Using Computer Vision to Count Aedes aegypti Eggs with a Smartphone

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BACKGROUND

In 2016, the Abt Associates-led Africa Indoor Residual Spraying Project (AIRS), funded by the President’s Malaria Initiative (PMI), expanded its scope to support USAID Malaria and Encephalitis Programs in Latin America and the Caribbean to contain the Zika virus epidemic. The initiative comprised an emergency response, funded by the United States Agency for International Development (USAID), known as the Zika AIRS Project (ZAP). ZAP aimed to build capacity in the region and implement vector control and entomological monitoring operations in the Dominican Republic, El Salvador, Guatemala, Haiti, Jamaica, Honduras, Eastern and Southern Caribbean Islands, and other South American countries. ZAP ended activities in September 2019.

The contact between mosquitoes and humans facilitates the transmission of infectious diseases such as Zika, dengue fever and chikungunya. Given that there is not a defined treatment for these mosquito-borne diseases, but no vaccine available, the most effective strategy relies on the control of the insects (mosquitoes) that transmit these diseases.

CHALLENGE

A critical element of ZAP was to maintain consistent surveillance of Aedes aegypti mosquito populations. Collecting and counting mosquito eggs are essential when conducting surveillance of Aedes aegypti which is recognized as the Zika vector. When mosquito surveillance is conducted as a regular activity by public health programs, the labor of counting eggs is generally done using a magnifying glass, or a stereoscope.

Tracking numbers of mosquito eggs is useful when this surveillance is applied on a large scale, including hundreds of houses as sampling units. In this way, health authorities attempt to capture a more realistic picture of mosquito populations. Collecting and counting mosquito eggs are essential when conducting surveillance in regions of the world where dengue, Zika, and chikungunya are abundant and tropical diseases such as dengue, Zika and chikungunya represent a serious burden for the local communities and health authorities.

METHODOLOGY

ZAP teams in Haiti, Dominican Republic, Honduras, Guatemala, El Salvador and Jamaica conducted regular entomological surveillance in sentinel sites chosen according to epidemiological data and previous information recorded by Ministries of Health. Aedes aegypti populations were described as abundant. On average, countries established four sentinel sites and conducted surveillance using ovitraps with a 1% dry hanging. Ovitraps were distributed in total of 180 houses per site, checked every five days. Eggs were collected in paper towels, transported to laboratories, counted, and registered on a weekly basis. The surveillance using ovitraps was conducted for continuous periods of time during ZAP implementation from 2016 to 2019. Specific dates of surveillance varied according to the work plan of the individual countries. All operations in the field were conducted by ZAP employees with the close collaboration and agreement of the local Ministry of Health.

The development of MECVision comprised trials in order to test the App performance, using different photo quality, and other variables such as lighting, minimal egg Jacques (deposition, bias), and minimal training on the use of the App.

Overview

At the initiative was to create a simple and free tool to track Aedes aegypti mosquito surveillance. The development of MECVision comprised trials in order to test the App performance, using different photo quality, and other variables such as lighting, minimal egg Jacques (deposition, bias), and minimal training on the use of the App.

RESULTS

• We created an accessible, and free smartphone application, MECVision, that can be used to conduct fast and accurate egg counts of A. aegypti mosquitoes. The application can be used with no internet connectivity, in any type of smartphone, iOS or Android or even desktop web browsers.

• The comparison between human counts vs. machine counts had no significant difference.

• Our ultimate goal was to support global health teams to solve a problem that could improve the quality of mosquito surveillance in regions of the world where A. aegypti is widely abundant and tropical diseases such as dengue, Zika and chikungunya represent a serious burden for the local communities and health authorities.

Next Steps

MECVision is currently being used in the field in Jamaica, El Salvador, Honduras, and Argentina, and given that it is under an open GPL license, others are free to contribute and customize the project to their needs and environment. This project also provides a basis for moving into more sophisticated technician-trained machine learning models for even greater accuracy and precision.

TECHNOLOGY

MECVision is made up of a modern, flexible, and open-source technology stack.

• Value: Web framework that controls the user interface and settings of the App.

• Wampy: Design Library that allows the app to be flexible, accessible, and modular.

• OpenCV: Industry-standard computer vision object recognition — the algorithms underlying the segmentation and identification of the eggs.

• Processing (Java App (FWA)). Allows for the web App to be used offline, secure, modular, and scalable.

• HTML / CSS / JS. Most universal and accessible programming languages of the web — allowing for the greatest accessibility by the most software engineers today and into the future.

Figure 1. A field technician counting mosquito eggs. Technicians used a magnifying glass or a stereoscope when available.

Figure 2. Example of ovitrap paper and close-up of mosquito eggs.

Figure 3. A field technician counting mosquito eggs. Technicians used a magnifying glass or a stereoscope when available.

Figure 4. Field trials of MECVision in ZAP countries.

Figure 5. Algorithm walkthrough of the app — starting with the 1) Original image, 2) Thresholding Values, i.e. converting to black and white, 3) Edge Segmenting, and 4) Object Sort (single eggs vs egg clusters).

Figure 6. Comparison of time worse (in minutes) employed by human versus MECVision when counting Aedes aegypti eggs on a single paper trap.

Figure 7. A Smartphone App that uses the phone’s digital camera to photograph a collected egg paper sample, capture eggs and egg clusters, and instantly report the estimated total number of eggs.

Figure 8. Example of counting paper and closer view of mosquito eggs.

Figure 9. Time charts showing how much time is required to count 10 papers by hand.

Figure 10. App calculates egg count per single sheet when compared to MECVision。“

Figure 11. App provides a basis for moving into more sophisticated technician-trained machine learning models for even greater accuracy and precision.

Figure 12. App can be used offline, secure, scalable, and accessible.

Figure 13. App can be used offline, secure, scalable, and accessible.

Figure 14. App can be used offline, secure, scalable, and accessible.

Figure 15. App can be used offline, secure, scalable, and accessible.