# Poster: Fighting Dengue Fever with Aerial Drones


K.T.Y. Mahima, Malith Weerasekara, Kasun De Zoysa, Chamath Keppitiyagama
University of Colombo
yasasm@scorelab.org, malithk@scorelab.org, kasun@ucsc.cmb.ac.lk, chamath@ucsc.cmb.ac.lk

Luca Mottola, Thiemo Voigt
Uppsala University and RISE Computer Science
luca.mottla@it.uu.se, thiemo.voigt@it.uu.se

Markus Flierl
Electrical Engineering and Computer Science
KTH Royal Institute of Technology
mflierl@kth.se


## 1 Overview

Dengue and Zika are two arboviral viruses that affect a significant portion of the world population. Each year, almost 400 million dengue infections happen. Due to severe dengue fever, around half a million people each year are in need of hospitalization [6] and about 36.000 people die [2].

Dengue spreads rapidly in densely populated urban areas. The principle vector species of both dengue and zika viruses are the Aedes aegypti and Aedes albopictus mosquitoes [1]. They breed in very slow-flowing or standing water pools. It is important to reduce and control such potential breeding grounds to contain the spread of these diseases.

We describe our system design and presents initial results. We employ mmWave radios to detect water retention areas as potential mosquito habitats. Next, we use multi-spectral images to analyze the water area, measure the depth of the water, and understand the larvae density. After that, we fuse the results for the final classification of the water area.

## 2 System Description

The detection of the breeding places happens in two steps: first drones are sent on scanning flights at high altitude, say around 300 meters, to identify areas that need to be more closely investigated. The scanning flights are based on digital maps that indicate potential breeding places, using open formats such as OpenStreetMap Keyhole Markup Language (KML) that facilitate the exchange of map information among involved stakeholders.

We construct the initial version of the maps with the help of public health instructors who currently do this job manually and hence have in-depth knowledge. We then automatically update the maps with data from new flights from drones equipped with sensors (see Fig. 1) as well as weather information, e.g., to include the effects of recent rainfalls that may create new potential breeding places. Based on the updated maps we construct the paths that consist of the waypoints, that is, the potential breeding places for closer inspection.


This work has been partly funded by Digital Futures and the Swedish Research Council (Grant 2018-05024 ).


Figure 1: MicaSense RedEdge-MX camera integrated into the DJI Phantom 4 drone.

In the second step, drones visit the waypoints. When arriving at a potential breeding place, the drone detects and analyzes the water area to determine whether it contains mosquito larvae. We investigate a two-step approach to solve this problem. First, we employ mmWave radios to detect water retention areas as potential mosquito habitats. Next, we use multi-spectral images to analyze the water area, measure the depth of the water and understand the larvae density. After that, we fuse the results for the final classification of the water area. We believe that broadening the spectral footprint using both mmWave radios and imagery will make our results more reliable. Once we detect a breeding place with mosquito larvae, the public health authorities and building owners are informed to ensure removal of the breeding place.

## 3 Using mmWave Radios

We integrate a TI IWR1843boost mmWave sensor with a DJI Phantom 4 drone. To log data from the mmWave sensor, we develop a Python script and run it on a Raspberry Pi Zero W module connected via USB.

For our current experiments, we record two data sets targeting ground and water by hovering the drone at the same height. As depicted in Fig. 2, the received power from wa-

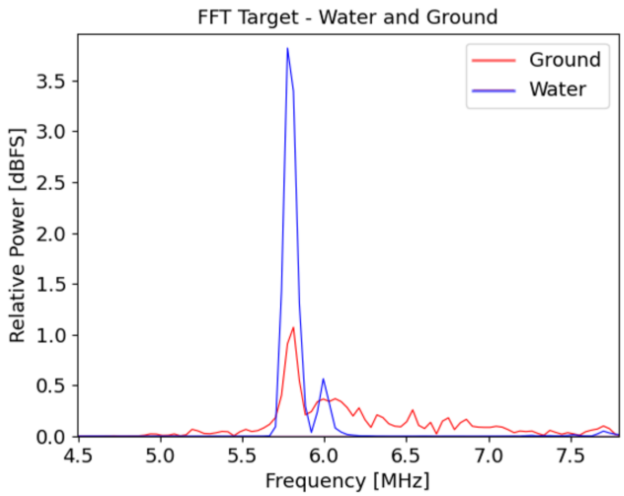


Figure 2: Received power for ground and water using a mmWave sensor.

