass						

TABLE 39 RESULTS OF INTEGRATION TESTING OF NIGHT-LIGHT MODULE V1

Test Writer:			
Test Case Name:	Night-Light Module Integration Testing	**Test ID # :**	IT_NLMv1
Description:	Integration test if the combination of photoresistor and LED Lights can work as night-light.	**Type:**	☐ white box ☐ black box
Tester Information			
Name of Tester:	Sunny A. Dy	**Date:**	April 10, 2023
Hardware Version:	PC NLMv1 Hardware	**Time :**	4:00 PM
Setup :	The Night-Light module is connected to a power source with specific codes inputted.		

Step	Action	Expected Result	Pass	Fail	N/A	Comments
1	Power Test	The module will start once the power is being applied.	✓			
2	Uploading Test	The program or code will be uploaded without any error and will function properly.		✓		There is an error within the code.
3	Functionality Test	The LED Lights will automatically turn on if photoresistor senses lackness of light; and vice versa		✓		The LED lights didn't work due to wiring problems.
Overall Test Result: Fail						

TABLE 40 RESULTS OF INTEGRATION TESTING OF NIGHT-LIGHT MODULE V2

Test Writer:			
Test Case Name:	Night-Light Module Integration Testing	**Test ID # :**	IT_NLMv2
Description:	Integration test if the combination of photoresistor and LED Lights can work as night-light.	**Type:**	☐ white box ☐ black box
Tester Information			
Name of Tester:	Sunny A. Dy	**Date:**	April 10, 2023
Hardware Version:	PC NLMv2 Hardware	**Time :**	4:10 PM
Setup :	The Night-Light module is connected to a power source with specific codes inputted.		

Step	Action	Expected Result	Pass	Fail	N/A	Comments
1	Power Test	The module will start once the power is being applied.	✓			
2	Uploading Test	The program or code will be uploaded without any error and will function properly.	✓			
3	Functionality Test	The LED Lights will automatically turn on if photoresistor senses lackness of light; and vice versa	✓			The LED Lights turn on automatically if the module senses lackness of light, and turns off if it senses a great amount of light.

Overall Test Result: Pass

TABLE 41 RESULTS OF INTEGRATION TESTING OF DISPENSING SERVO MODULE V1

Test Writer:						
Test Case Name:	Dispensing Servo Module Integration Testing		**Test ID # :**	IT_DSMv1		
Description:	Integration test if the servo functions based on the manual and automatic feeding.		**Type:**	☐ white box ☐ black box		
Tester Information						
Name of Tester:	Christian S. Manong		**Date:**	April 12, 2023		
Hardware Version:	PC DSMv1 Hardware		**Time :**	11:00 AM		
Setup :	The Dispensing Servo Module is connected to a power source and will be tested for checking if it follows the fixed time for food dispensing.					
Step	**Action**	**Expected Result**	**Pass**	**Fail**	**N/A**	**Comments**
1	Power Test	The module will start once the power is being applied.	✓			
2	Uploading Test	The program or code will be uploaded without any error and will function properly.		✓		An error occurred when running the code.
3	Functionality Test	The DS Module will function according to the given table for food distribution.		✓		The DS module didn't work due to connectivity problems between the firebase. Also, there is a problem in the code.
Overall Test Result: Fail						

TABLE 42 RESULTS OF INTEGRATION TESTING OF DISPENSING SERVO MODULE V2

Test Writer:			
Test Case Name:	Dispensing Servo Module Integration Testing	**Test ID # :**	IT_DSMv2
Description:	Integration test if the servo functions based on the manual and automatic feeding.	**Type:**	☐ white box ☐ black box
Tester Information			
Name of Tester:	Christian S. Manong	**Date:**	April 23, 2023
Hardware Version:	PC DSMv2 Hardware	**Time :**	3:00 PM
Setup :	The Dispensing Servo Module is connected to a power source and will be tested for checking if it follows the fixed time for food dispensing.		

Step	Action	Expected Result	Pass	Fail	N/A	Comments
1	Power Test	The module will start once the power is being applied.	✓			
2	Uploading Test	The program or code will be uploaded without any error and will function properly.	✓			
3	Functionality Test	The DS Module will function according to the given table for food distribution.		✓		The function is still not working properly.
Overall Test Result: Fail						

TABLE 43 RESULTS OF INTEGRATION TESTING OF DISPENSING SERVO MODULE V3

Test Writer:			
Test Case Name:	Dispensing Servo Module Integration Testing	**Test ID # :**	IT_DSMv3
Description:	Integration test if the servo functions based on the manual and automatic feeding.	**Type:**	☐ white box ☐ black box
Tester Information			
Name of Tester:	Christian S. Manong	**Date:**	April 27, 2023
Hardware Version:	PC DSMv3 Hardware	**Time :**	4:30 PM
Setup :	The Dispensing Servo Module is connected to a power source and will be tested for checking if it follows the fixed time for food dispensing.		

Step	Action	Expected Result	Pass	Fail	N/A	Comments
1	Power Test	The module will start once the power is being applied.	✓			
2	Uploading Test	The program or code will be uploaded without any error and will function properly.		✓		An error occurred when running the code.
3	Functionality Test	The DS Module will function according to the given table for food distribution.		✓		The error in the code was fixed but still does not function as expected.
Overall Test Result: Fail						

TABLE 44 RESULTS OF INTEGRATION TESTING OF DISPENSING SERVO MODULE V4

Test Writer:			
Test Case Name:	Dispensing Servo Module Integration Testing	**Test ID # :**	IT_DSMv4
Description:	Integration test if the servo functions based on the manual and automatic feeding.	**Type:**	☐ white box ☐ black box
Tester Information			
Name of Tester:	Christian S. Manong	**Date:**	May 5, 2023
Hardware Version:	PC DSMv4 Hardware	**Time :**	4:30 PM
Setup :	The Dispensing Servo Module is connected to a power source and will be tested for checking if it follows the fixed time for food dispensing.		

Step	Action	Expected Result	Pass	Fail	N/A	Comments
1	Power Test	The module will start once the power is being applied.	✓			
2	Uploading Test	The program or code will be uploaded without any error and will function properly.	✓			
3	Functionality Test	The DS Module will function according to the given table for food distribution.	✓			The DS Module works according to the given schedule on the table. It functions according to the fixed time and also works whenever the manual button for dispensing is pressed.

