Dog Bowel Pad Training IoT by Automatic Snack Feeder and Owner's Voice Compliment Speaker for Human Convenience

Subin Kim
The Division of Computer Convergence
Chungnam National University
Yuseong-gu, Daejeon, Republic of Korea
soo010410@o.cnu.ac.kr

Eunsoo Kim
The Division of Computer Convergence
Chungnam National University
Yuseong-gu, Daejeon, Republic of Korea
loveangelina@o.cnu.ac.kr

Choeun Lee
The Division of Computer Convergence
Chungnam National University
Yuseong-gu, Daejeon, Republic of Korea
choeun15@o.cnu.ac.kr

Yujin Jeong
The Division of Computer Convergence
Chungnam National University
Yuseong-gu, Daejeon, Republic of Korea
jyoojin1597@o.cnu.ac.kr

Ahyeon Song
School of Business
Chungnam National University
Yuseong-gu, Daejeon, Republic of Korea
mushr2001m@o.cnu.ac.kr

Jaden Soroka
Computer and Information Technology
Purdue University
West Lafayette, Indiana, United States
jsoroka@purdue.edu

Anthony Smith
Computer and Information Technology
Purdue University
West Lafayette, Indiana, United States
ahsmith@purdue.edu

***Abstract*—Dog bowel pad training is a common activity for indoor dog owners. Dog owners have been training bowel pads through reward learning to dogs directly. Dog owners are impossible to observe dogs 24 hours a day and difficult to conduct identical bowel pad training each time. This paper aims to create an IoT (Internet of Things) system that helps dog bowel pad training proceed equally each time without time constraints. It includes a system for detecting dog bowel movements on a pad, an automatic snack feeder system, an owner's compliment voice playback speaker system, and a product execution data collection website. The use of sensors to verify the accuracy of checking a dog bowel movement is explained by experiments on the dog's defecation temperature information and weight information. For future works, actual dog testing is expected to provide better accuracy.**

***Index Terms*—Bowel Pad Training, IoT, Load Cell, Thermal Camera, Reward Learning**

I. Introduction

For dog owners, dog bowel pad training is a time-consuming and labor-intensive process. On average, dog bowel pad training takes 4 to 6 months [1]. If the dog owner trains the dog around the clock, dog bowel pad training is possible in 7 to 14 days [1]. It is inefficient for dog owners to monitor dogs 24 hours a day for dog bowel training. To solve this problem, the bowel pad that provides snacks after detecting bowel movements [2], [3], and the bowel pad that provides snacks and plays back the owner's compliment voice after detecting urine [4] appeared. These products have been shown to help automate dog bowel pad training. On the other hand, there were many problems such as recognizing objects that are not defecation as defecation, detecting only urine except feces, and not separating the bowel movement space as a dining space. To solve the problem of interfering with bowel training, it is necessary to plan a product that detects the dog bowel movement and trains the dog based on reward learning [5].

This paper aims to facilitate dog owners to conduct complete dog bowel pad training. Therefore, it proposes a product that detects dog bowel pad activity and provides snacks and owners' voices as rewards. The proposed product focuses on accurately detecting bowel movements through weight and heat, providing snacks and the owner's voice in separate locations from the bowel pad location, and providing a fixed amount of snacks and the owner's compliment voices. This product uses weight sensors to recognize the dog bowel pad movement and a thermal camera to check the dog's defecation. Bluetooth is used to transmit the signal about detecting the dog bowel movement in order to separate the bowel movement space from the dining space, and then run an automatic snack feeder and the owner's complimentary voice. It provides quantitative snacks through the stepper motor and plays the owner's compliment voice through a Bluetooth speaker.

The accuracy of the product is confirmed by testing the product based on the dog's defecation temperature information and weight information. This product accurately detects bowel movements on the dog's pad and provides reward learning with snacks and the owner's compliment voice in a location separated from the bowel movement space for train the bowel

pad. This product helps dog owners conveniently carry out dog bowel pad training and helps dogs to succeed in bowel pad training. Therefore, this product has the potential to automate dog bowel pad training for human convenience.