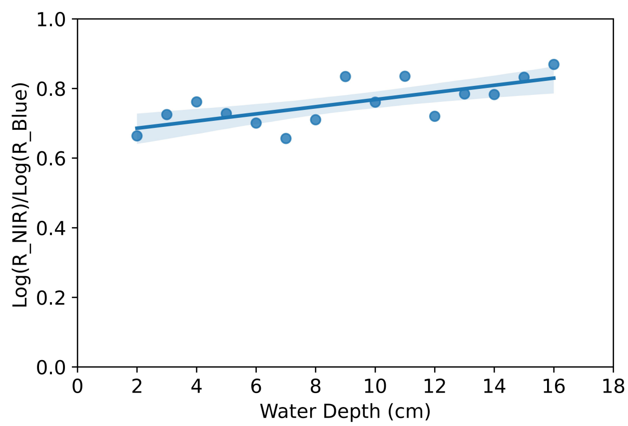


Figure 3: Regression plot of water depth vs. log-ratio of the NIR and Blue band reflectance values.

ter areas are relatively high compared to the ground areas. This suggests that the mmWave radios can detect water from drones. Since the vibration of the drone generates instability in the received power of the signal, we use the average values over a sliding window to smooth out the signal.

Our initial results demonstrate that using mmWaves to detect water areas is feasible but further experiments are needed to determine the reliability of this sensing modality.

## 4 Using Multi-spectral Imagery

The depth of water is a vital factor that influences mosquito larval development [4]. Several studies exist to determine the depth of coastal waters using multi-spectral satellite imagery [5]. Sarira et al. conduct a study to determine the minimum water depth such that water areas can be accurately identified by multi-spectral images [3]. They find that there is a considerable statistical dependency between Near-Infrared (NIR) reflectance and water depth. Moreover, it requires at least 5-10 cm depth for an accurate identification of inundated areas using NIR images only.

For our experiments, we collect an image dataset with a MicaSense RedEdge-MX multi-spectral camera fitted onto a DJI Phantom 4 drone (see Fig. 1). The sensor has five spectral bands: Blue, Green, Red, Red Edge, and Near-Infrared (NIR). We use water buckets with varying water depths, ranging from 2-16 cm, increasing the depth by 1 cm each time and study bathymetric models to relate water depth and measured band reflectance values. We apply a log-ratio algorithm [5] to determine the logarithm of the reflectance of the NIR band $R(NIR)$ and normalize it by the logarithm of the reflectance of the Blue band $R(Blue)$. The model assumes a linear relation between the depth and the log-ratio, as in

$$Z = m\frac{\log R(\lambda_i)}{\log R(\lambda_j)} + c, \tag{1}$$

where $Z$ denotes the water depth, $R(\lambda_i)$ and $R(\lambda_j)$ are the reflectance values of the NIR and Blue bands, respectively, and $m$ and $c$ are model parameters that can be determined by linear regression.

Fig. 3 depicts the regression plot of our experiment. A linear relationship between $\log R(NIR)/\log R(Blue)$ and water depth is visible. The observed $R^2$ value is moderate. This indicates that we can use the bathymetric log-ratio method to estimate the water depth from drone-based multi-spectral images. However, several data points are still outliers and impact the accuracy of the estimation. We expect that using two modalities, mmWave and imagery, will help us to improve the accuracy.

## 5 Conclusion

We described our system design to fight dengue fever by using aerial drones. We showed promising results for using mmWave radios to detect water retention areas as potential mosquito habitats and for using multi-spectral images to analyze the depth of the water. We plan to improve the quality of the data to measure the depth of extreme shallow water areas more accurately. We also expect that fusing the results from mmWave radio and multi-spectral imagery will make the results more reliable.

## 6 References


[1] Centers for Disease Control and Prevention. Surveillance and control of aedes aegypti and aedes albopictus in the united states. http://www.cdc.gov/chikungunya/resources/vector-control.html. Accessed: 2016-04-11.

[2] Mosquito Reviews. Statistics for mosquito-borne diseases deaths. https://www.worldmosquitoprogram.org/en/learn/mosquito-borne-diseases/dengue, 2022. Accessed: 2022-05-20.

[3] T. V. Sarira, K. D. Clarke, P. Weinstein, L. P. Koh, and M. M. Lewis. Rapid identification of shallow inundation for mosquito disease mitigation using drone-derived multispectral imagery. *Geospatial health*, 15 1, 2020.

[4] M. C. Stanton, P. Kalonde, K. Zembere, R. H. Spaans, and C. M. Jones. The application of drones for mosquito larval habitat identification in rural environments: a practical approach for malaria control? *Malaria journal*, 20(1):1–17, 2021.

[5] R. P. Stumpf, K. Holderied, and M. Sinclair. Determination of water depth with high-resolution satellite imagery over variable bottom types. *Limnology and Oceanography*, 48(1part2):547–556, 2003.

[6] World Mosquito Program. Statistics for mosquito-borne diseases deaths. https://mosquitoreviews.com/learn/disease-death-statistics, 2022. Accessed: 2022-05-20.