Android-Based Food Dispenser for Small Dogs with Global System for Mobile Communication (GSM) and Cloud Technology

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Keywords

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ABSTRACT

The Android-Based Food Dispenser for small dogs with a global system for mobile communication (GSM) and cloud technology is an application for dog owners. It has the functionality to choose the amount of food, schedule the desired feeding time, and give the precise amount of dog food based on the dog's weight. The system can operate wirelessly only once the GSM module receives a Short Message Service (SMS) command from the owner. The study is a developmental research design concentrating on the dog food dispenser's android application and NodeMCU microcontroller for the hardware device to help the dog owner feed their pet from a distance. The study also uses a descriptive design to evaluate and test the application in terms of successful or failed system accuracy in dispensing and to determine whether the device output is within the acceptable range. The proponents tested the system's overall performance in terms of accuracy in dispensing the amount of food at a given time. The 20 trials per testing tool in dispensing dog food resulted in acceptable accuracy of the device output at 100 grams and 100% system response in terms of success rate that is also accepted. It is concluded that internet connection would be a critical factor for the system's performance in term of system response.

RODUCTION

Pet dogs play a significant role in improving the physiological welfare of individuals (Le Roux & Kemp, 2009). Rearing a puppy at home is one of those responsibilities that pays off because it can make pets fun, attractive, loyal, and playful companion at home. According to Walsh (2009), pets are often considered members of the family who take a significant part of human life.

However, because people are busier nowadays than they used to be, they are more likely to forget a lot of their responsibilities, including proper feeding of their pets. As a result, pet breeders frequently struggle to overcome several problems such as unplanned travels, just being stuck in traffic, and commitments coming from a busy everyday life (Nogueira et al., 2019). Issues such as these are among the primary reasons for dog owners' negligence in caring for their dogs. Specifically, feeding is one of the most critical aspects of puppy care (Vineeth et al., 2020) that pet owners could neglect. Unfortunately, improper food management that includes overfeeding or underfeeding the pets results in illness, obesity, and malnutrition (Prasad et al., 2020).

The bond between the owner/s and their pets strengthens by giving the pets a treat or feeding them (Tobie et al., 2015). Therefore, pets must be fed with the proper amount of food without negligence to avoid health problems such as pet obesity, which is the product of overfeeding, and irrational conduct like trash tearing, searching through the foodstuff, and others caused by underfeeding (Hall, 2014). According to the study of Philpotts et al. (2019), understanding the development of dogs, especially their welfare, is essential. It also relates to the practices or behavior of the owners towards their dogs that impact their pets' growth and nutrition. As reported by the National Research Council (NRC) (as cited by Sanderson, 2013), the accepted international recommendations towards the daily intake of essential food nutrients must guarantee the complete balanced diet of the dogs when fed at maintenance requirements. Hence, a modern pet feeder is made to efficiently substitute for the manual pet feeding method (Koley et al., 2021).

The objectives of the android-based dog food dispenser include the development of a GSM module with SMS-based command where the users can control the amount of food to be dispensed on the bowl, using the users' android smartphone that can monitor the process of food dispensing (Karyono & Nugroho, 2016). It also aims to develop a Wi-Fi module with wireless control systems for dogs (Jung & Kim, 2006) and a communication process for either the prototype or the researchers can access through an application made from MIT application inventor 2. It likewise aims to develop an automated device that can dispense the exact amount of the food that the dog could eat (Quiñonez et al., 2021) and a food disposal feature added to prevent the dog from eating spoiled dog food left in the container.

A dispensing device can obtain these objectives through an android mobile with an installed dog feeder application that can also view the notification via a short messaging service (SMS) command. The dispensing process with a notification includes the food and water storage level of the system. Through this, an automated dog food dispenser with a machine-readable program for command controls can subsequently send and receive processed data between them.