Overall Test Result: Pass

TABLE 45 RESULTS OF INTEGRATION TESTING OF DISPOSING SERVO MODULE V1

Test Writer:			
Test Case Name:	Disposing Servo Module Integration Testing	**Test ID # :**	IT_DISMv1
Description:	Integration test if the servo functions based on the manual and automatic disposing.	**Type:**	☐ white box ☐ black box
Tester Information			
Name of Tester:	Christian S. Manong	**Date:**	May 8, 2023
Hardware Version:	PC DISMv1 Hardware	**Time :**	7:00 PM
Setup :	The Disposing Servo Module is connected to a power source and will be tested for checking if it follows the fixed time for food disposing		

Step	Action	Expected Result	Pass	Fail	N/A	Comments
1	Power Test	The module will start once the power is being applied.	✓			
2	Uploading Test	The program or code will be uploaded without any error and will function properly.		✓		An error occurred when running the code.
3	Functionality Test	The DIS Module will function according to the button for manual disposal and scheduled span of time for automatic.		✓		The DS module didn't work due to some code errors.
Overall Test Result: Fail						

TABLE 46 RESULTS OF INTEGRATION TESTING OF DISPOSING SERVO MODULE V2

Test Writer:			
Test Case Name:	Disposing Servo Module Integration Testing	**Test ID # :**	IT_DISMv2
Description:	Integration test if the servo functions based on the manual and automatic disposing.	**Type:**	☐ white box ☐ black box
Tester Information			
Name of Tester:	Christian S. Manong	**Date:**	May 12, 2023
Hardware Version:	PC DISMv2 Hardware	**Time :**	5:00 PM
Setup :	The Disposing Servo Module is connected to a power source and will be tested for checking if it follows the fixed time for food disposing		

Step	Action	Expected Result	Pass	Fail	N/A	Comments
1	Power Test	The module will start once the power is being applied.	✓			
2	Uploading Test	The program or code will be uploaded without any error and will function properly.	✓			
3	Functionality Test	The DIS Module will function according to the button for manual disposal and scheduled span of time for automatic.	✓			The DIS Module automatically disposes food 15 minutes after the automatic dispensing, and also functions whenever the manual disposal button is pressed.

Overall Test Result: Pass

TABLE 47 RESULTS OF INTEGRATION TESTING OF CAMERA MODULE V1

Test Writer:						
Test Case Name:	Camera Module Integration Testing		**Test ID # :**	IT_CAMv1		
Description:	Integration test if the ESP32 Cam works		**Type:**	☐ white box ☐ black box		
Tester Information						
Name of Tester:	Christian Dave C. Codilla		**Date:**	April 2, 2023		
Hardware Version:	PC CAMv1 Hardware		**Time :**	5:00 PM		
Setup :	The Camera will be tested if it shows live video in the mobile application.					
Step	**Action**	**Expected Result**	**Pass**	**Fail**	**N/A**	**Comments**
1	Power Test	The module will start once the power is being applied.	✓			
2	Uploading Test	The program or code will be uploaded without any error and will function properly.		✓		The program didn't work due to some missing libraries. It is important to install or add the right libraries so that the program will work properly.
3	Functionality Test	The Camera Module will work and can be accessed through mobile application.		✓		The camera didn't work due to connectivity problems between the ESP32 cam, firebase, and MIT app. Also, there is an error in the program.
Overall Test Result: Fail						

TABLE 48 RESULTS OF INTEGRATION TESTING OF CAMERA MODULE V2

Test Writer:			
Test Case Name:	Camera Module Integration Testing	**Test ID # :**	IT_CAMv2
Description:	Integration test if the ESP32 Cam works	**Type:**	☐ white box ☐ black box
Tester Information			
Name of Tester:	Christian Dave C. Codilla	**Date:**	April 17, 2023
Hardware Version:	PC CAMv2 Hardware	**Time :**	5:00 PM
Setup :	The Camera will be tested if it shows live video in the mobile application.		

Step	Action	Expected Result	Pass	Fail	N/A	Comments
1	Power Test	The module will start once the power is being applied.	✓			
2	Uploading Test	The program or code will be uploaded without any error and will function properly.	✓			The program works properly because all the libraries needed are downloaded or added.
3	Functionality Test	The Camera Module will work and can be accessed through mobile application.		✓		Code works but still lacking of expected functionality
Overall Test Result: Fail						

TABLE 49 RESULTS OF INTEGRATION TESTING OF CAMERA MODULE V3

Test Writer:			
Test Case Name:	Camera Module Integration Testing	**Test ID # :**	IT_CAMv3
Description:	Integration test if the ESP32 Cam works	**Type:**	☐ white box ☐ black box
Tester Information			
Name of Tester:	Christian Dave C. Codilla	**Date:**	April 27, 2023
Hardware Version:	PC CAMv3 Hardware	**Time :**	4:00 PM
Setup :	The Camera will be tested if it shows live video in the mobile application.		

Step	Action	Expected Result	Pass	Fail	N/A	Comments
1	Power Test	The module will start once the power is being applied.	✓			
2	Uploading Test	The program or code will be uploaded without any error and will function properly.	✓			
3	Functionality Test	The Camera Module will work and can be accessed through mobile application.	✓			The Camera is accessible through the mobile application and works real-time.

Overall Test Result: Pass

TABLE 50 RESULTS OF SYSTEM TESTING OF MOBILE APPLICATION V1

Test Writer:						
Test Case Name:	Mobile Application System Tesing		**Test ID # :**	ST_MAv1		
Description:	System testing for Mobile Application		**Type:**	☐ white box ☐ black box		
Tester Information						
Name of Tester:	Jaycion Ray H. Manicio/ Sunny A. Dy		**Date:**	May 9, 2023		
Version:	PC MAv1		**Time :**	1:00 PM		
Setup :	The Mobile Application will be tested if it sends data to Firebase to hardware.					
Step	**Action**	**Expected Result**	**Pass**	**Fail**	**N/A**	**Comments**
1	Functionality Test	The buttons work as expected.	✓			
2	Data Sending	The functionality buttons sends data to firebase and then hardware		✓		The buttons in the mobile application didn't send data to the firebase.
3	Saving Data	The app saves data set by the user	✓			
Overall Test Result: Fail						

TABLE 51 RESULTS OF SYSTEM TESTING OF MOBILE APPLICATION V2

Test Writer:			
Test Case Name:	Mobile Application System Tesing	**Test ID # :**	ST_MAv2
Description:	System testing for Mobile Application	**Type:**	☐ white box ☐ black box
Tester Information			
Name of Tester:	Jaycion Ray H. Manicio/ Sunny A. Dy	**Date:**	May 14, 2023
Version:	PC MAv2 Hardware	**Time :**	2:00 PM
Setup :	The Mobile Application will be tested if it sends data to Firebase to hardware.		

