Presented at the 11th DLSU Arts Congress
De La Salle University, Manila, Philippines
February 7 and 8, 2018

Animal Surveillance Quadcopter Using Thermal Imaging

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Abstract: Wildlife is present in all of the different ecosystems. From deserts, to forests, and even places where urban sites are developed, all have particular types of animal life. Researches show that as the population of man and their necessities grow, they are leaving less and less space for the wildlife. This inversely proportional relationship gives off multiple threats for the latter. As a matter of solving this problem, a has proved that aerial drones, when compared to the traditional ground-based methods, are actually far better in performing monitoring operations that would also include wildlife monitoring. This dissertation will be making use of a thermal camera mounted on to a quadrotor to create a system that would be able to detect the presence of animals in their own habitat. In this implementation, image processing will also be used to provide observations of animal presence into the system.

Key Words: Tensorflow - open source library dedicated for machine learning;

1. INTRODUCTION

1.1 Background of the Study

Wildlife is present in all of the different ecosystems. From deserts, to forests, and even places where urban sites are developed, all have particular types of natural life. Although the term “wildlife” traditionally alludes to creatures that are untouched by human factors, some animals have already adapted to rural situations. This incorporates such creatures as cats, dogs, gerbils, and many other animals that are considered tamable. With this in mind, most researchers concur that much natural life is influenced by human activities.

Nature conservation is the act of securing plants, animal species and their habitats that are in danger of extinction. For an effective nature preservation approach, information with regards to the conceivable dangers to plants and animals is a necessity. Such dangers can be partitioned into three classifications, specifically, disease, poaching, and habitat loss. With this in mind, further prevention of these problems can be practiced by monitoring the behavioral number of the animals. [1]

As a matter of solving this problem, a study in 2016 led by Dr. Rohan Clarke has proved that aerial drones, when compared to the traditional ground-based methods, are actually far better in performing monitoring operations that would also include wildlife monitoring. Unmanned aerial vehicles (UAVs), also casually referred to as drones, do not only offer a more reliable and secure method for researchers to watch their subjects, but also offer usually less expensive, more effective, and more precise methodologies than others. [3]

1.2 Statement of the Problem

There are over 5,000 species that are endangered in the planet. Because of this, wildlife monitoring is necessary for their conservation. It is necessary because it monitors the behavior and movement of animals, their habitat and population, poaching occurrence or illegal wildlife trade. There are also problems of animals not wanting to be disturbed. Some of these animals are wild that physical contact is dangerous. There are several organizations asking for volunteers to help in the conservation of wildlife. Since it is dangerous, the use of technology will be a big help with this problem. This is where the safety of human and animals will not be compromised. In connection with this, the safety of the scientists who studies the behavior of animals is being taken into consideration as well. There are also some inconsistencies of data gathering when the monitoring is done on ground. [5]

Here in the Philippines, wildlife drones are not yet fully developed and used. There are also several endangered animals here in the Philippines that can benefit from the drones. A number of local animals are hard to approach and dangerous to be disturbed if ground-monitoring is used. A group of undergraduate students from De La Salle University created a helicopter that can detect humans. A similar approach can be done to monitor and detect animals. One of their recommendations is using a quadcopter and a better camera. The use of quadcopter and a thermal camera will be a huge development. [6]

1.3 Objectives

1.3.1 General Objectives

- To develop a quadcopter with thermal camera that would detect animal presence in its surroundings.

1.3.2 Specific Objectives

- To modify a quadcopter by equipping thermal camera and Global Positioning System(GPS) chip.
- To have a success rate of at least 70% in detecting animals.
- To utilize the thermal camera used for video-streaming and surveillance.
- To monitor thermal camera in real time and integrate the video feed to differentiate animals from their surrounding environment.
- To develop a program that would identify the number of animals present within the coverage of the camera when the quadcopter is in standby mode.
- To implement a communication medium that would have the quadcopter transmit the data to the user through SMS.

1.4 Scope, and Delimitations

The paper focuses on the detection of animals, therefore the subject pertaining to the quadrotor itself will not be under this study. The quadrotor will mainly be used in order for the thermal camera to roam around the vicinity.