The idea of cloud computing, which is an internet-based process of remotely accessing data and program applications (Dixon Jr, 2012) at this Internet Age, can make any job easier than it should be. A smart dog feeder can be built by integrating the Internet of Things (IoT) or cloud technology idea. Moreover, it is one of the best ways to manage the quality of life since the IoT-based applications allow things to be dealt with easily (Soumyalatha, 2016). As Chen & Elshakankiri (2020) studied, the processed data collected from the sensors are displayed on the application installed on a smartphone. With new technology, the dog feeder can become smarter and can communicate with other devices. As a result, this study will develop a smart dog feeder to resolve the problems raised (Vania et al., 2016).

Designing the Android-based dog food dispenser for small dogs with a global system for mobile communication (GSM) and cloud technology was based on various studies and literature. The Automated Dog Food Dispenser is a pre-programmed feeding system that automatically distributes a reasonable amount of food to pets. The end-users can take care of the pet's feeding schedule with this gadget (Mathur, 2013). Programmable Pet Feeder feeds automatically using microchip's PIC18F4520 microcontroller. According to Dogo et al. (2014), the PIC18F4520 microcontroller is responsible for displaying the message read from the GSM Module on a dot matrix display. The SIM card is inserted into the modem to read the message before sending the AT command to the modem. Moreover, as a stepper motor regulates the speed and positioning, the food is dispensed by a direct current (DC) motor. Based on the study by Situmorang (2011), a potentiometer is attached from the stepper motor with a variable regulated power supply, and the DC motor is applied with the output voltage of the power supply.

The name of the food dispenser is Turn-Table, which is divided into four parts and can dispense a variety of foods. When feeding time has come, and the meal has been served, a buzzer will sound. The user may use the liquid crystal display (LCD) to set the schedule for each section and input their desired timing (Clary, 2015). Then, the food is dispensed and distributed across three layers of the automatic feeder.

An Arduino regulates the feeding mechanism, and a weight sensor determines the serving size. Through the sensors, the information surrounding the area can be obtained and sent through the internet to access without having the trouble of being away from the prototype (Ibrahim et al., 2015). The automatic feeder and pooping pad are both monitored using a Raspberry Pi camera. Through the camera, the pet owners can check the status of their pet, such as their dogs, as well as the other components like the food dispenser and pooping pad (Kim, 2016). The Raspberry Pi serves as both a client and a server that functions using Wi-Fi to wirelessly transfer files into the server and support wireless communication by connecting to a wireless adapter (Zhao et al., 2015).

Moreover, the user can choose a serving size and a feeding schedule three times in the app (Kim, 2016). The Smart Pet Feeder suggested designing and fabricating a dog food dispenser that would discourage one pet from consuming the food for another dog. The researchers created the feeding system to assist pet owners who are normally busy and cannot feed their pets on a regular basis (Heil et al., 2008). In the Automatic Pet Monitoring and Feeding System, one functionality is to track a pet's location through the Internet of Things as IoT enables the feature of machine-to-machine and machine-to-person communication. Thus, devices can connect through the internet to reach the potential of modern society (Mahmoud & Mohamad, 2016). As stated in the study of Doukas (2012), it consists of four components: the brain of the devices called Main Control Units (MCU); sensors that can collect signals and information from the environment; electronic modules of communication; and sources of power or electricity. Hence, a Wi-Fi module is used in the system to send and request data in real-time. Using a Thing Speak and a Cloud server, the device can collect data from the Cloud server and generate an output (Subaashri et al., 2017).

The main goal of this research was to design and develop an integrated Android-based dog food dispenser for small dogs with a global system for mobile communication and cloud technology. These features will provide pet owners a more convenient and effective way to feed their pets using the cloud technology approach. Specifically, the study aimed at the following technical features: (1) This device can automatically dispense dog food, and the user can schedule the time and amount of dry dog food to be provided by using an Android smartphone with the system's mobile app-enabled. (2) The system can connect to the internet and access the Firebase Cloud database by the use of NodeMCU that will also serve as the main microcontroller of the system. (3) The system is equipped with a global system for mobile communication to allow the user to control the feeding device through Short Message Service whenever internet access is unavailable. (4) A left-over disposal feature is to dispose of the remaining dog food to another container to avoid spoilage.

