Internet of Things based Pet Feeder Automation using Raspberry Pi

Adetokunbo A. Adenowo , Jonathan C. Anyi, James A. Akobada

Abstract— Household pets need special treatment and care. They need to be attended to as at when due with food, drinks, and medication. Due to busy life style of most owners, this task may not be as simple as expected. Lack of adequate attention to pets' needs might have great consequential effects, such as starvation, ill health, among others. In view of the foregoing, this work proposes an Internet of Things based automated feeder system that uses Raspberry pi to drive its remote control, scheduling and intelligence. Its design and subsequent implementation is expected to, at least, take care of the nutritional aspects of pets by providing as either scheduled or intelligently the food, drinks and medication of pets as at when due in the absence of the owner. Thus, this work aims to automate the monitoring and feeding process that is usually done manually by pet owners. To achieve the foregoing, the proposed system uses a food dispenser that is connected to a microcomputer which is programmed to control the feeder as scheduled, remotely or intelligently. Thus, allowing the user to have full control over the time a pet is fed and the amount of food consumed by the pet. The feeder can be controlled through a secure web application hosted on a local server and through advance scheduling. The results of the evaluation show that the design is viable and that the prototype automatic feeder system worked as designed.

Index Terms— Automation, Automated Feeder, Internet of Things, Pet Feeder, Raspberry Pi, Remote Control, Secure Web Application.

1 Introduction

Household pets need special treatment and care. Owners need to ensure food, drinks, and medication are served as at when due. Lack of adequate attention to pets' needs might have great consequential effects, such as starvation, ill health, among others. Due to concurrent tasks demanding owners' attention, couple with busy life style, management of these pets may not be as simple as expected. Hence, the need to migrate from manual to technology-based management of pets' daily needs. An Internet of Things (IoT) based automatic feeder system comes handy to assist in the management of pets needs. The latter technology will enable pet owners to remotely manage critical needs that are automatable while engaged in other time and attention demanding tasks.

In the literature, several works have been done in attempt to automate diverse human activities. For instance, Asadullah et al. [1] deployed a home automation system to remotely control up to eighteen (18) home appliances using Arduino board, Bluetooth, Smartphone, ultrasonic sensor and moisture sensor. The technology can also detect water level and soil moisture if deployed as plant irrigation system. Ricci [2] proposed methods and systems for home automation that determines state of and/or activities within a household and provide information to remotely located owner. Thus, the house owner can remotely identify occupants and monitor their activities. Orr et al. [3] presented a speech-enabled technology using virtual assistant that accepts speech as input to control electronic devices in remote location. The virtual assistant has natural language processing capability. Thus, via speech, devices within the technology network can be remotely controlled.

According to Singh et al. [4], automation based Internet of Things (IoT) is becoming versatile and popular. The technology enhances human life due to its capability to provide smart management of appliances at target locations. In view of this, the latter developed a prototype that controls home appliances such as light, fan, energy consumption, level of Gas cylinder, among others, using sensor and Arduino device. With the solution, they were able to detect the presence or absence of human object in the target location, manage energy consumption and check gas level.

In the same light, an IoT-based feeder system should be able to automate feeding and other related provisions or needs of pets. Such IoT-based feeder system can be designed in a way that it dispenses precise amount of food or other provisions at specific time intervals, reduce the amount of time owners spend on feeding and monitoring of household pets [5]. In addition to the relief the automated feeder system gives to pet owners, it can be programmed in such a way that it can be controlled with the push of a button or remotely through voice commands (as in [3]) and via a web application with a good user friendly interface.

Asides the benefits automatic pet feeders give its users, it can also regulates the amount of food given to pets since it can be programmed to dispense specific amount of food, thereby ensuring pets are not malnourished or overfed which may lead to obesity especially when the pets are still very young. In view of the aforementioned benefits, Ibrahim et al. [5] developed an Arduino microcontroller based mechanism. The microcontroller is used to control a pet feeder. In determining the