II. Related Works

Several systems, such as the Learning machine for toilet training of pet dog [2], [3], Pet waste station and training device [4], have emerged to overcome the limitations of human-progressed dog bowel pad training. However, all of them have limits. This section provides a brief motivation for bowel movement detection with the thermal camera, automatic snack feeder system with stepper motor, and owner's compliment voice playback speaker via Bluetooth speaker compared to the proposed approach in existing systems.

A. Learning machine for toilet training of pet dog

Y. Kim [2], [3] provides a training tool that recognizes bowel movements on pads and provides snacks for the convenience of dog bowel pad training. The author uses a load cell weight sensor to recognize bowel movement [3]. The dog defecates on the bowel pad and comes down from the bowel pad [3]. When the weight of the bowel pad containing defecation reaches the specified range, it is recognized that the dog has defecated [3]. Recognizing bowel movements provides snacks by operating the transfer motor for a certain period or at a certain number of rotations [3]. However, the product did not take into account the case where other objects such as toys, not defecation, were placed on the bowel pad and did not consider the size of the snacks, so that a large number of snacks are provided.

B. Pet waste station and training device

H. Scanlan and *R. J. Schweizer* [4] provide a training tool that recognizes urine and provides snacks and an owner's compliment voice for the convenience of dog bowel pad training. The authors used an infrared sensor to detect heat in urine that gathers along the valve hole to recognize urine [4]. The automatic snack feeder is operated by a servo motor and provides one or more snacks to the dog [4]. The speaker built into the product plays the owner's compliment voice to help the dog's bowel training [4]. However, this product detects dog urine except for dog feces. In addition, since snacks are provided near the bowel pad, dogs are not well-trained for bowel movement since they recognize the bowel movement space as a dining space [6].

The proposed system shows an accurate detection of a dog's bowel movement and provides reward learning. Compared to the two products, the system uses a thermal camera. After checking the dog's access to the bowel pad with a weight sensor, photograph the pad with a thermal camera to see if the dog defecates. Use the stepper motor to manufacture an automatic snack feeder to provide the same amount of snacks for each training. The automatic snack feeder and the owner's compliment voice playback speaker are separated by connecting the pad with Bluetooth, accordingly the dog will separate the bowel movement space and the dining space. Previous products are difficult to train for accurate bowel movements, while the proposed system is possible.

III. Methodology

The system is divided into 3 parts detecting the bowel movement of the dog, the automatic snack feeder part, and the owner's compliment voice speaker part. The overview of all procedures is illustrated in Fig. 1.

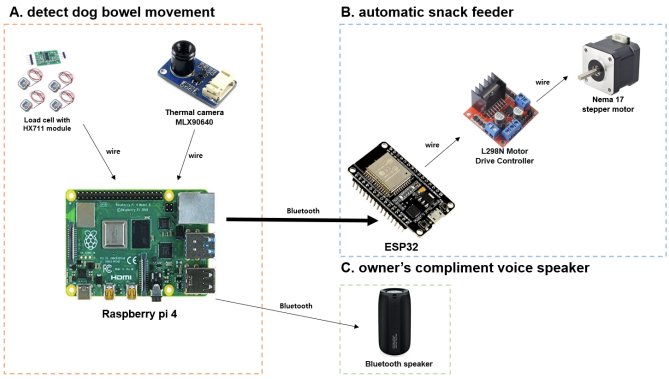


Fig. 1: Architecture Design

Subsection A describes detection of the dog bowel movement by connecting Raspberry Pi 4 to Load cells with the HX711 module and MLX90640 thermal camera. In the beginning, confirmation is prosecuted whether the dog existed on the pad by detecting the weight through Load cells with the HX711 module. If the dog got off the pad after defecation, the MLX90640 thermal camera starts operating [7]. When the temperature of the captured image exceeds the threshold, the Raspberry Pi sends a signal to ESP32 through Bluetooth [8]. Subsequently, Subsection B is conducted, which is responsible for the automatic snack feeder. By L298N Motor Drive Controller, the voltage and the electric current are amplified and Nema 17 stepper motor is controlled. An automatic snack feeder provides a certain amount of snacks to the dog through constant angular rotation. Subsection C, Owner's compliment voice speaker part, follows. The owner's complimentary voice for proper bowel movement is played through a Bluetooth speaker connected to Raspberry Pi.

