Golden Apple Snail “Kuhol” Eggs Detection Using MATLAB Image Processing

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2022 IEEE 14th International Conference on Humanoid, Nanotechnology, Information Technology, Communication and Control, Environment, and Management (HNICEM) | 978-1-6654-6493-2/22/$31.00 ©2022 IEEE | DOI: 10.1109/HNICEM57413.2022.10109586

***Abstract*—Golden apple snail, locally known as kuhol, is a major pest of rice that contributes to crop yield loss in the Philippines. This study was conducted to develop a program that helps decrease the damage caused by the infestation of these snails. It created a standalone application that detects the golden apple snail eggs and locates the infested area from drone images. The application displays the pre-processed images, the detection results, and the coordinates of the images with detected snail eggs in latitude and longitude. Gathered data were analyzed using a confusion matrix and computing the percent accuracy and error. The developed program using MATLAB acquired an 88% accuracy in detecting the snail eggs. It was also determined that the developed program could detect golden apple snail eggs from drone images accurately up to a height of 2.5 meters from the rice fields.**

***Index Terms*—image processing, MATLAB, Golden Snail ”Kuhol”, rice production**

I. Introduction

Golden Apple Snail (Pomacea canaliculate) is a major pest of rice crops. It has a high nutritional value as food for humans and farm animals. Unfortunately, it became a highly invasive pest in rice crop production years after it was introduced in the Philippines. Its invasion of rice fields has led farmers to begin using pesticides. This led to an increase in rice production costs and currently poses a significant threat to rice-growing countries like the Philippines [1]. Out of 3 million hectares of rice land in the country, 1.2 to 1.6 million hectares were heavily damaged by golden apple snails [1], with the first infestation recorded in 1986, wherein around 300 hectares of rice farms in the Cagayan Valley were infested. The Philippines had the most significant estimated snail-infested area in Asia, with 4 million hectares infested in 1989 [2]. The infestation of rice crops has been increasing until today. Golden apple snail has a muddy brown shell and golden pinkish or orange-yellow flesh. They are bigger and lighter in color compared to native snails. The eggs of golden apple snails are bright pink. They cut the rice stem at the base, destroying the whole plant to confirm its existence on the rice field, missing hills, cut leaves, and cut stems would be evident. Snails spread rapidly through streams and irrigation canals. When they reached the rice fields, they found an ideal habitat. Their rapid growth and reproduction, in which females lay egg masses of up to 500 eggs once a week and can live up to 3 years, results in population masses that can destroy entire rice crops. If not handled correctly, golden apple snails will overpopulate and deplete native species’ resources, altering natural ecological processes.

Local farmers have used cultural, biological, and chemical management measures to combat golden apple snail infestations in rice fields. Throughout the year, the cultural method is simple hand-selecting of snail eggs, especially in the summer when reproduction and growth are at their optimum. Biological control is putting ducks in the fields. The ducks patrol the farm every day, eating any little pests they can discover. This process ensures that the farm’s crops are pesticide-free. The FDA has two synthetic approved chemicals that are good for controlling the snails, (1) the molluscicides niclosamide and (2) the metaldehyde. These substances provide effective control while causing no harm to the environment or humans. Because of their rapid decomposition, these molluscicides are harmless to agricultural ecosystems and the environment when used carefully. Pesticides can effectively control these snails but have long-term toxicity consequences, particularly

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for cattle grazing on grasslands, fish populations, and human health after rice production. However, even implementing these measures, golden apple snail persists at high levels in infested rice [3].

Technologies have improved new and existing farming practices and tools already in use on farms [4], [5], [6], [7], [8]. Image processing incorporates new technology to improve agricultural practices, leading to precise and efficient farming and reducing manual monitoring of farmers while still providing high production. Image processing techniques were applied to agriculture by gathering photos using remote sensing techniques utilizing airplanes or satellites, which were then processed and evaluated using computers. Farmers could observe, assess, and control agricultural practices through this method, like giving suitable fertilizers, pesticides, and water usage [9]. Imaging techniques solve numerous challenges in agriculture due to new technology breakthroughs in picture capture and data processing [10]. The advancement of computer-vision-based applications in agriculture was also proven effective in imaging techniques, weed detection, and fruit grading. At the same time, analysis of agricultural parameters such as canopy, yield, and quality of products is accurate and more efficient than traditional methods [11].

The main objective of this paper is to develop a program that will detect golden apple snail "kuhol" eggs from drone images. Specifically, the researchers aim 1) to combine various image processing techniques and algorithms for the detection of golden apple snail eggs using MATLAB; 2) to determine the location of golden apple snail egg infestation in the rice field; 3) to compare the performance of the developed program for the detection of golden snail eggs over the traditional method.