- *Adetokunbo A. Adenowo is a lecturer in the dept of Electronic & Computer Engineering,Faculty of Engineering,Lagos State University,Lagos, Nigeria. E-mail: adetokyom@yahoo.com.*
- *Jonathan C. Anyi is a student in the dept of Electronic & Computer Engineering,Faculty of Engineering,Lagos State University,Lagos, Nigeria. E-mail: anyijonathan@yahoo.com*
- *James A. Akobada is a student in the dept of Electronic & Computer Engineering,Faculty of Engineering,Lagos State University,Lagos, Nigeria. E-mail: akobada7@gmail.com,*

ISSN 2229-5518

maximum stress the mechanism can withstand, the latter authors applied finite element analysis; they achieved appreciable success that provides insight into how to improve the mechanism. Jadhav et al. [6] used an existing Smartphone application (i.e. Blynk) to automate the feeding of fish. They argued that keeping and viewing fish at home can reduce stress when treated as pet like cats, dogs, cows, etc. Unlike other domestic animals or pets, fish requires extra care, thus the automation will minimized human effort in managing its needs.

In line with existing literatures, a typical pet feeder should have a dispenser that releases dry pet feeds; the amount of food dispensed can be regulated by a motor. The number of revolutions the motor makes usually determines the quantity of dry pet feeds dispensed. Part of the first automated pet feeder systems designed is the Gravity Feeder [7]; it has a hopper full of pet food which is dispensed evenly through its ports to a bowl. The feeder keeps filling up same bowl as dispensed food are consumed by the pet. Thus, the continuous filling of the bowl can be said to be the down side of this basic pet feeder. This implies that a pet owner would be unable to control the amount of food consumed by the pet. Similarly, Yaomin [8] designed an automatic pet feeder mechanism that has a food hopper and feeds serving tray. The hopper is designed such that its bottom is larger than its top, a cylindrical shaft fitted at its center, and with a tapered outer wall.

Vittuari et al. [9] designed an automatic distribution apparatus that can supply consumables to pets, particularly dogs and cats which are fed even when the owner is not around. It makes use of card programmed according to the users control panel. The apparatus makes use of mechanical operations through the use of a volumetric screw feeder which ensures precise feeding operation even when varying size of pellets is used. Furthermore, Krishnamurthy [10] developed a pet feeder that consists of a base, feeding bowl, a timer module and a lock which holds the entire unit in place. This invention can also serve as a playmate when the pet owner is not around; this was achieved by connecting a toy holder which when actuated by an ejector throws off the toy at specified distance, the toy holder is also actuated by a string connected to a motor which is programmed by microprocessors.

Currently, there are lots of pet feeding devices in the market, aimed at ensuring that pets get a healthy amount of feeds even when the pet owner is away. The major difference in the various pet feeding devices is the degree of control that these devices could give to pet owners and the methodology used to achieve it.. Hence, this study proposes a pet feeder system that is IoT driven. The proposed solution, with the aid of a user friendly interface and the integration of IoT into pet feeder device, would allow users / owners control the pet feeder remotely. Also, it will enable owners monitor the pet to ensure that proper feeding is always carried out. The proposed design would give pet owners the freedom to travel knowing that with the automatic pet feeder, the pet would be well taken care of.

1.1 Theoretical background

Part of objectives of this work is to enable remote access to the automatic pet feeder in order to feed a pet from any part of the world. For that to be possible access to a network is needed; this can be achieved via an Internet protocol (IP) address.

1.1.1 IP Address:

An IP address is a unique numerical label assigned to devices connected to a network. For the automatic pet feeder to be accessed remotely, an IP Address would have to be assigned to the pet feeder through the network interface of the Raspberry pi. There are two types of IP address that are indicative of locations of a network, namely:

- Private IP address - A private address is an address assigned to devices expected to communicate within a LAN only.
- Public IP address - A public IP address is an address that uniquely identifies devices over the Internet. Seems the automatic pet feeder is expected to communicate with the pet owner over the Internet, a public IP address would have to be assigned to it by a service provider. Current study, the automatic pet feeder is expected to be connected to a trusted home network.

1.1.2 Routing protocol:

For devices on different network to communicate, a routing protocol must be setup. This would ensure the pet owner's network would communicate effectively with the home network where the pet feeder is located. Internet service providers make use of border gate protocol (BGP) to route or send data over different networks [11]. BGP is a path vector protocol that is designed to exchange routing and reach-ability information among various autonomous systems on the Internet. With a BGP routing protocol setup, a home network should be able to effectively communicate with the pet owners' network. Fig 1 below illustrates a home network topology that connects the pet feeder.