A. Dog Bowel Movement Detection

A weight-sensing system indicates if the dog is positioned exactly on the bowel pad. Weighing is performed with four 3-wire load cells that scale up to 50kg. These four load cells are mounted to the four vertices of the platform on which the bowel pad is to be placed. They uphold the platform stably and facilitate accurate measurements by forming a full-bridge. The measured values from load cells are converted to digital signals through HX711 [9], a high-precision A/D converter chip. HX711 is the bridge between load cells and Raspberry Pi [9]. A calibration process is conducted to affirm the accuracy of the weight readings. When the weight sensing system detects a weight change of more than 500g, it is

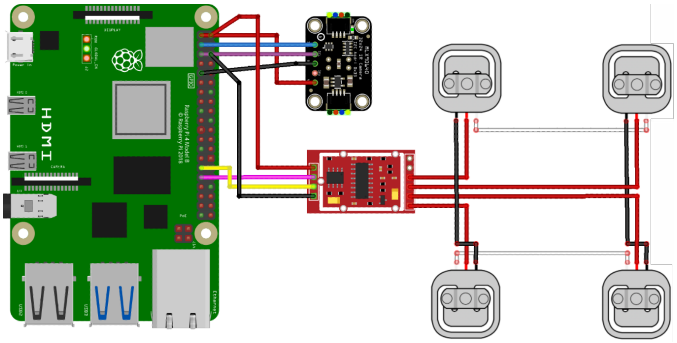


Fig. 2: Raspberry pi 4 connected to Load cells and Thermal camera

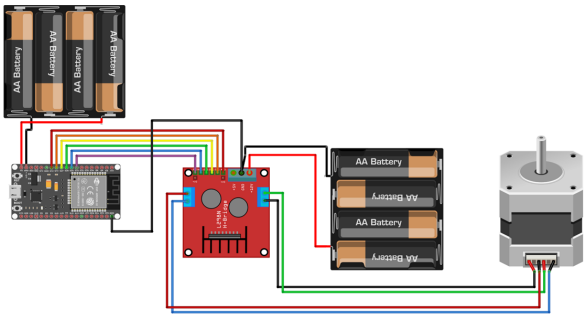


Fig. 3: ESP32 connected to Stepper Motor

considered that the dog moves in and out of the pad. If the system decides that the dog got off the pad, the thermal camera is activated for detecting whether the dog has performed bowel movements on the pad.

After recognizing that the dog got off the pad by weight sensor, the MLX90640 thermal camera starts operating. The MLX90640 is a 32x24 pixels thermal IR array with digital interface, and it is used for high precision non-contact temperature measurements [7], [10]. The MLX90640 thermal camera captures the moment and produces the image through the detection of infrared ray [7]. Fig. 2 shows the wiring diagram for the MLX90640 to Raspberry Pi. The camera and Raspberry Pi communicate via the Inter-Integrated Circuit(I2C) protocol [7], [11]. I2C protocol is a communication protocol which conducts serial communication with 2 wires, allowing one master device controls one or other slave devices [11]. After reading the values from MLX90640, thermal image visualization is performed with the data. To improve the quality of the thermal image, an interpolation is implemented to plot the raw values from the MLX90640 for the resolution [12]. Using a *zoom* method from an image processing toolbox of the Python library, the basic resolution is improved [12]. By comparing the threshold of the dog's excrement temperature and the max temperature value in the array, it is detected whether it is a real excrement. If the detecting result is a real excrement, the auto feeder is activated and the compliment voice of the owner is played for compensation. Then, the measured values are sent to Thingsboard and the picture is uploaded to Google drive.

