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Semi Autonomous Quadcopter for Early Rat Infestation Detection

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ABSTRACT

This research implemented a quadcopter setup capable of autonomous flight, geared towards early detection of rat infestation. This employed the Tarot 650 Iron Man as the drone frame along with an FLIR Duo R thermal camera. Programming language used was Python, along with OpenCV and Qt Designer for the code and GUI implementation. A simulated controlled setup was created to test the project. The drone was programmed to fly over the controlled setup for it to scan the area and detect the rats that were placed in different parts of the setup. Thermal pictures taken by the drone are processed by the code and output is the maximum number of rats detected along with the waypoints were the maximum value was detected. Each waypoint would correspond to a specific location, and will let the user know which part of the land has the highest density of rats.

Key words : Quadcopter, Rat Infestation, Thermal Imaging, Unmanned Aerial Vehicle, Farming

1. INTRODUCTION

The Philippines is a country where agriculture is the main source of livelihood for a lot of people, especially those living in the rural areas. This is composed of 4 subsectors namely farming, fishery, livestock and forestry. Among the main agricultural crops are rice, corn, coconut, sugarcane, bananas, pineapple, coffee, mangoes, tobacco and abaca. The Philippines used to be a net exporter of these products, and different countries were sending their students to our country to study in our agricultural universities. However, things have changed and we have become net importers of these same products.

In the Philippines, farmers are among the cornerstones of our country in terms of agriculture. Farmers experience many challenges, including uncontrollable weather as well as pest infestations in the field. Aside from consuming or destroying crops, some pests, especially rats, also pose a threat to the farmers and the community due to diseases they may bring. Rats are a big threat to farmers because of their elusiveness. By the time infestation is detected, rats typically would have already caused much damage. This is counterproductive to the farmers who continuously strive to improve their yield.

Farmers continue to play an important role, aside from helping the economy of the country, they contribute to food security of the country. Over the years, old fashioned ways of managing farmlands has become less efficient, this is due to the manual methods of detection of pest infestation, along with the chemicals used to kill pests, which also pose some health risks brought about by pesticide residue in the crops. To keep up with the demand of our growing population, farmers turn to technological advancements to protect and improve their yields.

This research focuses on solving the problem of rat infestation in farmlands using a quadcopter equipped with a thermal camera. This captures and stores images that are processed to determine where rats are detected. Rats are deployed in the test area in cages. Each cage has a different number of rats and the system must determine which part of the land has the highest density of rats.

2. PRIOR STUDIES

The journal on Pest Detection and Control Techniques Using Wireless Sensor Network: A Review [1] provides us information on the ways pest control are being implemented today. It analyzes and classifies pest control mechanism in technological, non-technological and integrated solutions. The paper also described wireless sensor network (WSN) and its application in agriculture.

The work done in Early Pest Detection from Crop using Image Processing and Computational Intelligence [2] presents an automatic approach for early pest detection. It discusses the importance of using technology such as Computer vision techniques and Support Vector Machine (SVM) for better farming.

The study done on A Comparative Study on Different Types of Image Pre-processing Methods for Noise Removal [3] provides an input on possible sources of noise in images.

The main research that the group based this study on is titled Machine Vision for Rat Detection Using Thermal and Visual Information [4]. A machine vision system was built using thermal and visual recognizable proof of rat identification. It was concluded that the use of thermal imaging was more accurate in detecting and locating rodents than using the visual camera. This used the FLIR One thermal camera which has a temperature measurement range of 20C to 120C. The said research encountered problems using both cameras. The visual camera had difficulty detecting rats with the presence of obstruction, which the thermal camera was well able to handle. However, a change in lighting was seen to cause errors on the FLIR camera when background subtraction method was executed by the system.

The paper on Low-Altitude Unmanned Aerial Vehicles-Based Internet of Things Services: Comprehensive Survey and Future Perspectives [5] provide us input on the possible role of UAV in the Internet of Things (IoT) vision while presenting the need to overcome the relevant challenging issues.