International Journal of Scientific & Engineering Research Volume 11, Issue 8, August-2020
ISSN 2229-5518

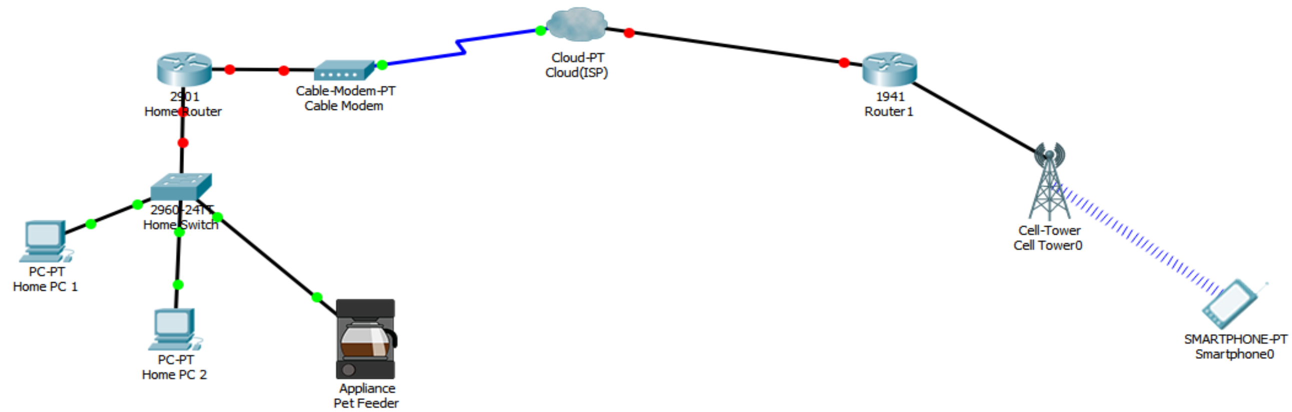

Fig 1: A network that connects the feeder to the Internet

2 MATERIALS & METHODS

This section explains the materials, as well as the methods adopted in this study. The section discusses the components used and concepts that relate to this work. In addition, the process of choosing individual material and procedure for fabrication and assembly of the proposed automated pet feeder is explained.

2.1 Components

The materials that would be needed for the fabrication of the automated pet feeder consists a Raspberry pi, a shaft, stepper motor, relay and food container.

2.1.1 Raspberry pi

Raspberry pi is a series of micro-computers developed in the United Kingdom by the Raspberry Pi Foundation. The major reason for the development of Raspberry Pi is to promote basic computer skills in schools and developing countries around the world. According to Raspberry Pi Foundation, an approximate of 5 million or more Raspberry Pi units were sold in the year 2015 and by early 2018, the total sale reached over 19 million. Raspberry pi gradually became the world third best-selling general purpose computer due to its use of Python as a major programming language [12].

Raspberry pi has several release models such as Raspberry Pi 1, 2, zero, 3 models B and B+, among others. Raspberry Pi model B is one of the latest; it was released in the year 2016. It comprises of a 1.2GHz 64-bit quad core processor, with on board 802.11n Wi-Fi and USB boot capability. Two years after, the Raspberry pi model B plus (+) was released. It has a faster processor (1.4GHz), Power over Ethernet (PoE), USB boot capability and a network Boot which makes model B + a perfect microcomputer for this study due to its processor speed and its ability to connect to a home network for remote access [12].

2.1.2 Cortex-A53

The power engine behind the operation of Raspberry Pi B+ is the Cortex-A53. The processor is mostly 64bit making it a very fast processor. The Cortex-A53 processor has up to four cores, each of the cores has an L1 memory system and a single shared L2 cache. The most advantageous feature of the Cortex-A53 processor is its performance and high level of power efficiency [13].

2.1.3 Pi Camera module

The Raspberry Pi Camera Module is a high quality 8 megapixel Sony IMX219 image sensor designed for Raspberry Pi, featuring a fixed focus lens. The Raspberry Pi module became prominent from the release of Raspberry Pi Zero [14]. The Pi camera supports up to 1080p30, 720p60 and 640x480p90 video making it a valuable piece for implementing a monitoring system for the study.