B. Automatic Snack Feeder

The automatic snack feeder is composed of a stepper motor SY42STH38-1684A, ESP32, and a motor driver L298N. The stepper motor is needed to rotate the automatic feeder in which there are snacks for dogs. The stepper motor controls the angle set by the user [13]. Moving the motor requires a large amount of voltage/current. The rated current of both ESP32 and Raspberry Pi are generally lower than the requirements of the motor. Accordingly, the motor driver L298N is needed to amplify voltage/current and to control the motor [14]. To operate ESP32, supply extra voltage by connecting a 6V external battery to the VIN pin and GND pin [15].

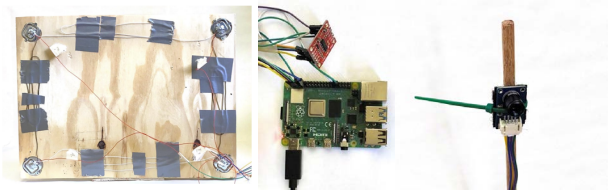
The automatic snack feeder is a short cylindrical shape, and consists of two parts. First is the inner part which has 8 compartments [16]. Second is the cover part which has a hole at the bottom to fit the size of a compartment. When the thermal camera detects a dog bowel movement, Raspberry Pi sends a signal to ESP32. ESP32 receives the signal to serve snacks from the Raspberry Pi by Bluetooth, and the inner part of the feeder rotates. The stepper motor is attached to the inner part, so it rotates 45 degrees clockwise each time when the signal is received. Then, snacks inside the automatic snack feeder fall.

C. Owner's Compliment Voice Speaker

A speaker is used to provide compensation to the dog through the owner's compliments [17]. The speaker is connected to the Raspberry Pi via Bluetooth. Raspberry Pi 4 and the speaker have built-in Bluetooth modules [18]. The recorded owner's audio file is stored in the Raspberry Pi. The owner's compliment voice mp3 file is played as a reward whenever the dog has completed the correct bowel movement on the bowel pad.

IV. Implementation

A. Dog Bowel Pad Training Product



(a) Load Cells (b) HX711 (c) Thermal Camera

Fig. 4: Dog Bowel Movement Detection Pad

Fig. 4 shows the Dog Bowel Movement Detection system. It detects the weight changes employing 4pc 50kg strain gauge load cells. An outer square is attached to the training pad so that an inner part must be flexible to obtain the resistance

change of the strain gauge [19], [20]. Thus, the inner square should be floating in the air and the outer side hole is 0.08 inches, and the inner side hole is 0.16 inches hole.

Algorithm 1 Detect weight changes

```
while true do
    weightVal ← recentWeightValue
    append weightVal to last_val
    if the length of last_val more than 60 then
        pop the last value out of last_val
    end if
    if weightVal < standardOfEmptyPad then
        filter last_val over weightVal + 500
        if last_val ≠ 0 then
            set last_val empty
            open thermal camera file
        end if
    end if
end while
```

Raspberry Pi needs the HX711 library to get measurements from load cells [21]. So, Dog bowel movement detects with Algorithm 1 and HX711 opensource library [22]. When the load cells file runs, weight values measured in one minute get inside the last_val list and the last_val list is updated in the loop. While the power turns on, load cells are running for detecting dog bowel movements. If it detects 500g weight loss after and before dog movement, the thermal camera file runs and the thermal camera takes a heat image.

After recognizing that the dog got off from the pad, the thermal camera works. The camera has been placed on a stick to take pictures of the whole pads, and perform the role of recognizing whether it is excrement or not. The thermal camera and Raspberry Pi communicate via the I2C protocol and capture a thermal image. After reading the values of MLX90640 breakout board using *Adafruit* library, an image interpolation from the arrays of the data is conducted for smoother depiction of the temperature [12]. Using the *zoom* method of nd image tool box from the Python library *Scipy*, the original resolution 24x32 is changed to 240x320 [12].