Step	Action	Expected Result	Pass	Fail	N/A	Comments
1	Functionality Test	The buttons work as expected.	✓			
2	Data Sending	The functionality buttons sends data to firebase and then hardware	✓			Mobile Application works as expected, saving and sending data to firebase and to hardware.
3	Saving Data	The app saves data set by the user	✓			
Overall Test Result: Pass						

TABLE 52 RESULTS OF SYSTEM TESTING OF FIREBASE V1

Test Writer:			
Test Case Name:	Firebase System Testing	**Test ID # :**	ST_FBv1
Description:	System testing for Firebase	**Type:**	☐ white box ☐ black box
Tester Information			
Name of Tester:	Jaycion Ray H. Manicio / Sunny A. Dy	**Date:**	May 16, 2023
Version:	PC FBv1	**Time :**	3:00 PM
Setup :	Testing the Firebase if it serves as a medium for mobile application and hardware.		

Step	Action	Expected Result	Pass	Fail	N/A	Comments
1	Data Sending	The functionality buttons sends data to firebase and then hardware	✓			The Firebase receives data from Mobile Application and sends data to hardware.
2	Data Receiving	The app saves data set by the user	✓			

Overall Test Result: Pass

TABLE 53 RESULTS OF SYSTEM TESTING OF TIMING MECHANISM V1

Test Writer:			
Test Case Name:	Timing Mechanism System Testing	**Test ID # :**	ST_TMv1
Description:	System testing for Time Mechanism/ Scheduling	**Type:**	☐ white box ☐ black box
Tester Information			
Name of Tester:	Christian S. Manong	**Date:**	May 18, 2023
Version:	PC TMv1	**Time :**	7:00 PM
Setup :	Testing the servos assigned for dispensing and disposing of food using the mobile application.		

Step	Action	Expected Result	Pass	Fail	N/A	Comments
1	Scheduling	The modules for dispensing and disposing food function based on the fixed time schedule from the given table.	✓			Properly dispenses and disposes food on a fixed time schedule from the given table.
2	Accuracy	The delay of servos are exact for appropriate measurement of food serving.		✓		The timing for servo rotations is not giving the recommended amount of food based on the table.
Overall Test Result: Fail						

TABLE 54 RESULTS OF SYSTEM TESTING OF TIMING MECHANISM V2

Test Writer:			
Test Case Name:	Timing Mechanism System Testing	**Test ID # :**	ST_TMv2
Description:	System testing for Time Mechanism/ Scheduling	**Type:**	☐ white box ☐ black box
Tester Information			
Name of Tester:	Christian S. Manong	**Date:**	May 20, 2023
Version:	PC TMv2	**Time :**	10:00 AM
Setup :	Testing the servos assigned for dispensing and disposing of food using the mobile application.		

Step	Action	Expected Result	Pass	Fail	N/A	Comments
1	Scheduling	The modules for dispensing and disposing food function based on the fixed time schedule from the given table.	✓			Properly dispenses and disposes food on a fixed time schedule from the given table.
2	Accuracy	The delay of servos are exact for appropriate measurement of food serving.	✓			The timing for servo rotations is giving the recommended amount of food based on the table.

Overall Test Result: The timing for every feature is working exactly as expected.

TABLE 55 RESULTS OF SYSTEM TESTING OF ALERT NOTIFICATION V1

Test Writer:			
Test Case Name:	Alert Notification System Testing	**Test ID # :**	ST_ANv1
Description:	System testing for Alert Notification	**Type:**	☐ white box ☐ black box
Tester Information			
Name of Tester:	Sunny A. Dy/ Jaycion Ray H. Manicio	**Date:**	May 15, 2023
Version:	PC ANv1	**Time :**	2:00 PM
Setup :	Testing if the load cell triggers the alert system giving off a notification if the level of food is at low level. And sending notification if the prototype automatically dispensed and disposed of food.		

Step	Action	Expected Result	Pass	Fail	N/A	Comments
1	Load Cell Calibration	The Load Cell measures the amount of food inside the container.		✓		The load cell didn't measure the amount of dog food in the container due to code error.
2	Notification for food level	Sending notification if food level is at 1 kg or 33%.		✓		Didn't send notification because the load cell is not working.
3	Notification for automatic dispensing and disposing	The system sends a notification to the mobile app if the prototype automatically dispenses or disposes of food.	✓			
Overall Test Result: Fail						

TABLE 56 RESULTS OF SYSTEM TESTING OF ALERT NOTIFICATION V2

Test Writer:			
Test Case Name:	Alert Notification System Testing	**Test ID # :**	ST_ANv2
Description:	System testing for Alert Notification	**Type:**	☐ white box ☐ black box
Tester Information			
Name of Tester:	Sunny A. Dy/ Jaycion Ray H. Manicio	**Date:**	May 24, 2023
Version:	PC ANv2	**Time :**	12:00 AM
Setup :	Testing if the load cell triggers the alert system giving off a notification if the level of food is at low level. And sending notification if the prototype automatically dispensed and disposed of food.		