(5) It can evaluate the performance of the system in terms of (a) the accuracy of the system during the dispensing operation and (b) the success rate of the system trial result.

This study covered the development of the Android-based food dispensing application with the use of GSM, Arduino module, and cloud technology. The device is designed for a small breed type of dog, weighing within the range of 10 to 20 pounds. The storage of the device can only store up to 800 grams of dry type of dog food and up to 1 liter of water. The system can dispense four different amounts of dog food starting from a ¼ cup, ½ cup, ¾ cup, and 1 cup, where one cup is equivalent to 100 grams of dry dog food. The system also accesses data storage through a wireless internet connection to the Firebase cloud database. SMS is also supported to allow the users to send a command for the device to operate. The limitations of this study mainly include internet and telecommunication network connections through Wi-Fi. The GSM modules will depend on the network service provider of the users. The leftover bin storage of the dispenser can only hold at least 200 grams of dog food. This study is limited to the accuracy in dispensing the dog food and the development of the project.

This application can help solve the most common problem of dog owners in terms of feeding and will benefit mainly the dog owners by being able to feed their pets even without their physical presence. How? They can schedule the feeding time and regulate the amount of food for their dog. They can control the dispensing device through an Android mobile with an installed dog feeder application that can also view the notification via a short messaging service (SMS) command. The dogs may also benefit from this research study because they can have their meals on time and may never skip a meal as long as they set the device. This research study may guide future researchers who would like to innovate or conduct the same research.

The steps in developing the dispensing device system are divided into four phases. The first phase is the development of the mobile application, firebase cloud database, and the communication between the mobile app to the cloud database. In the second phase, the researchers were able to establish the configuration of communication between the dispensing device to the cloud database and the global system for mobile communication (GSM) module. The third phase was the development of the dispensing device structure and an algorithm on how the different components operate during the dispensing operation. Finally, the fourth phase was the operational testing of the dispensing device. Test results would then be used to troubleshoot the dispensing device.

The Input, Process, and Output diagram show the rudiments of the food dispensing device system flow. The users can input the desired time and amount of dog food to dispense using an android device with an installed dog feeder application. The mobile app then sends the data to the cloud database by sending an SMS command to the dispensing device. Subsequently, the microcontroller gathers the data from the cloud database and uses it as a variable for the time and amount of the dispensing operation. The dispensing device performs the dispensing operation when the microcontroller receives an SMS command via the GSM module. The output is the time and amount of dog food to be dispensed depending on the microcontroller data.

METHODOLOGY

The research team conducted a developmental research design focusing on the system of an automated dog food dispensing device. They studied the ways to analytically create the system to develop a device that can significantly help dog owners feed their pets. The proponents developed an Android application for the system that could access the device's status from the firebase database. Also, communications between the system to the firebase database and the Android application to the firebase database were made. Another method used in the study is descriptive research to evaluate and test the application using the mean and percentage error to solve the system's response in terms of successful or failed system accuracy in dispensing to determine whether the device output is within the acceptable range. The researcher used purposive sampling with dog owners as the respondents of this study.

The block diagram shown in Figure 1, compose of android application connected to the microcontroller with servo motor and load cell. The fabrication and construction of the dog food dispensing device, the researcher designed a circuit that allows the two servo motors, two HX711 amplifiers, two load cells, and SIM900 GSM shield to have a specific pin connection to the NodeMCU microcontroller. It would enable each component to receive proper voltage to operate accordingly and integrate the device's weighing scale. The GSM modem is a highly flexible plug-and-play quad band SIM900A GSM modem for direct and easy integration to RS232 applications. It supports features like Voice, SMS, Data/Fax, GPRS, and integrated TCP/IP stack. The shield requires a SIM card provided by a network provider (Mary et al., 2019). The NodeMcu Microcontroller is an open-source firmware and development kit that plays a vital role in designing a proper IoT product using a few script lines (Al Dahoud & Fezari, 2018). It serves as the gateway to the internet (Bohora et al., 2016), where sensors and microcontrollers connect. According to (Mohamd, 2018), the pet feeder system with a scheduled feeding time to feed the pet and monitor the amount of food left can be accessed using a mobile application

Figure 1
Block diagram of Android-based food dispenser for small dogs with Global System for Mobile communication (GSM) and cloud technology.