If a person changes the pad after the dog has defecated, the product should not operate. Hence, the threshold of temperature needs to be higher than the temperature of the back of the human hand and lower than the temperature of the dog's excrement. When the temperature of the back of the human hand was measured through the thermal camera at a distance slightly shorter than the distance between the thermal camera and the bowel pad, the temperature of the back of the human hand was measured to be 34°C. Since the temperature of the dog's urine is 38°C, the threshold was set to 35°C, which is the value between them [23].

Comparing the threshold of the dog's excrement temperature and the max temperature value in the array, if the max temperature value exceeds the 35ºC as threshold, the automatic feeder is activated through Bluetooth communication with ESP32 and the compliment voice of the owner is played by

Algorithm 2 Detect the temperature

```
if max_temperature ≥ 35 then
    send temperature data to Thingsboard
end if
```

the Bluetooth speaker. Then the measurements are sent to the Thingsboard to enable real-time data visualization and the photos are saved and uploaded to Google Cloud.

When the thermal camera detects a temperature over 35°C, the Bluetooth speaker plays the audio file containing the owner's praise [24]. The audio message is stored on the Raspberry Pi SD card. *python-VLC* library is used to play the saved owner's compliment voice.

(a) Top View of Feeder (b) Side View of Feeder

Fig. 5: Automatic Snack Feeder

As shown in Fig. 5, an Automatic snack feeder is made by cutting the cardboard. The rotating partition is divided into 8 compartments, and the base which is located under the rotating partition is a round shape that is cut out 45 degrees. Snacks are placed in each of the 7 compartments. The other compartment is the exit where snacks come out. Therefore, When the ESP32 receives a Bluetooth signal from the Raspberry Pi that detected a temperature over 35°C, the stepper motor rotates 45 degrees. Snacks in each compartment move, and a snack at the exit compartment falls out by gravity.

B. IoT Platform

This paper includes a website to show when the dog poops, the dog's stool temperature, and how often the dog makes the bowel movement per day. This website used the Live Demo server provided by Thingsboard [25]. The device forwards the information to Thingsboard via the cURL command using the HTTP protocol [26]. Each device shows the web uniquely for each customer who uses the product through customer assignment.

As shown in Fig. 6 (a), users monitor the dog's bowel movement frequency per day with Timeseries Line Chart. When the system checks the dog bowel movement on the training pad, Raspberry Pi 4 transmits the dog's stool temperature data to Thingsboard via cURL code supported by HTTP Protocol [26]. Fig. 6 (a) presents the number of dog stool temperature data transmitted in a day. This website provides the dog's bowel movement frequency from Monday to Sunday weekly. Also, users know the count of the dog's bowel movement for the

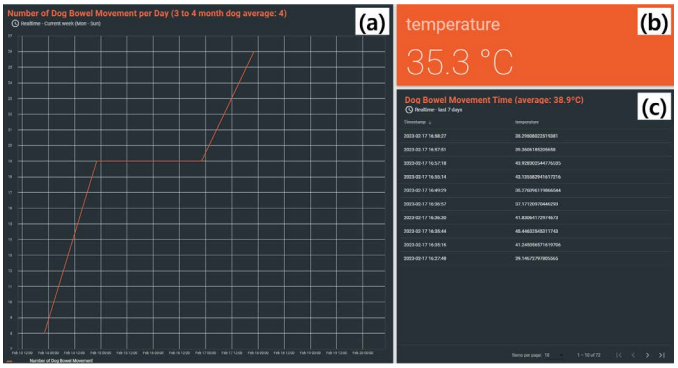


Fig. 6: Thingsboard IoT Platform

desired period by selecting a particular time. The name of the graph, "Number of Dog Bowel Movement per Day (3 to 4 month dog average: 4)" indicates that the 3 to 4 month old dog makes 4 bowel movements per day on average [27]. Thus, users diagnose their dog's health condition by comparing the number of measured values on the graph to the average number. Fig. 6 (b) shows the recent dog stool temperature to the first decimal place. In fig. 6 (c), it reveals the temperature data and time received by Raspberry Pi 4 for the last 7 days. When users choose the time range, (c) shows only the data corresponding to the time slot. As the name of the graph, "Dog Bowel Movement Time with Temperature (average: 38.9ºC)" tells, the average temperature of the dog stool is 38.9°C [23], [28]. Users determine their dog's condition between the dog's stool temperature and the average temperature of dogs.