Step	Action	Expected Result	Pass	Fail	N/A	Comments
1	Load Cell Calibration	The Load Cell measures the amount of food inside the container.		✓		The load cell didn't measure the amount of dog food in the container properly.
2	Notification for food level	Sending notification if food level is at 1 kg or 33%.	✓			
3	Notification for automatic dispensing and disposing	The system sends a notification to the mobile app if the prototype automatically dispenses or disposes of food.	✓			
Overall Test Result: Fail						

TABLE 57 RESULTS OF SYSTEM TESTING OF ALERT NOTIFICATION V3

Test Writer:			
Test Case Name:	Alert Notification System Testing	**Test ID # :**	ST_ANv3
Description:	System testing for Alert Notification	**Type:**	☐ white box ☐ black box
Tester Information			
Name of Tester:	Sunny A. Dy/ Jaycion Ray H. Manicio	**Date:**	May 28, 2023
Version:	PC ANv3	**Time :**	2:00 AM
Setup :	Testing if the load cell triggers the alert system giving off a notification if the level of food is at low level. And sending notification if the prototype automatically dispensed and disposed of food.		

Step	Action	Expected Result	Pass	Fail	N/A	Comments
1	Load Cell Calibration	The Load Cell measures the amount of food inside the container.	✓			
2	Notification for food level	Sending notification if food level is at 1 kg or 33%.	✓			Sends notification properly when the food level is at 1 kg or 33%.
3	Notification for automatic dispensing and disposing	The system sends a notification to the mobile app if the prototype automatically dispenses or disposes of food.	✓			The notification system functions as expected, sending notification when: prototype automatically or manually dispensed or disposed of food, level of feeds in the container is at low level.
Overall Test Result: Pass						

TABLE 58 RESULTS OF SYSTEM TESTING OF LIVE CAMERA V1

Test Writer:			
Test Case Name:	Live Camera System Testing	**Test ID # :**	ST_LCv1
Description:	System testing for Live Camera	**Type:**	☐ white box ☐ black box
Tester Information			
Name of Tester:	Christian Dave C. Codilla	**Date:**	May 27, 2023
Version:	PC LCv1	**Time :**	11:00 PM
Setup :	Testing the camera through the mobile application if it shows video.		

Step	Action	Expected Result	Pass	Fail	N/A	Comments
1	Camera	The camera can be accessed through mobile application	✓			The camera is accessible through the mobile application.

Overall Test Result: Pass

Appendix E

Hardware Specification and Datasheets

Table 59: Hardware Specification Table

Item	Specification
Microcontroller	ESP8266, ESP32 CAM
Power Supply	12V DC/ 10A/ 240 W
Size	30.5cm/55cm x 25.5cm x 64cm/55cm (L (container/drawer) x W x H)
Connector	Jumper Wires (M to M, M to F, F to F)

Appendix F

Software Specifications

Table 60: Software Specifications Table

Item	Specification
Mobile Application	MIT App Inventor
Cloud Server	Firebase
Integrated Development Environment	Arduino IDE

APPENDIX G

Budget Breakdown

Table 61: Budget Breakdown

Items	Price
Electrical Components	₱5,000.00
Casing Labor Fee	₱3,000.00
Other materials (Prototype Maintenance)	₱4,100.00
	Total: **₱12,100.00**

APPENDIX H

User Manual

Pawsitive Care:

Automatic Dog Feeder

Introduction:

This prototype is made of different combinations of electrical components creating modules with unique functionalities. You MUST first train your dog on how to use it, familiarization of the dog with the gadget is highly RECOMMENDED.

Hardware Specifications:

Item	Specification
Microcontroller	ESP8266, ESP32 CAM
Power Supply	12V DC/ 10A/ 240 W
Size	30.5cm/55cm x 25.5cm x 64cm/55cm (L (container/drawer) x W x H)
Connector	Jumper Wires (M to M, M to F, F to F)

Note:

- It must be powered up with a 220 V outlet or any power source.
- Must be away from any forms of liquid.
- Must be handled with care.

Device/ Prototype:

1. Connect the device to a power source.
2. You must configure the Wi-Fi first for it to connect to the internet.
3. As it gets connected to the internet, the bowl will rotate signaling it's ready to use.

Mobile Application:

1. The loading screen showing the logo will show up first upon clicking the application.
2. You will be asked for your dog's name.
3. Then, you need to choose the correct selection for your dog's breed.
4. Next, select the appropriate age range for your dog.
5. And now, you will get to choose how many meals per day you want to serve for your dog. P.S. There will be a recommended table for food distribution, and it is already verified by an expert.
6. You will now be redirected to the Dashboard in which you can see the icon for Manual Dispensing (Treats) and Manual Disposing of Food.
7. The middle selection redirects you to the Live View in which you can access the camera and control it whatever direction you want.
8. Lastly, the third selection shows you the data and information about your dog.

APPENDIX I

Certificate of Proofreading

APPENDIX J

Multiple Constraints and Trade-Off Analysis

Technical Constraints

TECHNICAL (35%)

DESIGN A

Components	Description	Weight	Cell-Index Factor	Score	Score Function
		a	*b*	*c=a*b*	*d=c*35%*
Database	Firebase	0.1	5	0.5	0.175
Software	MIT App, Ardiuno IDE	0.2	4	0.8	0.28
Microcontroller	ESP 8266	0.2	3	0.6	0.21
Hardware	Servo Motor, Loadcell,	0.3	4	1.2	0.42
Manpower	in house	0.1	3	0.3	0.105
Controller Device	Mobile Application	0.1	3	0.3	0.105
		1			3.7

e= sum (d) / 35%

DESIGN B

Components	Description	Weight	Cell-Index Factor	Score	Score Function
Database	Firebase	0.1	5	0.5	0.175
Software	MIT App, Ardiuno IDE	0.2	4	0.8	0.28
Microcontroller	ESP 8266	0.2	3	0.6	0.21
Hardware	Servo Motor, Loadcell,	0.3	4	1.2	0.42
Manpower	in house	0.1	3	0.3	0.105
Controller Device	Mobile Application	0.1	3	0.3	0.105
		1			3.7

Total Score function	
4.1-5.0	Highly Acceptable
4	Acceptable
3	Neutral
2	Not Acceptable
1	Reject

DESIGN C

Components	Description	Weight	Cell-Index Factor	Score	Score Function
Database	Firebase	0.1	5	0.5	0.175
Software	MIT App, Ardiuno IDE	0.2	4	0.8	0.28
Microcontroller	ESP 8266, Arduino	0.3	5	1.5	0.525
Hardware	Servo Motor, Loadcell,	0.2	4	0.8	0.28
Manpower	in house	0.1	3	0.3	0.105
Controller Device	Mobile Application	0.1	3	0.3	0.105
		1			4.2