This research is limited to detecting golden apple snail eggs from drone images. This paper does not include other sources of an image such as satellites. The control and elimination of golden apple snail eggs are also not part of the scope of this research. This paper did not include other rice pests and their corresponding eggs.

II. Methodology

The study was conducted in selected rice fields in the municipality of Pagbilao and Lucena. Fig. 1 shows 1 of the three rice fields where the testing was conducted. The research method used is an applied-experimental approach for testing and evaluating the developed program.

A. Data Gathering

A drone is used to capture and gather images from rice fields. The proposed drone to use is the Phantom 4 series of DJI company, specifically the Phantom 4 standard for the data gathering process. With its propellers, this drone can part the rice leaves, making it possible to capture snail eggs that are attached to the lowest part of the rice stem. The GPS information of the drone images represented the drone's position when it captured the image. Thus, the researchers utilized the top view of the drone camera or the 0-degree angle of the camera. Different images were captured using this drone from different heights above the rice fields.

Fig. 1. Aerial shot of rice field in Lucena City

The drone images were then transferred to a laptop where the standalone application for detecting golden apple snail eggs was installed. Using the developed program, the drone images are processed. Processed drone images with detected snail eggs have their GPS information extracted and displayed as icons in Google Earth Pro to visualize the infested areas.

B. Programming and Image Processing

The standalone application was developed using MATLAB R2021a software, specifically MATLAB Image Processing and App Designer. Color thresholding and image binarization were used to detect the "pink" snail eggs from drone images. The Global Position System (GPS) information of the processed images with detected snail eggs is extracted into coordinates.

After coding the program, a standalone application was created to distribute the program. The standalone application only requires MATLAB Runtime to execute the program on the laptop, not the MATLAB application itself.

Fig. 2 shows the block diagram of the detection program. Images of rice crops acquired from the data gathering serve as the system's input. These images will be processed in MATLAB software using various image processing techniques. Color thresholding checks if the pixel values of the image are within the range of set values for the color of the snail eggs, which is pink. In binarizing the image, it is converted to a black-and-white; pixel values within the set range of values for snail eggs are set to 1s, and the opposite is set to 0s. If the program detects 1s after processing the images, the image will have a "Snail Eggs Detected" detection result; if not, it will display "Not Detected." The GPS information is extracted into coordinates with the detection result, which serve as the system's output.

Fig. 3 shows a sample screenshot of the graphical user interface (GUI) using a personal computer. The GUI is divided into three panels. The first panel on the left side shows the directory of the current or selected image folder. Users can

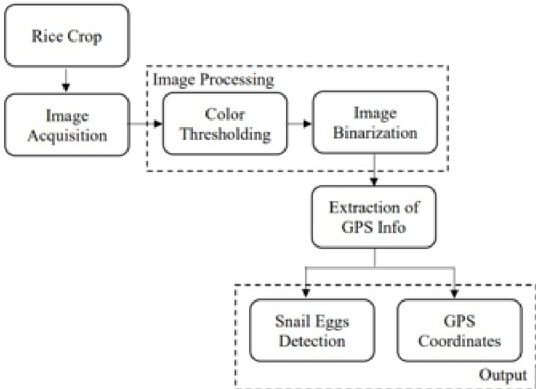

Fig. 2. Block Diagram of Golden Apple Snail Eggs Detection Program

verify the selected folder if it contains the images that need to be processed. The second panel in the middle displays the push buttons and the results of the processed images. The purpose of each push button is indicated in its label and is numbered to guide the user. The ”Results” panel shows the updated results of images while they are being processed one by one with an interval of 1 second. The third panel on the right side shows the pre-processed image, the message text box, which displays instructions and warnings, and a table where all the data displayed in ”Results” are stored. Users may track the results while the images are being processed.