2.1.4 Stepper motor

A stepper motor is a brushless DC motor that converts electrical power to mechanical power [15]. A stepper motor also called stepping motor divides full rotation into equal steps therefore, and the motor's position can be programmed to start of stop at specific steps. Stepper motors use the theory of operation for magnet to make its shaft turn in a particular distance. A stepper motor consists of stator and rotor with eight and six poles respectively. The rotor moves exactly 15 degrees for each pulse of electricity received.

Operationally, stepper motors mode of operation is very differently from DC brush motor. A stepper motor consists of multiple toothed electromagnets around a central gear. The electromagnets are controlled and energized by external microcontroller. For the stepper motor to turn, the electromagnet would be energized which in turn makes the gear's teeth attracted to the electromagnet's teeth. When the gear's teeth are aligned with the first electromagnet, it's slightly offset from the next electromagnet, therefore, when the next electromagnet is turned on and the first electromagnet turned off, the gear then rotates slightly which completes one full step (see [16] for detail description).

ISSN 2229-5518

2.1.5 Relay

Relays are electrically operated switch. Relays are mostly used when a circuit is to be controlled by an independent low power signal or where multiple circuits are to be controlled by just one signal. A simple electromagnetic relay would have a coil wrapped around a soft iron core, otherwise known as a solenoid, an iron York which is to provide low reluctance for magnetic flux and a movable iron armature [17].

When electrical current is passed through the coil, it would then generate a magnetic field which would then activate the armature. The movement of the movable contacts makes or breaks connection with the fixed contact. Contacts used in relays vary depending on the application of the relay.

2.2 The Automation Process

The process towards automating the proposed feeder system is depicted by the block diagram in Fig 2 below. Each aspect of the design is important for the system to be fully functional. The proposed system is designed to use Raspbian (a Linux based operating system – due to its compatibility with Raspberry pi) and powered by Cortex a-53 processor. Also, a local server (Apache) is installed to enable easy control of the entire system. In implementing the automation process as depicted in the fig. 2 below, Raspbian OS is installed first. This is followed by programming the Cortex A53 microprocessor which regulates the entire automated system.

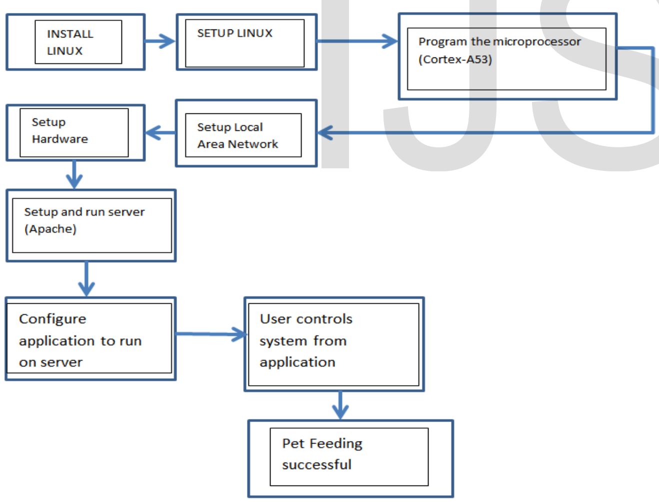

Fig 2: Block diagram of the proposed automated pet feeder system

2.2.1 Installing Raspbian OS

Raspbian is a Linux distribution operating system that is compatibility with Raspberry Pi models. The operating system supports python programming language which is required to write programs / scripts that run in microprocessor to achieve the automation objective. To install Raspbian, the following items are required: a microSD card (with no less than 8 GB), a PC with a space for it, and, obviously, a Raspberry Pi and other fundamental peripherals (such as a mouse, console, screen, and power source); and the following steps can be taken:

Step1: Download the Raspbian

Turn on a PC that is contented to the Internet and then download the Raspbian disc image. Note that the most recent variant of Raspbian can be found on the Raspberry Pi Foundation's site.

Step2: Unzip Raspbian File

The Raspbian disc image is compressed, so it should be unzipped. The file uses the ZIP64 format, so depending on how current built-in utilities are, one needs to use certain programs to unzip it. For instance, Unzip is used by Linux users.