Scale for Cell-Index Factor	
5	91-100
4	81-90
3	71-80
2	51-70
1	0-50

Economic Constraints

ECONOMIC (30%)

DESIGN A

Components	Description	Weight	Cell-Index Factor	Score	Score Function
		a	*b*	*c=a*b*	*d=c*30%*
Database	Firebase	0.1	4	0.4	0.14
Software	MIT App, Ardiuno IDE	0.2	4	0.8	0.28
Microcontroller	ESP 8266	0.2	3	0.6	0.21
Hardware	Servo Motor, Loadcell,	0.3	3	0.9	0.315
Manpower	in house	0.1	3	0.3	0.105
Controller Device	Mobile Application	0.1	1	0.1	0.035
		1			3.616666667

e= sum (d) / 30%

DESIGN B

Components	Description	Weight	Cell-Index Factor	Score	Score Function
Database	Firebase	0.1	4	0.4	0.14
Software	MIT App, Ardiuno IDE	0.2	4	0.8	0.28
Microcontroller	ESP 8266	0.2	3	0.6	0.21
Hardware	Servo Motor, Loadcell,	0.3	3	0.9	0.315
Manpower	in house	0.1	3	0.3	0.105
Controller Device	Mobile Application	0.1	1	0.1	0.035
		1			3.616666667

Total Score function	
4.1-5.0	Highly Acceptable
4	Acceptable
3	Neutral
2	Not Acceptable
1	Reject

DESIGN C

Components	Description	Weight	Cell-Index Factor	Score	Score Function
Database	Firebase	0.1	4	0.4	0.14
Software	MIT App, Ardiuno IDE	0.2	5	1	0.35
Microcontroller	ESP 8266, Arduino	0.3	3	0.9	0.315
Hardware	Servo Motor, Loadcell,	0.2	3	0.6	0.21
Manpower	in house	0.1	3	0.3	0.105
Controller Device	Mobile Application	0.1	1	0.1	0.035
		1			3.85

Scale for Cell-Index Factor	
5	91-100
4	81-90
3	71-80
2	51-70
1	0-50

Sustainability Constraints

SUSTAINABILITY (35%)

DESIGN A					
Components	Description	Weight	Cell-Index Factor	Score	Score Function
		a	*b*	*c=a*b*	*d=c*35%*
Database	Firebase	0.1	5	0.5	0.175
Software	MIT App, Ardiuno IDE	0.2	5	1	0.35
Microcontroller	ESP 8266	0.2	3	0.6	0.21
Hardware	Servo Motor, Loadcell,	0.3	4	1.2	0.42
Manpower	in house	0.1	3	0.3	0.105
Controller Device	Mobile Application	0.1	3	0.3	0.105
		1			3.9

e= sum (d) / 35%

DESIGN B					
Components	Description	Weight	Cell-Index Factor	Score	Score Function
Database	Firebase	0.1	5	0.5	0.175
Software	MIT App, Ardiuno IDE	0.2	5	1	0.35
Microcontroller	ESP 8266	0.2	3	0.6	0.21
Hardware	Servo Motor, Loadcell,E	0.3	4	1.2	0.42
Manpower	in house	0.1	3	0.3	0.105
Controller Device	Mobile Application	0.1	3	0.3	0.105
		1			3.9

Total Score function	
4.1-5.0	Highly Acceptable
4	Acceptable
3	Neutral
2	Not Acceptable
1	Reject

DESIGN C					
Components	Description	Weight	Cell-Index Factor	Score	Score Function
Database	Firebase	0.1	5	0.5	0.175
Software	MIT App, Ardiuno IDE	0.2	5	1	0.35
Microcontroller	ESP 8266, Arduino	0.3	5	1.5	0.525
Hardware	Servo Motor, Loadcell,E	0.2	4	0.8	0.28
Manpower	in house	0.1	3	0.3	0.105
Controller Device	Mobile Application	0.1	3	0.3	0.105
		1			4.4

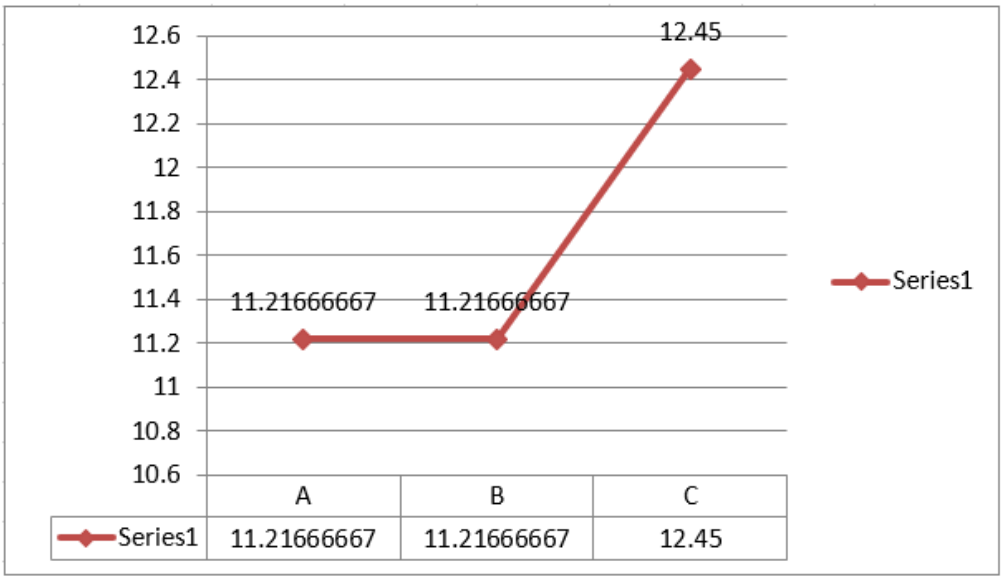
Scale for Cell-Index Factor	
5	91-100
4	81-90
3	71-80
2	51-70
1	0-50