3. DESIGN CONSIDERATION

Figure 1 describes the system block diagram. First the drone with the thermal camera captures the images at different waypoints on our identified test area. The resulting thermal images are saved on the SD card that is inside the camera. The images were processed by the computer through the graphical user interface using Python. The rats will be detected and counted for each frame. The system identifies the location with high number of rats from the covered area.

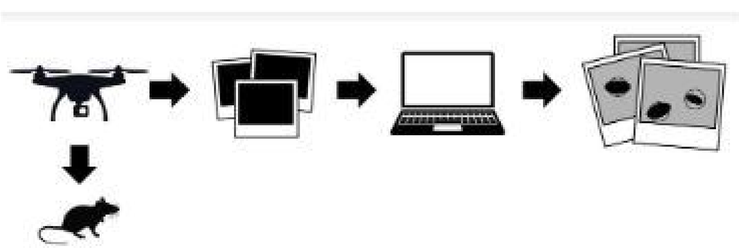

Figure 1: System Block Diagram

3.1 Rats

Albino rats (Rattus Norvegicus Domesticus) were used for this study. A total of 20 rats with different sizes were used, most of which were 3 to 5 inches long (tail not included) with a few rats 7 to 8 inches long. This species was chosen as the length is similar to field rats that typically grow to about 7.5 inches long.

3.2 Quadcopter

The project utilizes an assembled quadcopter capable of flying at an altitude of 2 meters given the additional weight of the batteries, camera and gimbal, and flight controller. Tarot 650 Iron Man was used as the drone frame. The flight controller used was Pixhawk. It is capable of storing the parameters needed for the drone's flight as well as triggering the camera for the detection of rats. Mission Planner was utilized as ground station for the quadcopter. It was also used for calibrating the drone's initial parameters. Through the use of the mission planner, the target area can be specified and will create a mission for the drone and follow a do command.

3.3 Thermal Images

The current condition of the environment must be observed during implementation. Hot metal palette is used as it has a satisfactory level of clarity and the color of the rat is better defined.

The settings for the thermal camera are dependent on the conditions during testing, see figure 2 for the different setting to be defined. The sky condition setting can be set either to clear, scattered or cloudy. The variations for humidity can be low, medium or high. Air temperature can be set up to 40C. The emissivity setting is dependent on the testing area so a constant 90% is set because the testing area is on soil. The subject distance is set to 2 meters due to the altitude selected for the testing is 2 meters.

Figure 2: Thermal Camera Settings

3.4 Image Processing

Python was used as the main programming language, along with OpenCV module, os module, and PyQt5 module was added to the code interpreter. Also, Pycharm text editor was used for editing the code and Qt Designer was used for creating the GUI implementation. OpenCV, or Open Source Computer Vision Library was used together with Python for image processing. There are many sources available for users to get started with it. The project uses some of functions available for handling the image processing, such as conversion of colors for easier processing, masking and thresholding the image, and especially the use of its Simple Blob Detector. Blobs inside the thermal image represent the rodent. The body heat emitted by the rats are greater than the ambient surrounding.

After selecting the directory of the run you want to process, the code reads the image using cv2.imread so that functions from the OpenCV module can be applied to it. After setting the variable for the image, cv2.GaussianBlur was applied. This reduces the noise in the image. See sample output in figure 3.

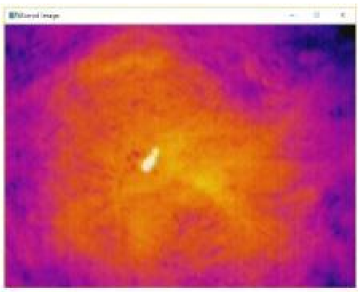

Figure 3: Blurred Image after cv2.GaussianBlur

A mask was applied over the image so that other parts of the image were blacked out leaving only the rats. It converted the color space of the image to HSV by using cv2.cvtColor, using the parameter cv2.COLORBGR-HSV, seen on Figure 4.