Step3: Write the disc image to microSD card

Insert the microSD card into a computer and write the disc image to it. The process of actually writing the image will be slightly different across programs. Each of these programs will require selecting the destination and the disc image (the unzipped Raspbian file). Choose, double-check, and then click on the write button (See fig. 3 below).

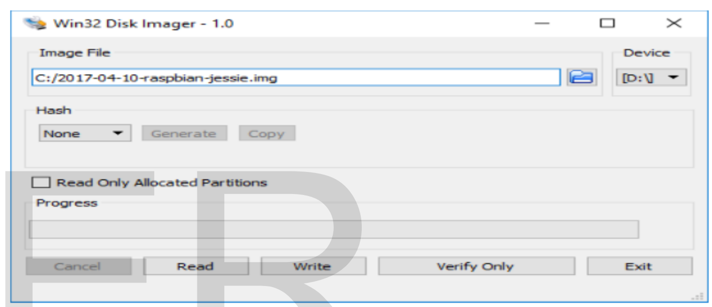

Fig 3: Installing Raspbian OS on Raspberry pi [18]

Step 4: Put the microSD card in the Raspberry Pi and boot up

After storing the disc image in the microSD card, put the microSD into the Raspberry Pi, plug in the peripherals and power source. The Raspbian will boot straightforwardly to the desktop. The following username: ***pi*** and password: ***raspberry*** can be used as default credentials. For further guide on how to install Raspbian OS, see online content [18].

2.2.2 Programming and Setup of Raspberry Pi

Python is an interpreter-based high-level computer programming language. Python's design philosophy lays emphasis code simplicity and readability. Python happens to be the major programming language used on all Raspberry Pi models. Thus, the Raspberry pi is purposely programmed for the pet feeder system in order to automate it. Thereafter, the Raspberry pi is setup using appropriate commands as stated in its technical documentation. For detail setup information, see Raspberry Pi user's guide [19].

2.2.3 Setup Electrical Components

After the Rasbian OS is setup, the next step is to wire-up the components that will be attached to the Pi's GPIO pins. Thereafter, a functionality test is undertaken by connecting the wired components to the Pi. Fig. 4 below is the schematic diagram of the proposed system showing the wired components as connected to the pi.

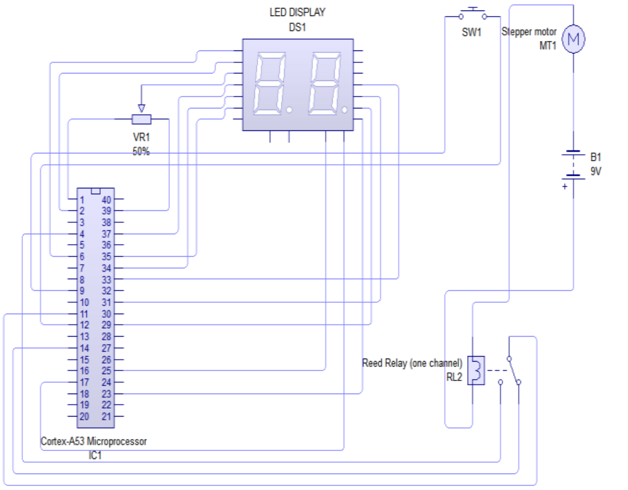

Fig. 4: Schematic diagram of the automated pet feeder system

The components wiring steps are presented below thus:

i. Wire button

ii. Wire and setup the stepper motor as in fig. 5.

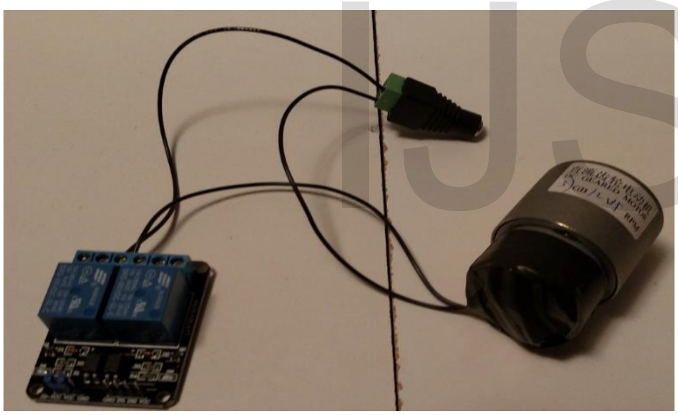

Fig. 5: Stepper motor setup

iii. Wire the LCD screen as shown in fig. 6.