Level of Acceptance

		Summation
TECHNICAL, ECONOMIC AND SUSTAINABILITY	A	11.21666667
	B	11.21666667
	C	12.45

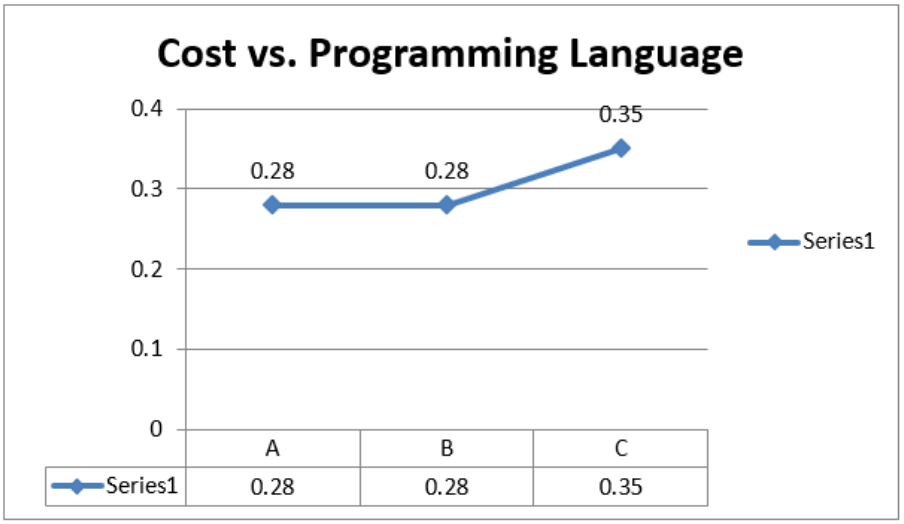
Discussion:

As shown in the graph, Design C is the most acceptable. All designs consist of Firebase as the Database of the system. With regards to the Programming Language, C++ for Arduino IDE was chosen since the project proponents are familiar with the language. With Microcontroller chosen, it was ESP8266 for design A and b and for design C, it included the Arduino IDE, which requires knowledge of C++ for the coding in Arduino IDE. Costs are lower with ESP8266 as the only microcontroller but less sustainable compared to the combination of Arduino Uno and ESP8266. Hardware used for all designs is Servo Motor, Loadcell, ESP32 Cam, and Photoresistor. Manpower for all design is all in-house and no outside help is needed to create the system. The controller Device in the most acceptable Design is the Mobile Application since freeware is used in doing the mobile application.