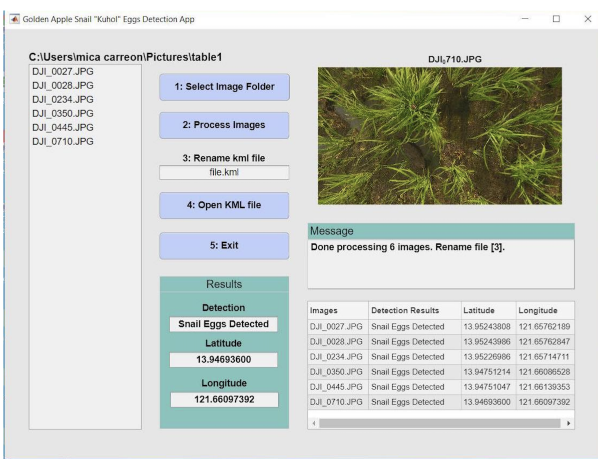

Fig. 3. Sample screenshot of the GUI of the standalone application

Fig. 4 shows the program flowchart exhibiting how the standalone application works. The program will start when the user opens the installed standalone application and Google Earth Pro. The user will be instructed to select an image folder. If the user does not specify a folder, the program will display the ”Invalid Selection. Select a folder.” message. If the user selects a folder, it will search for JPG files (drone images) and load these into the program. After this, the image is processed to detect snail eggs, and its GPS information is extracted. The results of the detection process are displayed and stored in a table. This is done for all JPG files contained in the selected folder. Once all the images are processed, the user will be asked to rename a Keyhole Markup Language (KML) file to be generated by the program. Once renamed, the program will open the KML file in Google Earth Pro. The GPS coordinates stored in the KML file are represented by pins that serve as markers, shown in Google Earth Pro. Fig. 5 displays a sample KML file generated by the program after processing the drone images.

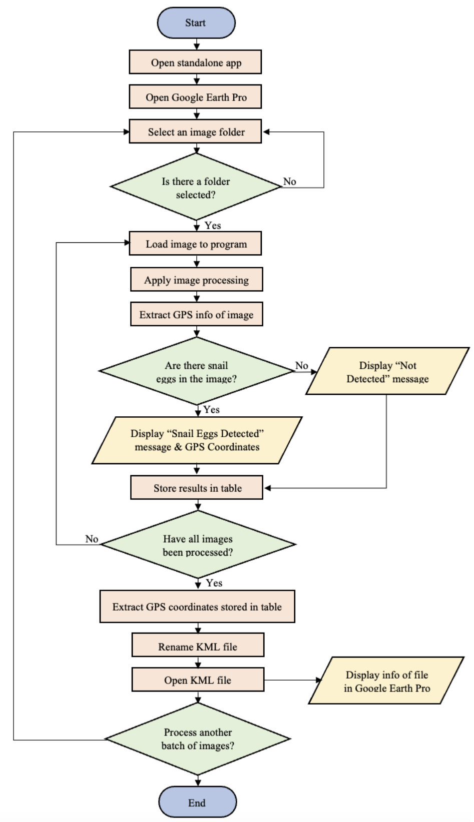

Fig. 4. Golden Apple Snail Eggs Detection Program Flowchart

Fig. 5. Sample KML file generated by the program

C. Testing and Evaluation

The detection accuracy of Golden Apple Snail eggs was calculated using equation 1 for percent accuracy where TP, TN, FP, and FN are the number of true positive, true negative, false positive, and false negative. The maximum height of the drone that will result in an acceptable accuracy were also determined by calculating the accuracy system for different images captured at different elevations.

$$\%accuracy = \frac{TN + TP}{TN + TP + FN + FP} \tag{1}$$

III. Results

This section provides the results obtained in this study. The subsections detail the results of utilizing statistical formulas to determine the prototype's accuracy in detecting and locating snail eggs.

A. Drone Images Dataset

A total of 743 images were captured using the Phantom 4 Series drone. Three hundred twenty-six captured images are labeled with golden apple snail eggs, while 417 drone images don't have any golden apple snail eggs. These images are captured from different elevations in the rice fields. Figure 6 shows sample drone images of rice fields with and without golden apple snail eggs

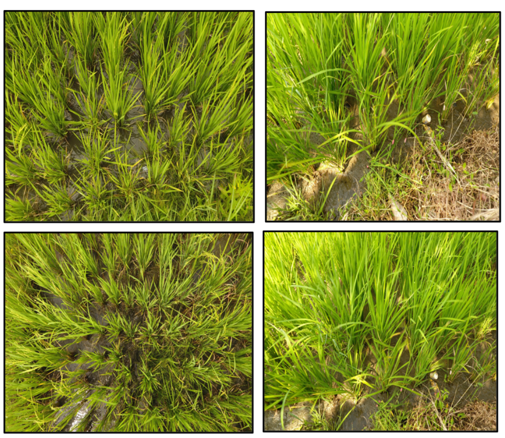

Fig. 6. Sample images with and without Golden Apple Snail Eggs

B. Image Color Thresholding and Binarization

Using the MATLAB image processing toolbox, the images captured by the drone were segmented by thresholding the three color channels namely Red, Green and Blue Channel. The obtained maximum and minimum values for each channel are tabulated on table 1. A sample close up image of the golden apple snail egg were also displayed on figure 7 before and after image color thresholding while figure 8 shows the final image after image binarization.