C. Test Result

Several tests have been conducted to prove the functionality of the proposed system. Bottles of water were used as a weight-sensing substitute for the dog. A dog is replaced with two 500g water bottles, since the average weight of a 3-month-old small dog which is starting bowel training is about 1kg [29]. Heated cloth and water were used in place of the dog's bowel movements in the tests. These objects were set to 38°C, the same as the dog's defecation temperature [23].

The test scenario is as follows. The weight sensors tare the scale when Raspberry Pi is first run. Afterwards, the weight on the pad is measured continuously. By putting two 500g water bottles on the pad and putting down after a certain period of time, the process of the dog defecation on the pad and coming down is reproduced. The dog's bowel movement is carried out by placing a cloth or water heated to 38°C on the pad. When the weight sensor detects weight loss of more than 500g by removing the water bottle from the pad, which means the dog is off the pad, the thermal camera takes a temperature image of the pad. The camera is installed 22 inches high from the pad to capture the entire pad. If the thermal camera detects temperatures above 35°C on the pad, it determines that the dog has defecated and sends a signal to the reward system. The scenario ends when the speaker and the automatic snack feeder receive a signal through Bluetooth and provide the owner's compliment voice and snack.

The reliability testing of the system is performed in two main aspects. First, the reward should be provided when the dog does the bowel movement on the pad. Second, the reward system should not operate in the rest of the situation other than the actual dog bowel activity. The test verifies that the system gives the desired results by using reference value of the dog's weight and defecation temperature.

- Replacing Pad: This test shows that when the owner changes the pads, the pressure and temperature of the hand triggers the system's compensation system. As the result, all 20 tests did not recognize the pad replacement process as defecation activity and the reward system did not work. While changing the pad, the weight change of more than 500g by hand pressure was measured. But the system avoided incorrect operation because the reference temperature was set higher than the temperature of the back of hand.
- Objects: The scenario supposes that the dog put the object like toys on the bowel pad while doing activities. It was tested with various objects used in daily life. Two 500g water bottles and an object being tested were placed together on the bowel pad to create a situation in which the dog bit the object and sat on the pad. As a result of the test, the objects were lower than 35°C, so all 20 tests did not recognize the objects as defecation. This shows that the system can distinguish between defecation and objects.
- Excrement: Excrement test verifies the reward system operates well when detect over then 500g weight changes and 35°C temperature. It premises the situation which dog do a bowel movement in practice. Cloth that heated to 38°C was used instead of feces, and hot water was used instead of urine. To detect the feces, two 500g water bottles and heated cloth were put on the bowel pad. After few second, the bottles were put off from the pad. The reward system worked properly in all 20 tests. In order to simulate dog's urine, two 500g water bottles were placed and then heated water was sprayed on the bowel pad. After that, the bottles were removed from the pad. In this case, the reward system worked 16 times out of 20 tests. In summary, the feces test had an accuracy of 100%, and the urine test had an accuracy of 80%. The reason for the lower accuracy in the urine test is that the urine cooled down before the dog went down the pad.

This test was not performed by using actual dogs. So, there is a limit to be tested in an artificial circumstance. It has a possibility to occur unexpected errors in the environment for real dogs. Each 20 times of the test is insufficient to get reliability. When the weight sensor detects a change in weight, the thermal imaging camera detects the temperature and if the maximum temperature is exceeded the threshold, it sends a Bluetooth signal to ESP32 to activate the automatic feeder and the Bluetooth speaker. The point is this mechanism

operates well 36 times out of all 40 tests, in other words, a probability of 90%. These results reflect the ultimate purpose of this system to increase human convenience in dog bowel training.