COST vs Database	
A	0.14
B	0.14
C	0.14

COST vs PL	
A	0.28
B	0.28
C	0.35



Pet Feeder Source Code

```
#include <FirebaseArduino.h>
#include <ESP8266WiFi.h>
#include <ESP8266HTTPClient.h>

//
#include <Servo.h>

// Replace with your Firebase project's credentials
#define FIREBASE_HOST "dog-feeder-5457c-default-rtdb.firebaseio.com"
#define FIREBASE_AUTH "Jm6xENGOGvwwtCDYwA9SeP9ZALhsKkHkWm5TjZsP"

// Replace with your network credentials
#define WIFI_SSID "NoWifi"
#define WIFI_PASSWORD "wifi12345"
#include <NTPtimeESP.h>
//
#include "HX711.h"
#define DOUT  D5
#define CLK  D6
HX711 scale(DOUT, CLK);

///
unsigned long previousMillis1 = 0;  // Variable to store the last time the message was printed
long noDataInterval1;  // Interval for "No data found" message (in milliseconds)
boolean displayDataFound1 = false;  // Flag to indicate if "Data found" should be displayed

///

float calibration_factor = 145.36;
float units;

// Watchdog timer interval in milliseconds
const unsigned long WATCHDOG_INTERVAL = 1000;
```

```
// Timer variables
unsigned long previousMillis = 0;


///
const unsigned long INTERVAL = 900000; // 15 minutes in milliseconds
unsigned long previousTime = 0;
//

#define DEBUG_ON
int done = 0;

NTPtime NTPch("ch.pool.ntp.org");   // Choose server pool as required
char *ssid      = "NoWifi";               // Set you WiFi SSID
char *password  = "wifi12345";               // Set you WiFi password

byte actualHour;
byte actualMinute;
byte actualsecond;
String feeding;
String feeds;
String ftrash;
String timenow;

int num = 0;
strDateTime dateTime;

//
const int LDR_PIN = A0;       // Analog input pin for LDR

const int LDR_THRESHOLD = 1000;  // Threshold value to determine darkness

//
```

```
unsigned long currentTime;

Servo servo, servo1;
void setup() {
  Serial.begin(115200);
  WiFi.begin(WIFI_SSID, WIFI_PASSWORD);
  Serial.print("Connecting to WiFi");
  while (WiFi.status() != WL_CONNECTED) {
    Serial.print(".");
    delay(500);
  }
  //Serial.println();
  //Serial.print("Connected to WiFi, IP address: ");
  //Serial.println(WiFi.localIP());
  Firebase.begin(FIREBASE_HOST, FIREBASE_AUTH);
  //
  //Serial.println("HX711 weighing");
  scale.set_scale(calibration_factor);
  scale.tare();
  // Serial.println("Readings:");
  ///
  pinMode(D2, OUTPUT);
  pinMode(D3, OUTPUT);
  servo.attach(D0);
  servo1.attach(D1);
  servo.write(135);
  servo1.write(60);
  digitalWrite(D3, HIGH);
  digitalWrite(D2, HIGH);
  while (! Serial);
  //  initializeWatchdog();
  ESP.wdtDisable();
  hw_wdt_disable();
}
```

```
void loop() {
  // Reset the watchdog timer
  //  resetWatchdog();

  // Your main code here
  fullcode();
  delay(50);
  yield();
  // Check if it's time to reset the watchdog timer
  //  unsigned long currentMillis = millis();
  //  if (currentMillis - previousMillis >= WATCHDOG_INTERVAL) {
  //    previousMillis = currentMillis;
  //    resetWatchdog();
  //  }
}
//
//void initializeWatchdog() {
//  ESP.wdtDisable();
//  ESP.wdtEnable(0);
//}
//
//// Function to reset the watchdog timer
//void resetWatchdog() {
//  ESP.wdtFeed();
//}
void hw_wdt_disable() {
  *((volatile uint32_t*) 0x60000900) &= ~(1); // Hardware WDT OFF
}
```

```
void fullcode() {
  timedata();
  feeding = (Firebase.getString("/dogfeeder/user/feed"));
  feeding.replace("\"", "");
  delay(50);
  yield();
  feeds = (Firebase.getString("/dogfeeder/user/feeding"));
  feeds.replace("\"", "");
  delay(50);
  yield();
  ftrash = (Firebase.getString("/dogfeeder/user/trash"));
  ftrash.replace("\"", "");
  delay(50);
  yield();
  //Serial.println(ftrash);

  if (feeds == "yes") {
    feed();
    timer();

    delay(50);
    yield();
  }

  else if ( ftrash == "yes") {
    trash();
    Firebase.setString("/dogfeeder/user/trash", "no");
    delay(50);
    yield();
  } else {
    kg();
    led();
    delay(50);
    yield();
```

```
if (feeding == "2") {

  //Serial.println("2 feeding per day");
  if (timenow == "8:0") {
    if (num == 0) {
      currentTime = millis();
      //Serial.println("feeding now 1st");
      feed();
      num = 1;
      timer();
    } else {
      //Serial.println("feeding done");
    }
  } if (timenow == "20:0") {
    if (num == 1) {
      currentTime = millis();
      //Serial.println("feeding now 2nd");
      feed();
      timer();
      num = 0;
    } else {
      //Serial.println("feeding done");
    }
  }
```

```
  } else if (feeding == "3") {
    //Serial.println("3 feeding per day");
    if (timenow == "7:0") {
      if (num == 0) {
        currentTime = millis();
        //Serial.println("feeding now 2nd");
        feed();
        timer();
        num = 1;
        //Serial.println("feeding now 1st");
      }
    } else if (timenow == "12:0") {
      if (num == 1) {
        currentTime = millis();
        //Serial.println("feeding now 2nd");
        feed();
        timer();
        num = 2;
        //Serial.println("feeding now 2nd");
      }
    } else if (timenow == "17:0") {
      if (num == 2) {
        currentTime = millis();
        //Serial.println("feeding now 2nd");
        feed();
        timer();
        num = 0;
        //Serial.println("feeding now 2nd");
      }
    }
  } else {
    //Serial.println("Invalid feeding value");
  }


      } else {
        //Serial.println("Invalid feeding value");
      }
      delay(50);
      yield();
    }
}
```

```
void timedata() {
  // first parameter: Time zone in floating point (for India); second parameter: 1 for European summer time;
  dateTime = NTPch.getNTPtime(+8.0, 8);

  // check dateTime.valid before using the returned time
  // Use "setSendInterval" or "setRecvTimeout" if required
  if (dateTime.valid) {
    actualHour = dateTime.hour;
    actualMinute = dateTime.minute;
    actualsecond = dateTime.second;
  }
  timenow = String(actualHour) + ":" + String(actualMinute);
  delay(50);
  yield();
  //Serial.println(timenow);
}
void timer() {
  if (currentTime - previousTime >= INTERVAL) {
    previousTime = currentTime; // Reset the timer
    trash();
    //Serial.println("Throwing the dog food");
  }
}

void feed() {
  String delay1 = (Firebase.getString("/dogfeeder/user/delay"));
  delay1.replace("\"", "");
  digitalWrite(D3, LOW);
  servo.write(10);
  delay(delay1.toInt());
  servo.write(135);
  digitalWrite(D3, HIGH);
  delay(delay1.toInt());
```

```
  Firebase.setString("/dogfeeder/user/feeding", "no");
  yield();
}
void trash() {
  servo1.write(180);
  delay(1000);
  servo1.write(-180);
  delay(1000);
  servo1.write(60);
  delay(50);
  yield();
}

void kg() {
  units = scale.get_units(), 10;
  if (units < 0)
  {
    units = 0.00;
  }

  Firebase.setString("/dogfeeder/user/weight", String(units));
  delay(50);
  yield();
}


///



void led() {
  int ldrValue = analogRead(LDR_PIN);

  if (ldrValue < LDR_THRESHOLD) {
    //Serial.println("On Light");
    digitalWrite(D2, HIGH);  // Turn on the light
  } else {
    //Serial.println("OFF Light");
    digitalWrite(D2, LOW);   // Turn off the light
  }

  //Serial.print("LDR Value: ");
  //Serial.println(ldrValue);

}
```