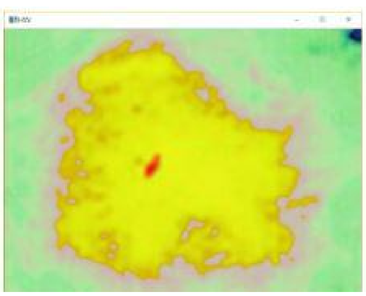

Figure 4: BGR color space to HSV color space

The thresholds for the mask was set using cv2.inRange. By specifying the minimum and maximum number to be accepted, the output image blacks out the rest of the parts of the image that does not fall within the range, thus creating the mask. Comparing the image of the mask and the newly masked image, the blob will have an initial color of white. After applying it to the image, the color changes to yellowish-white. For the next process, the masked image needs to be converted to grayscale color space by using cv2.cvtColor with the parameter cv2.COLOR-BGR2GRAY. After conversion, the image was converted to grayscale as seen in figure 5.

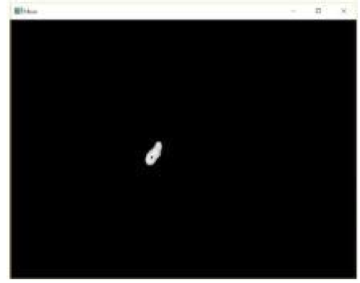

Figure 5: Masked Image Converted to grayscale using cv2.COLOR-BGR2GRAY

The code needs the image to be in black for it to be detected, thus, the image is inverted. The function used to convert the image was cv2.threshold then applying the parameter cv2.THRESH-BINARY-INV. The converted image can be seen in figure 6.

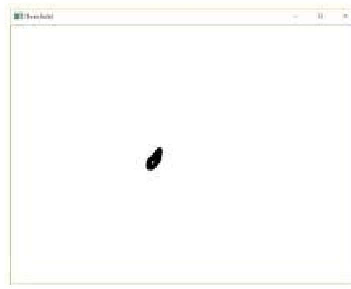

Figure 6: Thresholded image using the function cv.threshold with the parameter cv2.THRESH-BINARY-INV

The image was then processed using the cv2.SimpleBlobDetector function. The researchers set threshold parameters for the detector. Applying the detector to the thresholded image earlier, it detected where the blobs are satisfying the conditions of its parameters. For that, the function cv2.drawKeypoints with the parameter cv2.DRAW-MATCHES-FLAGS-DRAWRICH-KEYPOINTS and it drew circles on key points that were detected as seen in figure 7.

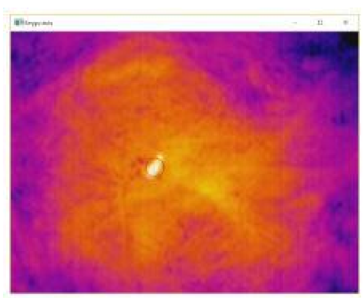

Figure 7: Keypoint (Red Circle) encircling the blob detected by the detector

After processing all images, the numbers of blobs are stored in an array. The maximum number of blobs is then identified using the function max. Along with the maximum value, the indexes that have these values were also identified to determine the location.

3.5 Graphical User Interface

The GUI was implemented using the Qt Designer Software. The researchers created a python code based on the GUI design using the function pyuic5 command as shown in figure 8.

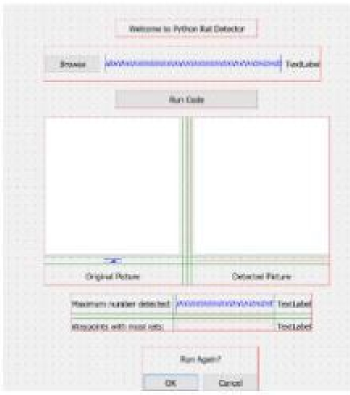

Figure 8. GUI Design Using Qt Designer software

4. METHODOLOGY

4.1 Setup

The rats were placed in 5 different cages. Four of the cages were of the same size (8cm x 6cm x 6.5cm) while the fifth one was larger (30cm x 17cm x 18cm). This allows for a controlled setup, wherein the density of the rodents are controlled and identified. This also mimics the rodents eating habits because according to research, rats eat in groups.