The quadcopter will not be tested above a body of water for its safety in case it malfunctions. The prototype will also not be tested in the real wilderness to ensure the safety of the researchers. Detection will mainly focus on land animals that are warm blooded. Detection will exclude animals with thick fur and animals that are too small. The system will not be able to detect animals that are blocked by obstacles like trees and animals that are touching each other since it will appear as one in the thermal camera.

2. RELATED LITERATURE

2.1 Existing Works

2.1.2 Thermal Imaging Surveillance Cameras

A company known as Silent Sentinel are known in developing products that are technologically advanced. They are well experience in producing CCTV cameras and ancillary equipment. They are also famous in developing Thermal Cameras.

Thermal Imaging Surveillance camera developed by Silent Sentinel are designed to operate without ambient light or illumination thus, it can provide excellent image quality in any given environment. It can be used as an independent security device. It also improve security systems. As thermal cameras can detect heat and produce high contrast images which suites video analytics and motion detection perfectly. Also Thermal Imaging cameras measure heat and converts it into a visible image which makes it ideal for zero light surveillance, and will operate in all weather conditions. It can provide clear image in the dark, fog and smoky environment thus making it best surveillance camera. Radiometric models will give an alarm output, when a parameter is breached. It covers a large distance. When combined with a video camera as in the Oculus, the best features of video and thermal are combined to provide the user with a surveillance device to capture any event. Silent Sentinel have a broad range of Thermal Imaging cameras within their product range from small fixed cameras, through the Oculus Ti range to the longer range capabilities of the Osiris PTZ positioning system. "Combining video with thermal imaging in the same device is becoming the most common style of unit we supply," said James Longcroft of Silent Sentinel. [9]

2.1.2 Conservation Drones for Animal Monitoring

This research focuses on the automatic surveillance of the animal distribution and abundance for the purpose of nature conservation. The author of this paper makes it a point that the use of drones would serve as a solution for a fast, efficient, and less expensive method of monitoring animals in their natural habitat. The objective of this paper is to be able to investigate the combination of drones with automatic detection techniques that would detect objects for the main purpose of performing manual animal surveying tasks.

Such an objective was met with the use of a quadcopter drone for obtaining and recording datasets for animal conservation tasks, specifically, animal detection and animal counting. These two types of computer vision tasks would then be evaluated with the use of three different algorithms consisting of different object detection methods. The results from the evaluation can be used to conclude that the techniques for detecting object are promising for nature conservation tasks. [3]

2.1.3 Computer-Aided Military Drone with Human-Detecting Capability using OpenCV

This dissertation paper was conducted by students taking up a degree in Electronics and Communications Engineering. Their aim was to develop a helicopter that can detect human in an upright position. The purpose of their study is to help the military and rescuers to locate people that are trapped inside a facility during a search and rescue operation. The students used a normal camera that was attached to the helicopter where the live feed was viewed in a laptop. They used an analog transmitter and receiver for the transmission of data and also a GPS in order to distinguish the location of the person. They were able to successfully assemble the prototype and also develop a code for image processing with the use of OpenCV. After several tests in the field, their program was able to detect human with a maximum success rate of 56%. [10]

2.1.4 Project KWAGO: Search and Rescue Drone

Drones are now being used in several applications such as security, disaster management, wildlife conservation. In the Philippines, disasters such as flood and earthquakes are often occurring. A group of Filipino researchers developed a search and rescue drone called Project Kwago. The project name came from the Filipino term of "owl". Owls have capabilities of hunting especially during night time. The group is composed of Mac Eugenio, Ari Trofeo, and Vince Villena. The group aims to help boost the search and rescue operations during calamities. Project Kwago also aims to provide more features in search and rescue drones used in the Philippines.