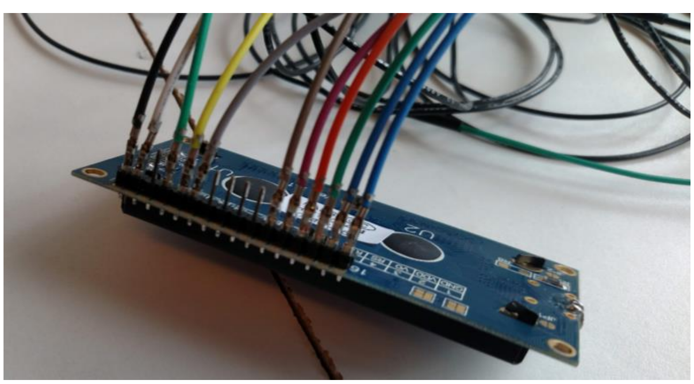

Fig. 6: Wiring of the LCD screen

iv. Connect and test wired components to Pi – the button, motor and LCD screen components are all connected to pi. Thereafter, a test is conducted to ensure everything is working correctly. See fig. 7 below.

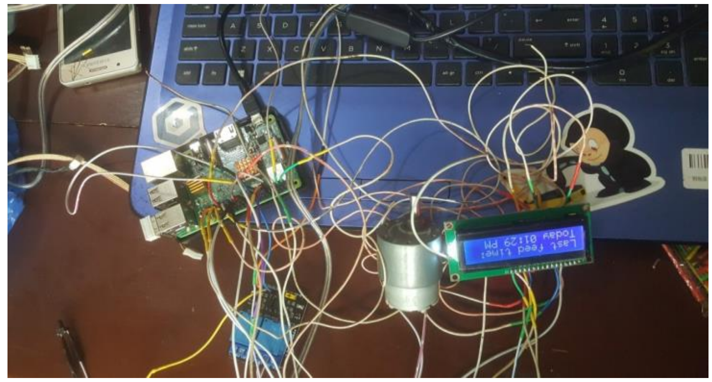

Fig. 7: Testing of the system before assembly

v. Construction of Box - Once it is verified that everything (i.e. step iv above) is working well, the Raspberry pi is shut down. This is followed by building the system box that will house all the components as shown in fig. 8 below.

Fig. 8: Initial assembly stage of the feeder system box

vi. Finally, assemble all the components and connect to have a complete working system. See Fig. 9 below.

Fig. 9: Advance assembly stage of the feeder system

3 TESTING AND RESULTS

In line with the main objective of this work, to design a system that automates the feeding process of common household pets with easy remote operation and user friendly interface, a prototype system was designed and evaluated. The critical aspect of this work is the human surveillance and controlled pet feeding. The foregoing is important due to the security issues of smart applications and obesity experienced by young household pets at early age.

Thus, for surveillance and in line with design methodology, motion detection Raspberry Pi camera was used along with OpenCV (an open source computer vision library). Python language acts as the main programming platform to program the raspberry device in order to achieve the desired automation.

Table 1: Results of evaluation of prototype

Testing	Operation Mode	Response Time (Sec)	Stepper Motor (Rev/Sec)	Size of Feeds Dispensed (in gram)	Remark
1	BUTTON	1	3	50	GOOD
	INTERNET (WAN)	NIL	NIL	NIL	BAD
2	BUTTON	1	3	50	GOOD
	INTERNET (WAN)	NIL	NIL	NIL	BAD
	INTERNET (WAN)	NIL	NIL	NIL	BAD
	INTERNET (WAN)	NIL	NIL	NIL	BAD
3	LOCAL AREA NETWORK	3	3	50	GOOD
4	LOCAL AREA NETWORK	3	3	50	GOOD

Table above shows a detailed result of the testing done after the prototype automatic feeder system was completed and evaluated. From table 1 above, both the button and operation via local area network showed good feeding operations from the pet feeder. An increase in the duration of the stepper motor gives an increase in the amount of feeds dispensed.