V. Conclusion

This paper suggests a system that helps the dog's bowel pad training for human convenience. It detects the dog on the dog's bowel training pad using load cells and checks whether the dog conducts the bowel movement through the thermal camera. When detecting a dog's bowel movement, this product helps the dog to constantly execute bowel movements in a set space through reward learning that gives snacks and the owner's compliment voice. The test of the product was conducted based on the dog's bowel temperature information and weight information. The product distinguished defecation from other objects such as toys and hands, and provided reward learning with snacks and the owner's compliment voice. Snacks were adjusted to the amount desired by the owner, and the dining space was separated from the bowel movement space. In other words, this product has the potential to provide convenience to humans by monitoring the presence or absence of bowel movements of dogs in real time and facilitating dog bowel movement training through reward learning. In future works, it is recommended to perform additional tests with actual dogs to compensate for defects in the product.

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References

[1] B. Qasim. "How to Potty Train A Puppy: Your Comprehensive Guide" Dr. Phillips Animal Hospital. https://drphillipsanimalhospital.com/2020/11/01/how-to-potty-train-a-puppy-your-comprehensive-guide/ (accessed Jan. 27, 2023).

[2] Toilet training for pet dog, by Y. Kim. (2011, Feb 21). K.R. Patent 10-2011-0014974 [Online]. Available: https://patentimages. storage.googleapis.com/a9/d8/7e/f4172454b72dd5/KR101039199B1.pdf

[3] Learning machine for toilet training of pet dog, by Y. Kim. (2013, Sep 6). K.R. Patent 10-2013-0106901 [Online]. Available: https://patentimages.storage.googleapis.com/65/4e/aa/2250d28f97b824/KR101329982B1.pdf

[4] Pet waste station and training device, by H. Scanlan and R. J. Schweizer. (2017, Aug 22). U.S. Patent 9,737,045 [Online]. Available: https://patentimages.storage.googleapis.com/1b/66/42/d671665ca451c3/US9737045.pdf

[5] L. China, D. S. Mills, J. J. Cooper, "Efficacy of Dog Training With and Without Remote Electronic Collars vs. a Focus on Positive Reinforcement,"in Front. Vet. Sci., Jul. 2020. [Online]. Available: https://www.frontiersin.org/articles/10.3389/fvets.2020.00508/full

[6] P. Oelze. "Why Do Dogs Only Poop In Certain Places." Wag!. https://wagwalking.com/behavior/why-do-dogs-only-poop-in-certain-places (accessed Jan. 28, 2023).

[7] Melexis. Datasheet for MLX90640. (2019). Accessed: Feb. 10, 2023. [Online]. Available: https://www.melexis.com/en/documents/documentation/datasheets/datasheet-mlx90640

[8] R. Mischianti. DOIT ESP32 DEV KIT v1 high resolution pinout and specs. (2023). Accessed: Feb. 21, 2023. [Online]. Available: https://www.mischianti.org/2021/02/17/doit-esp32-dev-kit-v1-high-resolution-pinout-and-specs/

[9] Sparkfun Electronics. "HX711 Datasheet by SparkFun Electronics." Digikey. https://www.digikey.com/htmldatasheets/production/1836471/0/0/1/hx711.html (accessed Feb. 10, 2023).

[10] G. Spasov, V. Tsvetkov and G. Petrova, "Using IR array MLX90640 to build an IoT solution for ALL and security smart systems," presented at the 2019 IEEE XXVIII International Scientific Conference Electronics - ET2019, Sozopol, Bulgaria, Sep.12-14, 2019.

[11] "I2C – what's that?." I2C Bus. https://www.i2c-bus.org/ (accessed Jan. 28, 2023).

[12] J. Hrisko. "High Resolution Thermal Camera with Raspberry Pi and MLX90640." Maker Portal. https://makersportal.com/blog/2020/6/8/high-resolution-thermal-camera-with-raspberry-pi-and-mlx90640 (accessed Feb. 21, 2023).