This setup was used to test whether or not the system can process the thermal images captured by the thermal camera on the drone and determine which location had the highest density of rats. Test area was a vacant lot measuring 10m x 10m.

4.2 Implementation

For the autonomous flight of the quadcopter, the locations of the waypoints where the quadcopter needs to go are determined and programmed. This is designed for the drone to be able to survey the 10m x 10m land given the field of view of the camera. A total of 35 waypoints were needed for this study. Because the camera image is rectangular, the total area covered was about 10.85m x 11.34m.

4.3 Data Gathering

The first step was assigning the waypoints where the quadcopter will stop for the thermal camera to automatically take pictures. Once this is done, the rats are placed in the 5 cages, and then deployed in various parts of the test area. Several runs were made, each with the cages placed in different locations. Aside from changing the locations of the cages, the numbers of rats per cage were also varied.

From the starting point, the quadcopter is programmed to scan the test area by flying to the assigned waypoints. The quadcopter stops at each waypoint for about 3 seconds to take thermal images before moving on to the next. After it reaches the 35^{th} waypoint, the quadcopter will return to home.

4.4 Python Code Testing

The images from each of the defined waypoints are then uploaded to the system for processing. After the code is executed, the output will show pictures where rats have been detected. The blobs are encircled and counted, which will be included and displayed in the output. In addition to this, the waypoint with the most number of rats is also determined.

4.5 Evaluation

The output of the system is evaluated against the controlled conditions (location and number of rats in each cage/location). The system is expected to output the correct count for each waypoint where the rats are located for each run. The number of maximum number of rats detected, along with the corresponding waypoint must also be tested.

5. RESULTS AND DISCUSSION

The output will be obtained from scanning the 35 pictures per run. They can be found inside a folder when the camera is opened. Each run is separated by each folder which is good to avoid confusion. The GUI that comes with the code will make it easier for the user to process the images. The python code produces output which encircles the rats being detected as well as counts them and then chooses which way point has the highest number of them.

The python codes were implemented to all of the 100 sets of 35 way points. Above is just an example to demonstrate the process. After gathering all of them, the table below shows the computation of the accuracy where the total number of way points that the code has implemented the count of rats properly over the total number of way points which is 500. After testing, the group was able to achieve the accuracy of 84.4 percent, a sufficient number given that the accuracy required for the research 80 percent. To achieve this, the group runs the drone 100 times over their test area, doing 2 runs every night to avoid over using the lithium battery supplying the power for the drone. The researchers summarized the data and were able to detect 78 way points were unsuccessful to detect the correct number of rats out of the 500 waypoints during the whole data gathering that have rats. This means that 422 waypoints were correct, thus the accuracy for the data is 84.4 percent.

6. CONCLUSION AND RECOMMENDATION

The researchers were able to assemble its quadcopter and have it fitted with the chosen thermal camera. The setup was successfully optimized to be able to run the defined flight path given the additional weight of the battery, thermal camera and other peripherals/attachments. The quadcopter was also able to go through the defined waypoints and capture the needed images. The system was able to return the correct count as well as the maximum count and corresponding waypoint. Accuracy achieved by the system was 84.4%. The quadcopter can switch between autonomous and manual control.

The Pixhawk microcontroller used in this study was powerful enough to store the parameters necessary for the drone's flight while triggering the camera to capture images when stopping at each waypoint.

For future studies, the researchers recommend the use of more compact parts, mainly to improve the battery life. A more updated frame is also recommended for better compatibility to newer motors, propellers, camera gimbals and other peripherals and components. Use of lower powered motor and smaller propellers would also help improve power consumption. Lastly, although the FLIP Duo R provides good value for its cost, a more updated camera is recommended for better resolution and ease of use.

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