4 CONCLUSION

This design of an IoT based automatic pet feeder system was done in consideration of some factors such as: economic application, user convenience, availability of components and research materials, efficiency, compatibility, portability and durability. As earlier stated, this work aims to enhance the management of pets, giving their owners greater flexibility in the provision of essential care and nutritional and medical needs, despite their multiple time and attention demanding tasks and busy schedules. The prototype and subsequent evaluation, however, indicates that the research goal is feasible and achievable. Thus, current work extends previous efforts in the management of household pets and can also be extended to cater or manage commercial farm birds.

ACKNOWLEDGMENT

The authors wish to thank colleagues that provided comments and helped improve this work.

REFERENCES

[1] M. Asadullah and K. Ullah, “Smart home automation system using Bluetooth technology,” In 2017 International Conference on Innovations in Electrical Engineering and Computational Technologies (ICIEECT), April, 2017, pp. 1-6, IEEE.

[2] C.P. Ricci, “Providing home automation information via communication with a vehicle,” U.S. Patent No. 9,378,601, issued June 28, 2016.

[3] R.M. Orr, G.R. Nell and B.L. Brumbaugh, “Intelligent assistant for home automation,” U.S. Patent No. 10,170,123, 2019.

[4] H. Singh, V. Pallagani, V. Khandelwal and U. Venkanna, “IoT based smart home automation system using sensor node,” In 2018 4th International Conference on Recent Advances in Information Technology (RAIT), March, 2018, pp. 1-5, IEEE.

[5] M. Ibrahim, H. Zakaria, and E.W. Xian, “Pet food autofeeder by using Arduino,” In IOP Conference Series: Materials Science and Engineering, Vol. 670, No. 1, November, 2019, p. 012069, IOP Publishing.

[6] K. Jadhav, G. Vaidya, A. Mali, V. Bankar, M. Mhetre and J. Gaikwad, “IOT based Automated Fish Feeder,” In 2020 International Conference on Industry 4.0 Technology (I4Tech), February, 2020, pp. 90-93, IEEE.

[7] A.R. Page, “Gravity feed dog feeder,” U.S. Patent No. 4,538,548, 1985.

[8] M.A. Yaomin, “Automatic pet feeder having rotating food hopper and food leaking plate,” U.S. Patent No. 9,560,834, 2017.

[9] E. Vittuari, G. Vittuari, M. Vittuari and M.R., “Automatic feed distribution apparatus for animals,” U.S. Patent No. 6,145,472, 2000.

[10] S. Krishnamurthy, “Automatic pet feeder,” U.S. Patent No. 7,650,855, 2010.

[11] K. Weitz, D. Woos, E. Torlak, M.D. Ernst, A. Krishnamurthy and Z. Tatlock, “Scalable verification of border gateway protocol configurations with an SMT solver,” In Proceedings of the 2016 ACM SIGPLAN International Conference on Object-Oriented Programming, Systems, Languages, and Applications, October, 2016, pp. 765-780.

[12] https://en.wikipedia.org/wiki/Raspberry_Pi

[13] J. Ivković and B. Radulović, “The advantages of using Raspberry Pi 3 compared to Raspberry Pi 2 SoC computers for sensor system support,” In proceedings of the 6th International Conference on applied internet and information technologies, Bitola, 3-4 June, 2016, 88-94.

[14] https://projects.raspberrypi.org/en/projects/getting-started-with-picamera.

[15] I. Ionică, M. Modreanu, A. Morega and C. Boboc, “Design and modeling of a hybrid stepper motor,” In 2017 10th International Symposium on Advanced Topics in Electrical Engineering (ATEE), March, 2017, pp. 192-195, IEEE.

[16] D.M. Considine and G.D. Considine, “Stepper Motors and Controls,” In: Considine D.M., Considine G.D. (eds) Standard Handbook of Industrial Automation. Chapman and Hall Advanced Industrial Technology Series, 1986, Springer, Boston, MA.

[17] V. Gurevich, Electric Relays: Principles and Applications. Taylor & Francis, 2016.

[18] https://dronee.aero/blogs/lychee/how-to-install-raspbian-on-lychee

ISSN 2229-5518

[19] G. Halfacree and E. Upton, Raspberry Pi User Guide. 1st Edition. Wiley Publishing, 2012.