[13] I. Virgala, M. Kelemen, A. Gmiterko, and T. Lipták, "Control of Stepper Motor by Microcontroller", Journal of Automation and Control, vol. 3, no. 3, pp. 131-134, 2015.

[14] R. Mathur. "Choosing the right motor-driver." SP Robotic Works. https://sproboticworks.com/blog/choosing-the-right-motor-driver (accessed Jan. 28, 2023).

[15] Kashif "Maximum Voltage ESP32 Can Take." linuxhint. https://linuxhint.com/maximum-voltage-esp32-take/ (accesed Feb. 21, 2023).

[16] A. Taniguchia, Y. Kitazonoa. (Sep. 2021). Fully Automatic Pet Sheet Disposal System Using Image Processing. Presented at 8th ICISIP. [Online]. Available: https://pdfs.semanticscholar.org/b962/199bc272679bd1d738cb870984722bc8e22a.pdf

[17] A. Sandoiu. "Why you should talk to your dog." Medicalnewstoday. https://www.medicalnewstoday.com/articles/321155 (accessed Jan. 26, 2023).

[18] Raspberry Pi. Raspberry Pi 4 Model B Datasheet. (2019). Accessed: Jan. 29, 2023. [Online]. Available: https://datasheets.raspberrypi.com/rpi4/raspberry-pi-4-datasheet.pdf

[19] Sparkfun. "Load Cell Amplifier HX711 Breakout Hookup Guide." Sparkfun. https://learn.sparkfun.com/tutorials/load-cell-amplifier-hx711-breakout-hookup-guide/all (accessed Feb. 10, 2023).

[20] I. Luuk. "50kg Load Cells with HX711 and Arduino. 4x, 2x, 1x Diagrams." curcuitjournal.com. https://circuitjournal.com/50kg-load-cells-with-HX711 (accessed Feb. 20, 2023).

[21] Tutorials for Raspberry Pi. "How-To: Bluetooth Connection between ESP32's and Raspberry Pi's." Tutorials for Raspberry Pi. https://tutorials-raspberrypi.com/esp32-bluetooth-connection-to-esp8266-and-raspberry-pi/ (accessed Feb. 7, 2023).

[22] Tatobari. "HX711 for Raspberry Pi." Github. https://github.com/tatobari/hx711py (accessed Jan. 4, 2023).

[23] R. Refinetti, G. Piccione. (2003). Daily Rhythmicity of Body Temperature in the Dog. [Online]. Available: https://www.jstage.jst.go.jp/article/jvms/65/8/65_8_935/_pdf/-char/ja

[24] A. Benjamin, K. Slocombe. (Mar. 2018). 'Who's a good boy?!' Dogs prefer naturalistic dog-directed speech. Presented at Anim Cogn. [Online]. Available: https://doi.org/10.1007/s10071-018-1172-4

[25] Thingsboard. *Guides, Live Demo Server*. (2023). Accessed: Jan. 16, 2023. [Online]. Available: https://thingsboard.io/docs/user-guide/live-demo/

[26] Curl. "The Art Of Scripting HTTP Requests Using Curl." Curl Docs. https://curl.se/docs/httpscripting.html (accessed Jan. 17, 2023).

[27] S. Mitchell. "How Often Do Puppies Poop?." petMD. https://www.petmd.com/dog/general-health/how-often-do-puppies-poop (accessed Jan. 16, 2023).

[28] W. O. Reece and H. H. Erickson and J. P. Goff and E. E. Uemera, "Section II: Body Fluids and Homeostasis" in Dukes' Physiology of Domestic Animals, vol. 13, Ithaca, NY, USA: Cornell University Press, 2015, pp. 150. [Online]. Available: https://vlm.ub.ac.id/pluginfile.php/43332/mod_resource/content/1/textbook.pdf

[29] S. Dianora. "Puppy Weight Chart - For Each Size Category." Dog Care Knowledge. https://www.dog-care-knowledge.com/puppy-weight-chart.html (accessed Feb. 21, 2023).