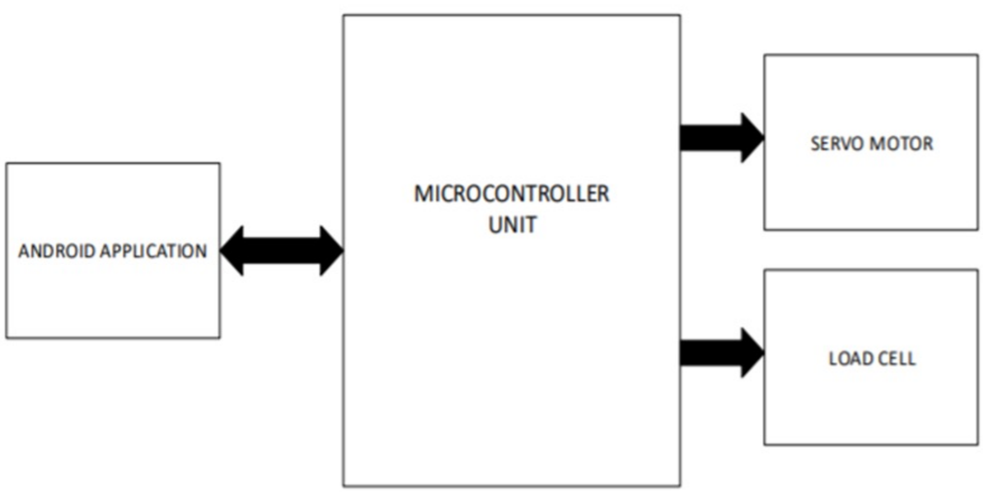
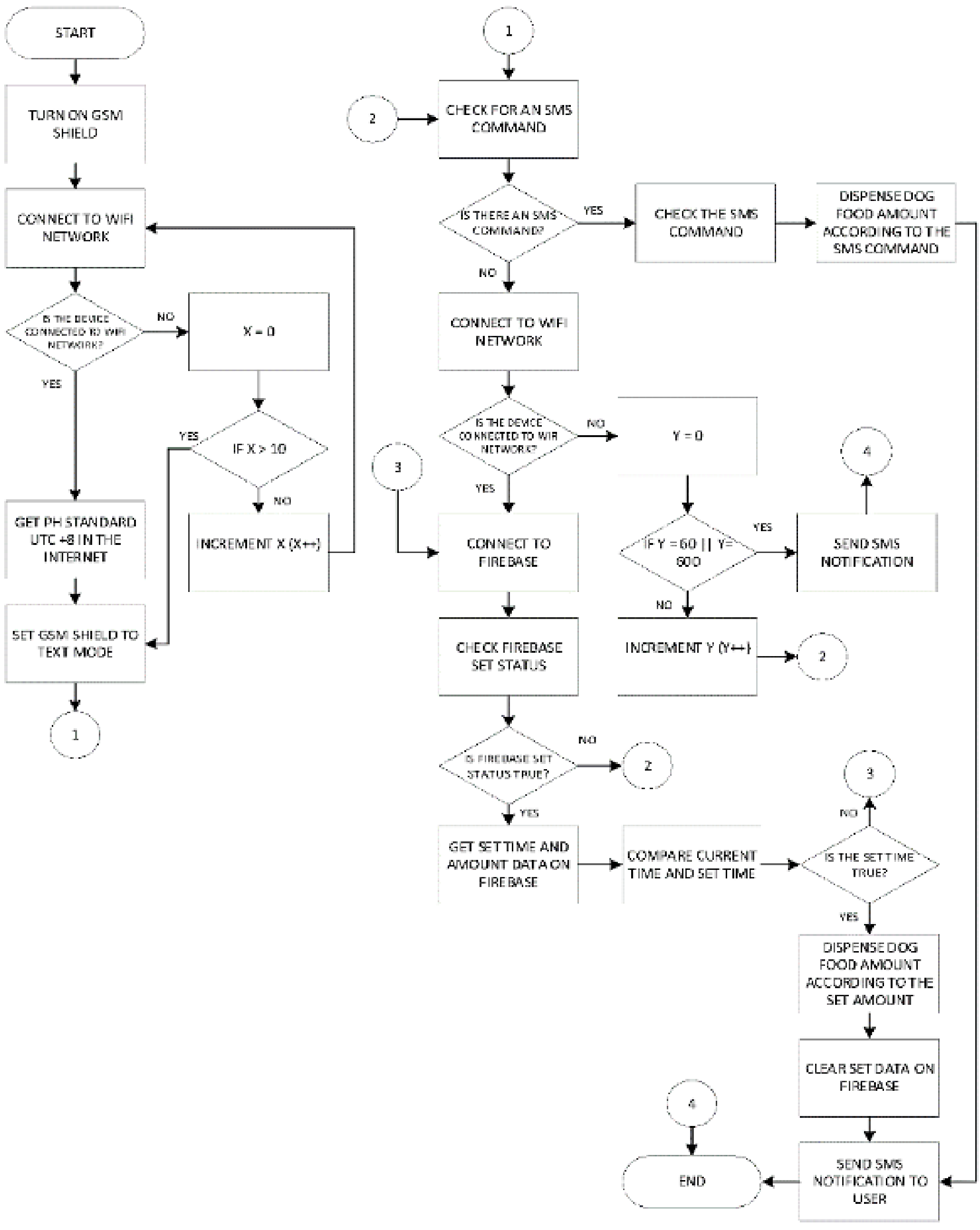


