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Detecting and counting *Aedes aegypti* egg using iot-ovitrap with computer vision approach

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Key words: *Aedes egypti* egg, CNN, Template matching, Open CV, Iot-ovitraps

Abstract

This study focuses on the critical investigation of the propagation of the *Aedes aegypti* mosquito, a vector responsible for transmitting various diseases. The significance lies in understanding its spread due to its potential to disseminate illnesses. Employing laboratory-engineered traps called IoT-Ovitraps, the research aims to construct maps illustrating egg deposition within a community. To achieve this, images featuring the objects of interest, namely *Aedes aegypti* eggs, are captured using a Raspberry Pi equipped with a micro lens. The primary objective centers on the detection and enumeration of *Aedes aegypti* eggs within the confines of Cauayan City. To ascertain the most effective methodology for achieving accurate egg quantification, the study employs three distinct models. These models are subsequently compared for their precision in estimating egg quantities present in the ovitraps. Among the models assessed, the convolutional neural network (CNN) emerges as the superior option in terms of efficiency and dependability. Remarkably, the CNN model attains an impressive accuracy rate of 99.5% in accurately detecting and enumerating *Aedes aegypti* eggs. This outcome underscores the potential of advanced machine learning techniques in contributing to effective disease vector monitoring and control strategies, highlighting the promising role of neural networks in tackling the challenges posed by disease-carrying mosquitoes.

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Introduction

An epidemic of dengue disease is spread by infected *Aedes aegypti*. When eggs were clumped with comparable things, disease carriers were difficult to locate. This illness has frequently endangered public health and even resulted in fatalities. To identify disease carriers at an early stage, several approaches and technologies, including computer vision and deep learning, had been explored. *Aedes aegypti* eggs can also be branded and mixed in with similar objects while still being recognized by a computer vision algorithm. Some studies (Bandong & Joelianto, 2019) (Santana *et al*., 2019) includes in their investigations are determined the size, shape, and color are the most important characteristics of eggs.

In the Philippines, the threat of dengue fever remains a significant public health concern due to the active transmission of the disease by the infected *Aedes aegypti* mosquito. The country has experienced recurrent outbreaks of dengue, posing substantial health risks and mortality rates. In response to the challenges posed by these disease carriers, innovative strategies and technological advancements have been explored to enhance early detection and control.

In order to effectively detect and count *Aedes aegypti* eggs in a particular location in Cauyan City, Isabela Province, Philippines. The researcher created a hardware which is called IoT-OviTrap that composed of Raspberry pi with micro lenses that is place over the black container with paddle or so called “DOST OL trap”. The hardware was being set with a time interval for capturing and automatically processed the capture images and then sends the result into the webserver.

The motivation of this study is to perform different computer vision models such as (OpenCV, Template Matching and Neural Network) to be package into the hardware and compare its results.

This study lies in its potential to address a pressing public health concern related to the spread of dengue disease through infected *Aedes aegypti* mosquitoes. Dengue outbreaks have posed a significant threat to public health, leading to substantial morbidity and mortality. The challenge of detecting disease carriers becomes more complex when *Aedes aegypti* eggs are clustered among similar objects, making their identification and control arduous. Early detection and monitoring of these disease vectors are critical to implementing timely control measures.

By exploring innovative approaches such as computer vision and deep learning, this study aims to contribute to the development of effective tools and techniques for the detection and counting of *Aedes aegypti* eggs. The creation of the IoT-OviTrap hardware, which integrates Raspberry Pi with micro lenses, offers a practical solution for real-time image capture and analysis. The utilization of computer vision models like OpenCV, Template Matching, and Neural Network within the hardware holds the potential to enhance the accuracy and efficiency of egg detection.

Ultimately, the study's findings have the potential to inform and guide public health interventions, aiding in the early identification and management of *Aedes aegypti* populations. This research could contribute significantly to the field of disease vector control and monitoring, offering insights into innovative technological solutions that can be applied in other regions facing similar challenges.

The emergence and propagation of dengue disease carried by *Aedes aegypti* mosquitoes have engendered substantial health risks, necessitating effective control measures. However, the challenge of identifying these disease vectors is compounded when their eggs are clustered alongside similar objects. Traditional detection methods often fall short in accurately locating and quantifying these eggs. In response, this study seeks to address the problem of efficient and reliable *Aedes aegypti* egg detection within a specific location in Cauayan City, Isabela Province, Philippines.

Despite previous research efforts, there is a need for advanced technological solutions that combine hardware and computer vision techniques to enhance the accuracy and speed of egg detection. The development of the IoT-OviTrap, encompassing Raspberry Pi with micro lenses and integrated computer vision models, seeks to provide a holistic solution to this problem. The comparative analysis of computer vision models—OpenCV, Template Matching, and Neural Network—within the hardware framework further enhances the potential for accurate and early identification of *Aedes aegypti* eggs.

Materials and methods

The methodology is based on egg collection through ovitraps, in a process of acquisition image and in the model denominated Decision Tree Classifier with CNN. All of these processes will be described here.

Study Area

The City of Cauayan, also known as Cauayan, is a third-class component city in the Philippine province of Isabela. Its population as of the 2020 census is 143,403 people. The province and the entire span outside the Cagayan Valley are centered in Cauayan. It's located around 375 kilometers northeast of Manila, 34.5 kilometers south of Ilagan, the capital of Isabela, 48 kilometers north of Santiago City, and 117 kilometers or so northeast of Tuguegarao City, the largest city in the Cagayan Province.