The drones used locally can only take photo and videos during daytime while Project Kwago can capture photo and videos even at night. It is also equipped with a thermal camera to detect heat signatures of human. The project operates by first taking an automated thermal scan on a specific area to detect heat signatures. It will then relay the detected signatures on the ground. It also contains sonars to avoid obstacles. The researchers also considered the cost of building this project since drones are known to be expensive. With the use of locally available materials, they were able to develop Kwago without sacrificing its quality. [11]

2.2 Lacking in the Approaches

Table 1.2 Summary of Lacking in the approaches

Conservation Drones for Animal Monitoring	**Animal Surveillance Quadcopter Using Thermal Camera**	**Computer-Aided Military Drone with Human-Detecting Capability using OpenCV**
Digital Camera	Thermal Camera	Digital Camera
Quadrotor	Quadrotor	Helicopter
Automatic Control	Manual Control	Manual Control
Non-real Time Viewing	Real-time Viewing	Real-time Viewing

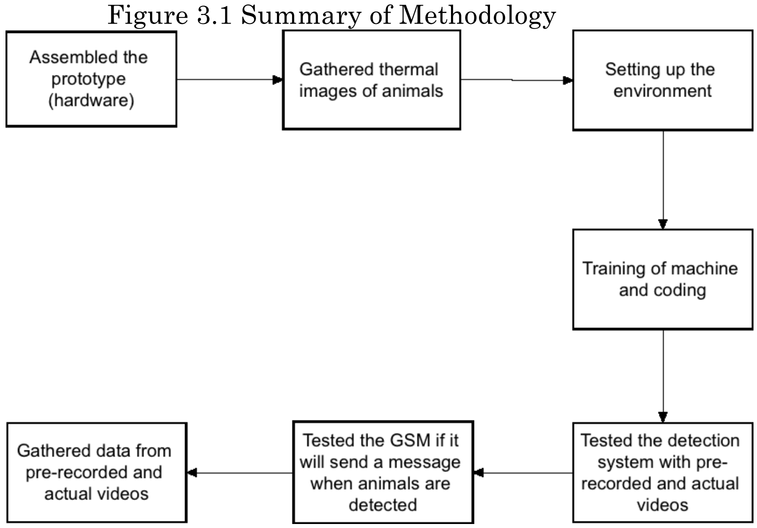
The use of thermal cameras are superior over the use of digital cameras since the former is capable of being used in the night. It is also more efficient than using night vision cameras since it can still be used to detect organisms in unpleasant conditions. Such conditions pertain to the environment situations like the presence of fog or smoke. [10]

Comparing the design of the drones, the two types of drone designs that were presented in the researches include the traditional frames of the quadrotor and the helicopter. The use of quadrotor drone design is more favored when compared to the helicopter because of its significant difference in payload. A quadrotor design offers more allowance of being able to carry an external load which is important due to the requirement of having to equip a camera into the drone. This would also give an advantage for the user of being able to control the drone with more ease and precision.

Being able to control the drones manually also offers the user real-time viewing unlike when drones are controlled automatically where users are only able to obtain the informations gathered after the drone was able to make its round of the vicinity. With this in mind, the users may be able to take immediate action in situations where the animals are threatened.

3. METHODOLOGY

Figure 3.1 Summary of Methodology



The implementation of the whole prototype started with the assembling of the quadrotor together with the thermal camera. Components such as the flight controller, transmitter, GPS, thermal camera and 1 Lipo battery was placed in a box where the components' weight were taken into consideration before assigning where it will be placed inside the box. This box was then attached to the quadcopter. The base station on the other hand consists of the receiver and the laptop where the feed of the camera is shown through the help of the device EasyCap. Before anything else, the environment where the code will be made needs to be setup first through Anaconda Cloud. Through the application anaconda, the group was able to create an environment only designated for the machine learning only. The packages needed were installed using the 'pip' command of python. The version of python was set to 3.5 since it is the version where tensorflow can be used.