Figure 2
System Flowchart



integrated into NodeMCU Microcontroller that can help in feeding the pet without the owner's physical appearance or manual feeding.

In software development, the researcher used the MIT application Inventor 2, an open-source web application to create Android devices. It provides a particular amount of information, such as tutorials found on the freeware tool or tool internet page (Inventor, 2018). MIT application inventor 2 has the drag and drop feature that is similar to other Android application IDE. MIT application also supports cloud database and firebase database extension, which the proponents used to store and retrieve important data. The proponent used the MIT application Inventor 2 because it is web-based; thus, it does not require downloading and installation of software. The only requirement of the MIT application inventor 2 is the computer that has a web browser and stable internet.

Figure 2 shows the overall system flowchart for the process of connecting to a Wi-Fi network, assessing time parameters, and checking for an SMS command to dispense the food amount and to inform the user. The flowchart contains elements that would ensure that there is seamless integration when utilizing the interface to meet the needs of the user.

The proponents developed the system program using Arduino IDE and C++ as the programming language; the proponents used different libraries for each component such as the HX711 library, servo library, firebase Arduino library, time library and esp8266wifi library to allow the proponents to create a simple program. The proponents used the internet to gather and study how to use each of the libraries, the proponents also based on the sample code of each library to analyze how to use the certain syntax. The flow of the developed program is to check repeatedly for data commands whether the data is from the firebase database or a short message service (SMS) from the SIM900 GSM module, when the system gathered or received a data, it will automatically interpret the data and operate a certain action according to the gathered or received data. When the system received a command, the system will first operate the servo motor for the leftover feature of the system, then it will operate the servo motor that is on the food storage to dispense a certain amount depending on the data. The proponents also programed the system to send a short message service (SMS) to the user as a notification after a dispensing operation is done.

In the data gathering procedure, the researcher gathered 20 dog owners. The researchers conducted an orientation regarding the objectives and procedures for using the dog food dispenser. The orientation was accompanied by a demonstration of how to use the device. An overall system test was conducted by dispensing a specific amount of dog food to each process. The researchers then conducted a series of dispensing trials according to the available amount of dry dog food to dispense, such as a ¼ cup, ½ cup, ¾ cup, and 1 cup, where 1 cup is equivalent to 100 grams. The data gathered from the system test were recorded in the test tools.