Camera Source Code

```
/*
  ESP32-CAM Save a captured photo(Base64) to firebase.
  Author : ChungYi Fu (Kaohsiung, Taiwan)  2019-8-16 23:00
  https://www.facebook.com/francefu

  Arduino core for ESP32 version 1.0.4

  Arduino IDE Library
  Firebase ESP32 Client by Mobizt version 3.2.1

  ESP32-CAM How to save a captured photo to Firebase
  https://youtu.be/Hx7bdpevlug

  How to set up Firebase
  https://iotdesignpro.com/projects/iot-controlled-led-using-firebase-database-and-esp32
*/

const char* ssid = "NoWifi";
const char* password = "wifi12345";

//https://console.firebase.google.com/project/xxxxxxxxx/settings/serviceaccounts/databasesecrets
String FIREBASE_HOST = "dog-feeder-5457c-default-rtdb.firebaseio.com";
String FIREBASE_AUTH = "Jm6xENGOGvwwtCDYwA98eP9ZALhsKkHkWm5TjZsP";

#include "FirebaseESP32.h"
FirebaseData firebaseData;

#include <WiFi.h>
#include "soc/soc.h"
#include "soc/rtc_cntl_reg.h"
#include "Base64.h"

#include "esp_camera.h"
//#include <ESP32Servo.h>
//
```

```
//
//#define PAN_PIN 14
//#define TILT_PIN 15
//
//Servo dummyServo1;
//Servo dummyServo2;
//Servo panServo;
//Servo tiltServo;
// WARNING!!! Make sure that you have either selected ESP32 Wrover Module,
//            or another board which has PSRAM enabled

//CAMERA_MODEL_AI_THINKER
#define PWDN_GPIO_NUM     32
#define RESET_GPIO_NUM    -1
#define XCLK_GPIO_NUM      0
#define SIOD_GPIO_NUM     26
#define SIOC_GPIO_NUM     27

#define Y9_GPIO_NUM       35
#define Y8_GPIO_NUM       34
#define Y7_GPIO_NUM       39
#define Y6_GPIO_NUM       36
#define Y5_GPIO_NUM       21
#define Y4_GPIO_NUM       19
#define Y3_GPIO_NUM       18
#define Y2_GPIO_NUM        5
#define VSYNC_GPIO_NUM    25
#define HREF_GPIO_NUM     23
#define PCLK_GPIO_NUM     22



void setup() {
  WRITE_PERI_REG(RTC_CNTL_BROWN_OUT_REG, 0);

  Serial.begin(115200);
  Serial.setDebugOutput(true);
  Serial.println();
  Serial.println("ssid: " + (String)ssid);
  Serial.println("password: " + (String)password);

  WiFi.begin(ssid, password);

  long int StartTime = millis();
  while (WiFi.status() != WL_CONNECTED) {
    delay(500);
    if ((StartTime + 10000) < millis()) break;
  }

  if (WiFi.status() == WL_CONNECTED) {
    char* apssid = "ESP32-CAM";
    char* appassword = "12345678";         //AP password require at least 8 characters.
    Serial.println("");
    Serial.print("Camera Ready! Use 'http://");
    Serial.print(WiFi.localIP());
    Serial.println("' to connect");
    WiFi.softAP((WiFi.localIP().toString() + "_" + (String)apssid).c_str(), appassword);
  }
  else {
    Serial.println("Connection failed");
    return;
  }
```

```
  camera_config_t config;
  config.ledc_channel = LEDC_CHANNEL_0;
  config.ledc_timer = LEDC_TIMER_0;
  config.pin_d0 = Y2_GPIO_NUM;
  config.pin_d1 = Y3_GPIO_NUM;
  config.pin_d2 = Y4_GPIO_NUM;
  config.pin_d3 = Y5_GPIO_NUM;
  config.pin_d4 = Y6_GPIO_NUM;
  config.pin_d5 = Y7_GPIO_NUM;
  config.pin_d6 = Y8_GPIO_NUM;
  config.pin_d7 = Y9_GPIO_NUM;
  config.pin_xclk = XCLK_GPIO_NUM;
  config.pin_pclk = PCLK_GPIO_NUM;
  config.pin_vsync = VSYNC_GPIO_NUM;
  config.pin_href = HREF_GPIO_NUM;
  config.pin_sscb_sda = SIOD_GPIO_NUM;
  config.pin_sscb_scl = SIOC_GPIO_NUM;
  config.pin_pwdn = PWDN_GPIO_NUM;
  config.pin_reset = RESET_GPIO_NUM;
  config.xclk_freq_hz = 20000000;
  config.pixel_format = PIXFORMAT_JPEG;
  //init with high specs to pre-allocate larger buffers
  if (psramFound()) {
    config.frame_size = FRAMESIZE_UXGA;
    config.jpeg_quality = 14;  //0-63 lower number means higher quality
    config.fb_count = 2;
  } else {
    config.frame_size = FRAMESIZE_SVGA;
    config.jpeg_quality = 14;  //0-63 lower number means higher quality
    config.fb_count = 1;
  }



  // camera init
  esp_err_t err = esp_camera_init(&config);
  if (err != ESP_OK) {
    Serial.printf("Camera init failed with error 0x%x", err);
    delay(1000);
    ESP.restart();
  }

  //drop down frame size for higher initial frame rate
  sensor_t * s = esp_camera_sensor_get();
  s->set_framesize(s, FRAMESIZE_QVGA);  // VGA|CIF|QVGA|HQVGA|QQVGA   ( UXGA? SXGA? XGA? SVGA? )

  Firebase.begin(FIREBASE_HOST, FIREBASE_AUTH);
  Firebase.reconnectWiFi(true);
  Firebase.setMaxRetry(firebaseData, 3);
  Firebase.setMaxErrorQueue(firebaseData, 30);
  Firebase.enableClassicRequest(firebaseData, true);

  //  String jsonData = "{\"photo\":\"" + Photo2Base64() + "\"}";
  //  String photoPath = "/dogfeeder/esp32-cam";

  Firebase.setString(firebaseData, "/dogfeeder/esp32-cam", Photo2Base64());

  //  if (Firebase.pushJSON(firebaseData, photoPath, jsonData)) {
  //    Serial.println(firebaseData.dataPath());
  //    Serial.println(firebaseData.pushName());
  //    Serial.println(firebaseData.dataPath() + "/"+ firebaseData.pushName());
  //  } else {
  //    Serial.println(firebaseData.errorReason());
  //  }

//
//  panServo.attach(PAN_PIN);
//  tiltServo.attach(TILT_PIN);
}
```

```
void loop() {
    Firebase.setString(firebaseData, "/dogfeeder/esp32-cam", Photo2Base64());
    delay(10);
}

String Photo2Base64() {
  camera_fb_t * fb = NULL;
  fb = esp_camera_fb_get();
  if (!fb) {
    Serial.println("Camera capture failed");
    return "";
  }

  String imageFile = "";
  char *input = (char *)fb->buf;
  char output[base64_enc_len(3)];
  for (int i = 0; i < fb->len; i++) {
    base64_encode(output, (input++), 3);
    if (i % 3 == 0) imageFile += urlencode(String(output));
  }

  esp_camera_fb_return(fb);

  return imageFile;
}
```

```
//https://github.com/zenmanenergy/ESP8266-Arduino-Examples/
String urlencode(String str)
{
  String encodedString = "";
  char c;
  char code0;
  char code1;
  char code2;
  for (int i = 0; i < str.length(); i++) {
    c = str.charAt(i);
    if (c == ' ') {
      encodedString += '+';
    } else if (isalnum(c)) {
      encodedString += c;
    } else {
      code1 = (c & 0xf) + '0';
      if ((c & 0xf) > 9) {
        code1 = (c & 0xf) - 10 + 'A';
      }
      c = (c >> 4) & 0xf;
      code0 = c + '0';
      if (c > 9) {
        code0 = c - 10 + 'A';
      }
      code2 = '\0';
      encodedString += '%';
      encodedString += code0;
      encodedString += code1;
      //encodedString+=code2;
    }
    yield();
  }
  return encodedString;
}
```