Figure 3.2 Transmitting side setup

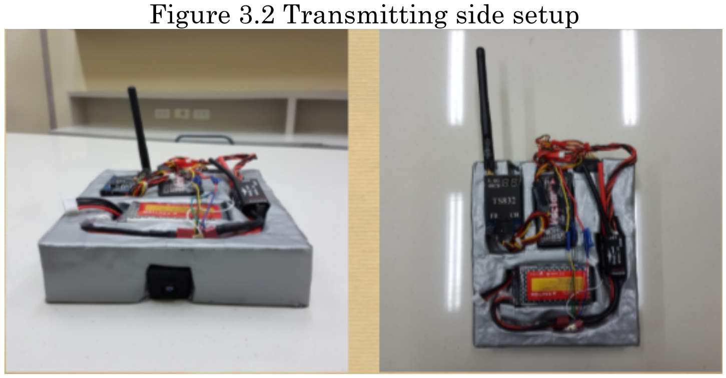
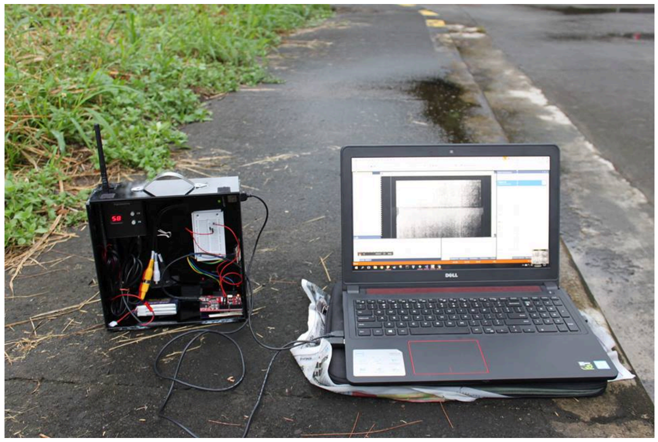


Figure 3.3 Base Station Setup



The next step that was done is gather thermal images of animals that will be used for the training of the machine. The group gathered pictures during daytime and nighttime to compare which situation will the animal detection be more accurate. Several files were generated in order to start the training. The XML files from the annotation tool was converted to CSV file. The label map code on the other hand contains the classes and at the same time the label of the object that is aimed to be detected. Once these files are gathered, the training of the machine was started.. The group was able to research a library that is mainly used for machine learning which is called Tensorflow. There were several tutorials and ready-made models available in github.