RESULTS AND DISCUSSION

The proponents tested the system's overall performance in terms of accuracy. Test tools were used for recording the results. The team conducted 20 trials per test tool using 500g of dry dog food. The following are the interpretation of the results collected from the statistical analysis.

After performing the accuracy for dispensing 25 grams in 20 trials, the researchers calculated the mean of the expected output and observed output to get the system's accuracy percentage error. Table 1 shows the results in testing the system's performance in terms of accuracy at 25 grams expected output and the system response in terms of success rate in each trial. The accuracy percentage error was 12.4, which is higher than the allowable 5% error. All trials were successful. These figures reveal that the accuracy of the device output at 25 grams is not accepted, but the system's response in terms of a success rate of 100% is accepted.

Table 2 shows the results in testing the system's performance in terms of accuracy at 50 grams expected output and the system response in each trial's success rate. The accuracy percentage error was 3.2, which is within the range of the accepted percentage of error, while all the trials were successful. These findings show that the accuracy of the device

Table 1
Accuracy at 25 grams

Trials	Expected (x)	Observed (x0)	Trial Result
1	25	22	Success
2	25	25	Success
3	25	28	Success
4	25	29	Success
5	25	34	Success
6	25	35	Success
7	25	32	Success
8	25	33	Success
9	25	36	Success
10	25	17	Success
11	25	30	Success
12	25	34	Success
13	25	28	Success
14	25	17	Success
15	25	23	Success
16	25	34	Success
17	25	20	Success
18	25	31	Success
19	25	28	Success
20	25	26	Success
Mean of Expected Output (x)		25	
Mean of Observed Output (x0)		28.1	
Percentage Error in Accuracy		12.4	

Table 2
Accuracy at 50 grams

Trials	Expected (x)	Observed (x0)	Trial Result
1	50	55	Success
2	50	58	Success
3	50	52	Success
4	50	58	Success
5	50	56	Success
6	50	67	Success
7	50	47	Success
8	50	69	Success
9	50	41	Success
10	50	14	Success
11	50	55	Success
12	50	49	Success
13	50	58	Success
14	50	59	Success
15	50	62	Success
16	50	57	Success
17	50	55	Success
18	50	58	Success
19	50	49	Success
20	50	13	Success
Mean of Expected Output (X)		50	
Mean of Observed Output (X0)		51.6	
Percent Error in Accuracy		3.2	

output at 50 grams is accepted, and the 100% system response in terms of success rate in every trial is likewise accepted.

Table 3 shows the results in testing the system's performance in terms of accuracy at 75 grams expected output and the system response in terms of success rate in each trial. The accuracy percentage error was 4.07, which is within the range of the accepted percentage of error, while all the trials revealed successful results. These results indicate that the accuracy of the device output at 75 grams is accepted, and the 100% system response in terms of success rate in every trial is accepted.

As shown in Table 4, after testing the system's performance in terms of accuracy at 100 grams expected output and the system response in terms of success rate in each trial, the tests showed the accuracy percentage error at 1.10, which is within the range of accepted percentage of error. All trial results were also successful. Trials revealed that the accuracy of the device output at 100 grams is accepted, and the 100% system response in terms of success rate in

Table 3
Accuracy at 75 grams

Trials	Expected (x)	Observed (x0)	Trial Result
1	75	70	Success
2	75	72	Success
3	75	70	Success
4	75	83	Success
5	75	62	Success
6	75	69	Success
7	75	62	Success
8	75	62	Success
9	75	75	Success
10	75	79	Success
11	75	71	Success
12	75	73	Success
13	75	69	Success
14	75	61	Success
15	75	74	Success
16	75	84	Success
17	75	80	Success
18	75	77	Success
19	75	70	Success
20	75	76	Success
Mean of Expected Output (X)		75	
Mean of Observed Output (X0)		71.95	
Percent Error in Accuracy		4.07	

every trial is accepted.