Ovitraps

Fig. 1. DOST Ovitrap

Utilizing DOST ovitraps, egg deposition was carried out. The World Health Organization recommends using this egg-trapping technique as one of the dengue vector surveillance methods. Currently, it is thought to be the most effective method, especially when egg density isn't high and the cost of operation is cheap. The Ovitrap is composed of 500 mL black-frosted plastic containers were used to make the traps. After filling the container with water, a wood fiber was fastened to the lid. The apparatus is shown in figure 1. A community of ovitraps are dispersed. They are gathered and brought to the lab where they go through a drying process and are then ready to be counted after a set amount of time.

Image Acquisitions

Fig. 2. Image acquisition system.

The acquisition of images is done through laboratory assembly. A "Raspberry Pi, with micro camera lens is used as shown in Figure 2.

The camera has been set up, and the settings need to be guarded against unauthorized changes. Only the upper light, which has lighting settings, was used with a low intensity to minimize the shadows. To achieve the sharpest possible images, the coupling height and focal length were varied to determine the main lens arrangement. Thirty minutes was the interval of each photograph as it is taken to avoid image blurring since the images are being taken automatically.

Computer Vision Techniques

In this study the researchers use three (3) computer vision techniques to be compared in the discussion part this study as follows:

Template Matching

Template matching (TM) plays an important role in several image processing applications (Cuevas *et al.*, 2017).

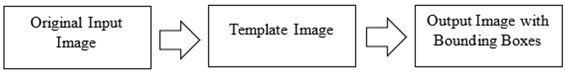

Fig. 3. Framework of Template Matching on detection and counting.

Template matching is a simple image detection algorithm that can easily detect different types of objects just by changing the template without tedious training procedures (Wijaya, 2022). Despite these advantages, template matching is not currently widely used. (Han, 2021). In this study the researcher uses it to see if it is reliable on detecting and counting the Aedes agypti see figure 3 above.

OpenCV (Blurring, Thresholding, Segmentation and Contour)

Object detection has a wide range of applications, including retrieval and surveillance. Object counting is a step after object detection that gets more exact and robust with the help of OpenCV (Shubham Mishra *et al.*, 2022).

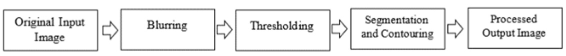

Fig. 4. Framework of OpenCV on detection and counting Aedes Egypti.

In this study, the OpenCV technique was also implemented due to it is simple and cost effective in terms of processing time. The original image was being converted into grayscale and then employ the blurry function, afterwards the blur image was being applied by adaptive thresholding with invers-binary and finally detects change in the image color and marks it as contour for counting the eggs. Most of the functionalities stem from image processing made available through OpenCV(Ghoshal *et al.*, 2021). With this, the researcher also uses the OpenCV for detecting and counting Aedes egypti see figure 4 above

Neural Network (Convolutional Neural Network)

Convolutional neural network (CNN), a class of artificial neural networks that has become dominant in various computer vision tasks, is attracting interest across a variety of domains (Yamashita *et al.*, 2018).

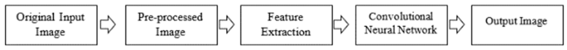

Fig. 5. Framework of CNN on detection and counting *Aedes egypti.*

In figure 5 above, the image processing technique of adaptive thresholding was used to produce the approximate values of eggs in the image. The processed image will then be sent to the CNN model which composed of two (2) Conv2D, MaxPooling layers, with two (2) dense layer for validation in order to assess the model's accuracy.

Results and discussion

In order to obtain a good technique for detecting and counting Aedes Egypti, it is necessary to optimized the parameters used when processing images. The followings are the result of the experimentation based on the captured data of the IoT-Ovitrap.

Template Matching

Fig. 6. Template Matching Result.

Experiment were implemented to test the performance using template matching which is the result was shown in figure 6 above. In order to find the possible exact match, the threshold used in this method was 90 percent and got an accuracy of 70% in detecting and counting Aedes Egypti Eggs.

OpenCV (Blurring, Thresholding, Segmentation and Contour)

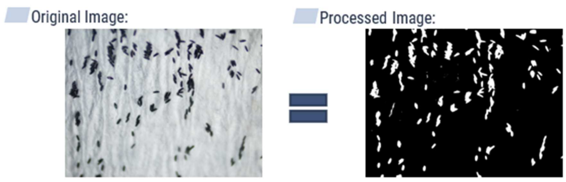

Fig. 7. OpenCV result.

In figure 7 above shows the result of OpenCV based on the following methods perform in achieving an accuracy of 98.8 percent in detecting and counting *Aedes egypti* eggs

Neural Network (Convolutional Neural Network)

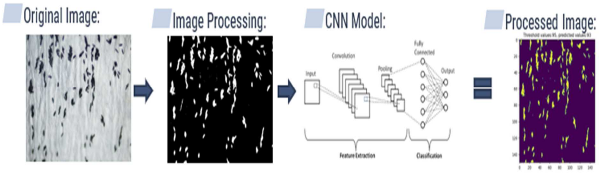

Fig. 8. CNN result.

The result of experimentation shows that with the used of neural network, especially the CNN, it garnered an accuracy of 99.5 in detecting and counting Aedes Egypti Eggs based on the framework used.

Conclusion

The primary causes of disease transmission are currently the subject of research; in some circumstances, this process calls for flexibility. The current effort is a technical improvement to the epidemiology laboratory as a result.

This work highlights the critical relevance of understanding the different approach because it makes it relatively simple to identify items in an image. This technique's great effectiveness and adaptability to the circumstances present in a particular scenario. The Iot-Ovitrap will have a higher chance of success the more taught it is; thus, it is crucial that the data contain standardization of the images, a large amount, and diversity.

Based on the three (3) method used, the neural network CNN was the most efficient and reliable way on detecting and counting Aedes Egypti Eggs over the two methods.

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