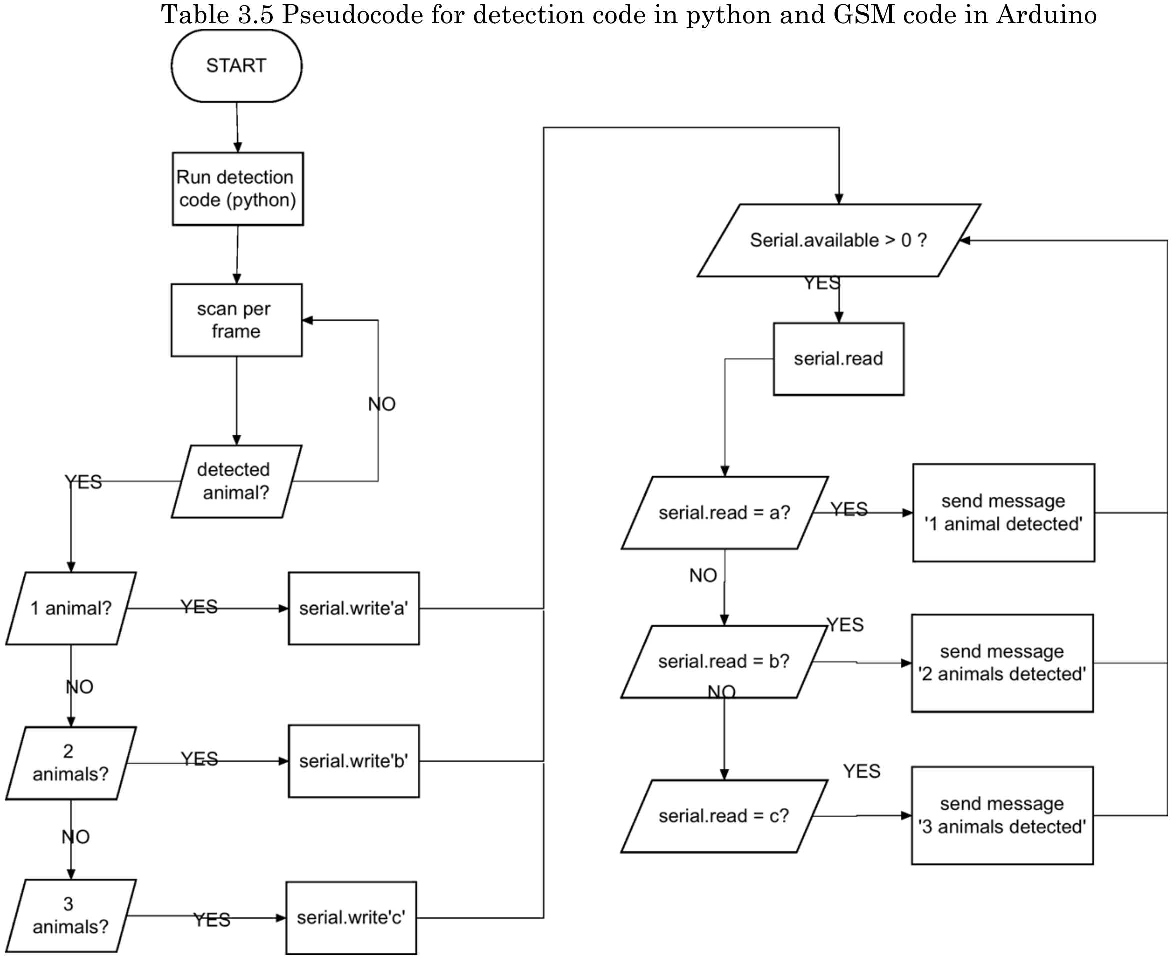
Figure 3.4 LabelImg

The detection model that the group chose is Single Shot Multibox Detection made by mobilenet. This model fulfills the real-time detection since it is categorized as fast detector model. On the side note, this model is less accurate compared to other models such as Regional Convolutional Neural Network. The downside of this model is that it will forfeit the real-time detection objective of the group's paper.

Before we stopped the training of the machine, the total loss during the training must be taken into consideration. The total loss must at least reach 1.5 to ensure that the machine training will yield good results. To further improve the output, the machine can be stopped when the loss hits a value of 1. On the group's machine training, when the total loss average reached a value of 1.3, it was stopped.

The detection was tested using drone pre-recorded videos of animals using the thermal camera. For the GSM part of the prototype, the group created a serial communication between Arduino and the python code where the GSM module will send a message to the user once an animal is detected.

Table 3.5 Pseudocode for detection code in python and GSM code in Arduino



For the actual gathering of data, the testing took place inside a village and the maximum number of animals that the group tested with is 3 animals. The testing scenario can be visualized with the picture below.
*pic actual test

4. RESULTS AND DISCUSSION

For the data gathering, the group used real-time videos in the following scenarios:

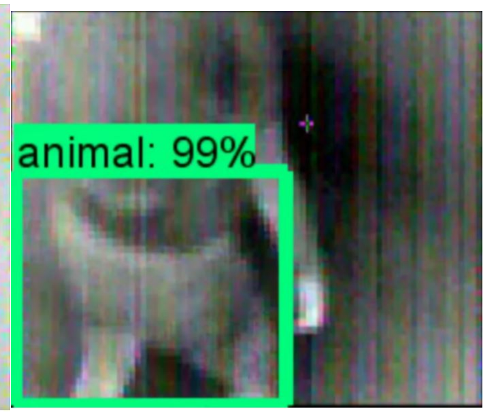
- Scenario 1 - Stable + daytime + 2 animal
- Scenario 2 - Moving + daytime + 1 animal
- Scenario 3 - Moving + nighttime + 1 animal
- Scenario 4 - Moving + daytime + 3 animals
- Scenario 5 - Moving + nighttime + 3 animals

Take note that all scenarios are taken in a village where the group borrowed animals from the people living in the neighborhood. The animals where we tested the detection are dogs only since the it is more accessible.

The data that the group took into consideration is the number of errors that occurred in one video, duration of the error, and type of error. The group considered 4 categories of error:

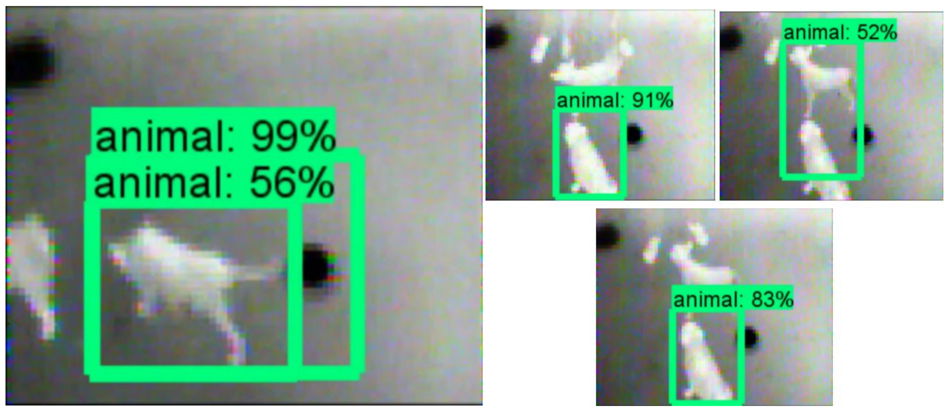
Animal not detected

Non-animal detected

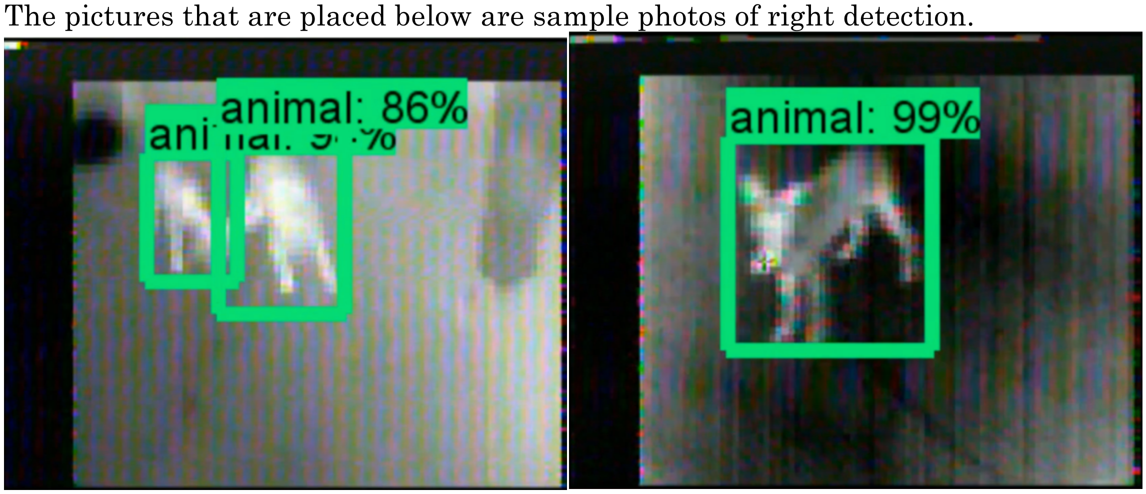


Multi-box

Sequential detection



The pictures that are placed below are sample photos of right detection.



Take note that the duration of each error is an estimate only. The short and long duration was manually counted based on the video.

Table 4.1 Classification of errors

Duration	Time
Single flicker	1 second
Continuous flickering	3 seconds
Short duration	Manually counted
Long duration	Manually counted

Table 4.2 Average data for Scenario 1

Scenario 1	
Total Duration of Errors	181 seconds
Total Length of Video	685 seconds
Percent Error	26.42%
Percent Accuracy	73.58%

Table 4.3 Average data for Scenario 2

Scenario 2	
Total Duration of Errors	52 seconds
Total Length of Video	530 seconds
Percent Error	9.81%
Percent Accuracy	90.19%

Table 4.4 Average data for Scenario 3

Scenario 3	
Total Duration of Errors	165 seconds
Total Length of Video	495 seconds
Percent Error	33.33%
Percent Accuracy	66.67%

Table 4.5 Average data for Scenario 4

Scenario 4	
Total Duration of Errors	27 seconds
Total Length of Video	100 seconds
Percent Error	27%
Percent Accuracy	73%

Table 4.6 Average data for Scenario 5

Scenario 5	
Total Duration of Errors	33 seconds
Total Length of Video	90 seconds
Percent Error	36.67%
Percent Accuracy	63.33%

Table 4.7 Average percentage for all scenarios

Average Percentage of all Scenarios	
Total Duration of Errors	463 seconds
Total Length of Video	1900 seconds
Percent Error	24.37%
Percent Accuracy	75.63%

5. CONCLUSIONS

The study was able to achieve the objectives that were presented during thesis 1. The prototype that was made by the group was able to detect animals using thermal camera. Based on the data that was gathered, the group achieved the 70% accuracy for the detection system. Using the transmitter and receiver, the computer and the camera were able to communicate with each other. The GSM module was able to successfully send a text message to the user alerting the user that an animal was detected. The serial communication between the Python code and the Arduino was made possible due to the integration of Pyserial. This allows Python to communicate with the Arduino and send data to it that an animal was detected. It is easier to test the prototype to a place with high mobile network coverage.