CONCLUSION AND RECOMMENDATIONS

The system's main components are the NodeMCU, SIM900 shield, two MGR996 servo motors, two load cells, and two HX711. This system can automatically dispense the dry type of dog food automatically, where the users can schedule the time and amount of dog food to be given by using an Android smartphone with an installed mobile application for the dispensing system.

The SIM900 shield sends a notification to the registered recipient through a short message service (SMS) after a dispensing process. Such notification includes the food and water storage level of the system.

The system's mobile application gives two options for the users to control the dispensing prototype. The first option is to "set device" where the users can set the time and choose an amount of dog food to be dispensed. It also requires an internet connection in both the Android smart and the dispensing system. The second option involves the short message service

Table 4
Accuracy at 100 grams

Trials	Expected (x)	Observed (x0)	Trial Result
1	100	70	Success
2	100	72	Success
3	100	70	Success
4	100	83	Success
5	100	62	Success
6	100	69	Success
7	100	62	Success
8	100	62	Success
9	100	75	Success
10	100	79	Success
11	100	71	Success
12	100	73	Success
13	100	69	Success
14	100	61	Success
15	100	74	Success
16	100	84	Success
17	100	80	Success
18	100	77	Success
19	100	70	Success
20	100	76	Success
Mean of Expected Output (X)		100	
Mean of Observed Output (X0)		101.1	
Percent Error in Accuracy		1.10	

(SMS), using the mobile application in which the users can choose the amount to dispense, and when sent, the dispensing system immediately operates upon identifying the SMS command. In addition, the system is provided with a left-over mechanism where the dog food that is left from the previous dispense can be drawn to the system leftover bin.

The hardware of the system is in a case made of plywood. The device consists of a NodeMCU, GSM SIM900 shield, two MGR996 servo motors, two load cells, and an HX711 amplifier. On the other hand, the researchers developed the software part using Arduino IDE to create a program for the hardware to operate accordingly. In addition, they created the system's Android application in the MIT application Inventor 2 and a firebase database that can store data.

Based on the system's test results, the team was able to successfully integrate the hardware components. The researchers were able to develop an Android application for the system, create a firebase database, establish communications between the system to firebase database and the Android application to firebase database, create an algorithm that integrated all the hardware components that developed the dispensing system, and, test and evaluate the performance of the system in terms of accuracy and system response.

Based on the test conducted by the researchers, a huge factor in the system's responsiveness depends on the Wi-Fi signal strength and internet. If the internet speed and Wi-Fi strength connection of the system is good, the response output in terms of the time of the system would be fast. However, the system's response would be slow whenever the internet speed is slow, or the Wi-Fi strength connection is weak. Under the short message service (SMS) feature of the system, the results suggested that the signal strength of the network provider and the location of the system would greatly affect the responsiveness output in terms of the time of the system.

They likewise concluded that this proposed design of a dog food dispensing mechanism cannot accurately dispense a set amount of dog food but can be calibrated by controlling the servo motor's rotation angle at a particular time. Therefore, the researchers created a program that can dispense near the expected value based on the gathered data during testing and evaluation. In addition, they were able to calibrate the load cell for the food and water storage of the system. However, the load cell used could not give a precise and steady output because of the lack of equipment.

Based on the data collected, the study recommends the following technical considerations to future researchers who want to innovate the Automated Android-Based Dog Food Dispenser for Small Dogs with Global System for Communication (GSM) and Cloud Technology: (1) Design a structure where the water storage compartment can be adjusted to the height of the dog. (2) Improve the dog food dispensing design mechanism to increase the storage capacity of food and dispense accurately; (3) Design the leftover bin drawer to increase the storage capacity. (4) Add a water bowl and water dispensing feature using a solenoid valve to eliminate the water nozzle. (5) Add a feature that a fixed schedule of dispensing dog food every day on a specific set of times. (6) Add a surveillance camera for monitoring features of the system. (7) Develop a mobile application that can be compatible with both IOS and Android. (8) Finally, conduct an acceptability survey before the commercialization of the device.

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Vol. 06, No. 1 (2019)

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