TABLE I
COLOR CHANNELS THRESHOLD VALUES

Color Channels	Min. Value	Max. Value
Red	220	255
Green	100	165
Blue	100	140

Fig. 7. Sample Golden Apple Snail Egg Before and After Image Thresholding

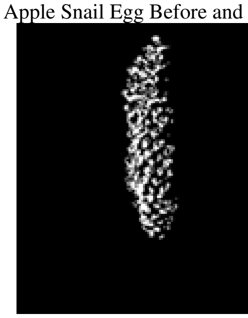

Fig. 8. Binarize Golden Apple Snail Egg

C. Accuracy of the Prototype's Detection Ability

Fig. 9 shows the confusion matrix used for determining the accuracy of the detection ability of the developed program. Out of 743 samples, 296 were predicted correctly with snail eggs and had snail eggs in actual (True Positive), 358 samples were predicted correctly without snail eggs and had no snail eggs in actual (True Negative), 59 samples had no snail eggs in actual but predicted with snail eggs (False Positive), 30 samples have snail eggs in actual but predicted without snail eggs (False Negative). Computing for accuracy, the developed program gives an 88.02% accuracy in detecting golden apple snail eggs from drone images.

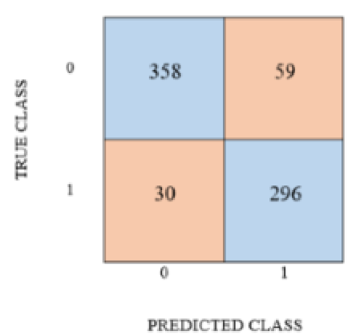

Fig. 9. Confusion Matrix of Golden Apple Snail Eggs Detection

D. Optimal Drone Elevation

The drone captures images at different heights to determine the drone's maximum size, where the program can achieve the highest detection accuracy. A total of 60 images with snail eggs were gathered and tested using the prototype at different heights from 0.5-3 meters, with an increment of 0.5 meters. Each height consisted of 10 images. The prototype obtained a 100% accuracy level in detecting golden apple snail eggs from 0.5-2 meters with no error while its accuracy was reduced to 40% when the drone's height is at 3 meters from the rice fields. Table 2 presents the results of the detection capability of the system at different heights.

TABLE II
ACCURACY OF THE SYSTEM AT DIFFERENT DRONE HEIGHTS

Height(m)	Correct Detection	Incorrect Detection	Error(%)
0.5	10	0	100
1.0	10	0	100
1.5	10	0	100
2.0	10	0	100
2.5	10	0	100
3.0	4	6	40

IV. DISCUSSION

In this study, MATLAB standalone application demonstrated image processing techniques using color thresholding and image binarization in detecting golden apple snail eggs from different rice fields. The confusion matrix in Fig. 9 presented the detection performance of the program with an overall accuracy of 88.02%. Moreover, the program achieved excellent accuracy in determining the location of the detected snail eggs using the GPS information, latitude, and longitude of the acquired images from the drone. Google Earth Pro provides more convenience in location tracking since it is the visualization map of the infested fields generated by extracting the image coordinates as a KML file. Additionally, the exceptional features of the drone provided satisfactory results in detecting snail eggs at different heights. Compared with the traditional way of detecting and eliminating snail eggs, this study reduces time consumption in manual detection and minimizes infestation. The program's ability to detect snail eggs at different heights and determine and visualize their locations in the field is an advantage over other studies. This study can be compared to the works of [12], [13], [14] in the detection and can surpass them, given its remarkable aspects.

V. CONCLUSION AND FUTURE WORKS

The researchers created a standalone application based on the MATLAB image processing toolbox, specifically through image processing techniques: color thresholding and image binarization. The application can work by installing a MATLAB Runtime on a computer or laptop. The GUI provides unique program features such as processing a batch of images, displaying detection results, coordinates of detected images, a summary of results, and an extracted KML file. Based on the results, the application obtained an overall accuracy of 88% in detecting snail eggs. This paper also shows that the optimal drone's height for a more efficient detection of golden apple snail eggs is up to 2.5 meters in elevation.

For future studies, this paper can be improved by using other image processing methods to produce higher accuracy in detecting snail eggs. Since it uses a drone to collect data, it is recommended to explore different camera angles to capture the snail eggs in rice crops. The application can also be used in detecting other pests of rice crops to maximize its scope.

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