Objectives are successfully met by the group and by testing the used materials along with a low spec thermal camera. The group concluded that it was hard for the system to detect animals during daytime since it will capture heat signature from the heat of the sun. In addition with the heat of the sun, the heat-conducting materials such as metals and cement also stores heat which reduces the accuracy of the detection since heat detection overlaps the surrounding and the animal. Based on the results, the group concluded that the animal detection is more accurate during nighttime than daytime due to less heat caused by nature and its surroundings

6. RECOMMENDATIONS

Flying of drones is prohibited in most public places that is why the group was unable to test the prototype to various animals such as animals not appropriate as pets. The group was only able to test the prototype to animals that are considered pets like dogs and cats in private places. To obtain more accurate results, it is recommended to test the prototype on various animals. Furthermore, it is also recommended to feed more pictures to the machine to obtain more accurate results.

Since the group used a thermal camera with low resolution, the drone is unable to fly higher since the camera would not able to capture the subjects below. Thus, the group recommends a higher resolution camera for better streaming which will cost more but will surely yield better detection results. With the use of better camera, small animals can also be detected. If possible, the next researchers may use a camera with color spectrum since the group only used a thermal camera limited to black and white. The use of thermal camera with colored spectrum, cold-blooded animals can be included in the future researches. Since the drone that the group used has a flight time of 13- 15 minutes only, testing of the prototype is limited to a short period of time. It is recommended to utilize a quadcopter with better specifications and battery life. This thesis is limited to detecting animals but unable to determine what kind of animal is detected. The group recommends to add a feature that determines what kind of animal is detected. To further test the accuracy of the detection system, future researchers may used a better camera and gather data while varying the altitude of the drone to see if the system will still be able to detect animal from a higher altitude. For a better prototype, the group recommends to add a feature of having a quadcopter that is able to have an automated flight that is directed by the users.

7. ACKNOWLEDGEMENT

First, we would like to thank God for the enlightenment and motivation that allowed us to accomplish our thesis.

The group would like to thank their parents, Roel and Maria Agnes Siccion, Jose and Elmadel Figueroa, Ariel and Nerissa Mendoza, Luisito and Zenaida Soliman, for their financial support and help in acquiring the needed materials for this project. Their endless guidance and support encouraged us to finish our thesis.

To our thesis adviser, Engr. Donabel Abuan, who is always so supportive with our project, suggested the machine learning part, and for guiding us all throughout the process of accomplishing our project.

To our panelists, Dr. Argel Bandala, Dr. Jay Robert del Rosario, Engr. Roderick Yap, for acknowledging the possible errors we might encounter in our project, suggesting possible solutions to them, and challenging us to make our thesis better.

The training and execution of our detection code would not be possible without the help of Macky Vergara, Ate Paday, Tita Josie Cruz, Ate She, Tita Sunny Vergara, Mayor Alvin Vergara, Tita Regina Aparri, Tito Donald Aparri, and Charlie Sheen Aparri. Their efforts in assisting us while taking photos and videos of their pets is greatly appreciated. Their guidance and support has contributed a lot to the development of the thesis. We are grateful for accommodating us into your homes and for allowing us to test our prototype on your pets.

We would like to extend our gratitude to the dogs, Toni G and her puppies, Stacey, Apollo, Hachiko, Chestnut, Cali, Gio, Athena, Hercules, Percy, Gab, Cibo, Chica, Brownie, who participated in our training and testing. Without these dogs, our thesis would not be accomplished.

We would also like to thank the Soliman family for accommodating us into your home that provided us a nice environment to create our thesis project. Their subdivision allowed us to test the quadrotor, and execute our finished prototype as well.

We would like to thank our friends, Joshua Rillo and Joseph Samuel Sazon, for helping us with our software and hardware for this thesis.

Above all, to the Great Almighty, the author of knowledge and wisdom, for his countless love.

To God be the glory.

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