BIOMEDICAL ENGINEERING

VectorCAM: A Digital Innovation to Advance Entomological Surveillance

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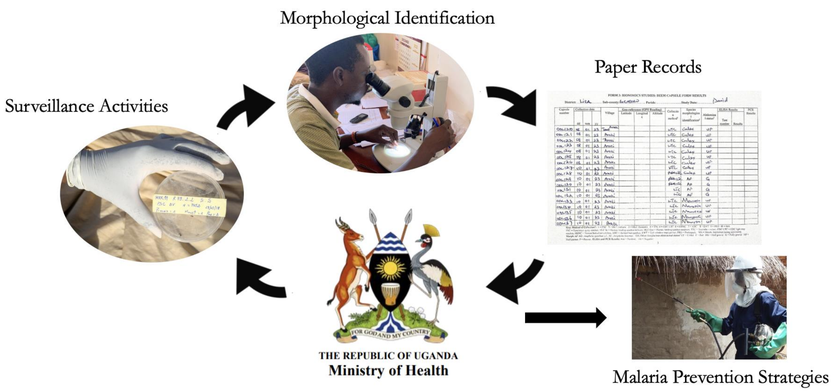
Abstract

VectorCam is a novel digital tool that automatically detects a mosquito's species, sex, and abdomen status, thereby deskilling the identification process. Task-shifting efforts to Village Health Teams (VHTs) will generate higher throughput and widespread surveillance coverage, enabling better-informed, data-driven malaria intervention decisions cost-effectively. Here we present our early-stage device and summative usability studies conducted

What is Vector Surveillance?

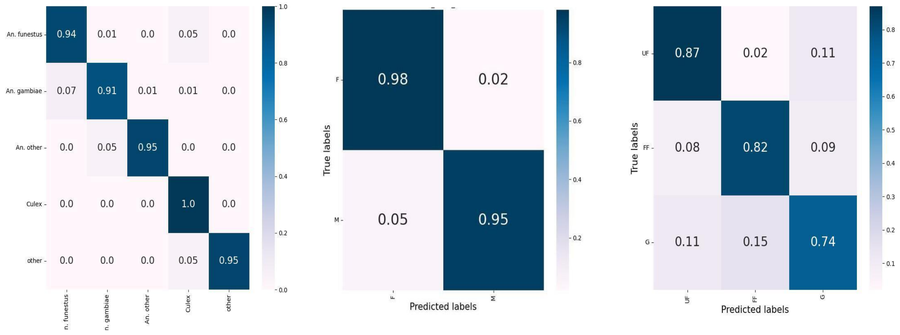
Malaria infects an estimated **227 million individuals** annually, resulting in over 400,000 deaths, most of whom are pregnant women and children under five in sub-Saharan Africa. Currently, efforts to eliminate malaria rely on monitoring vector species composition, abundance, distribution, and behavior across transmission geographies. A robust vector surveillance system should **drive targeted interventions and resource allocation for effective malaria control**. For example, one primary malaria vector, Anopheles funestus, has a different biting pattern than another, Anopheles gambiae, and therefore necessitates different intervention strategies.

The current structure of vector surveillance begins with mosquito collection, where mosquito specimens are collected at sentinel sites across the country using various collection methods by Vector Control Officers (VCOs), which inform malaria prevention strategies. However, there are **three main bottlenecks**, (1) not enough VCOs, (2) not enough surveillance funding, (3) incomplete data through current reporting



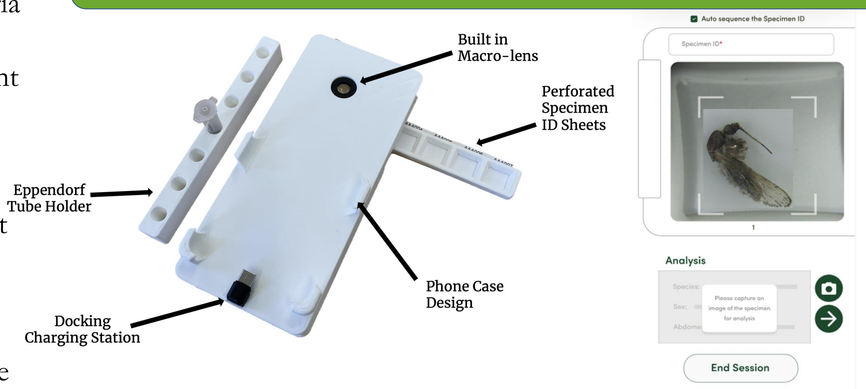
VectorCam Device

VectorCam's AI Performance

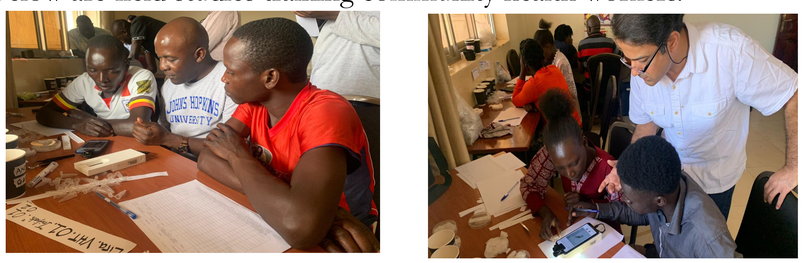


VectorCam runs three separate classifiers on each mosquito specimen and presented are each respective confusion matrices. The five-class model has an average accuracy of 95%, the sex classifier is 97%, and the abdomen accuracy of 81%.

VectorCam Hardware & Software

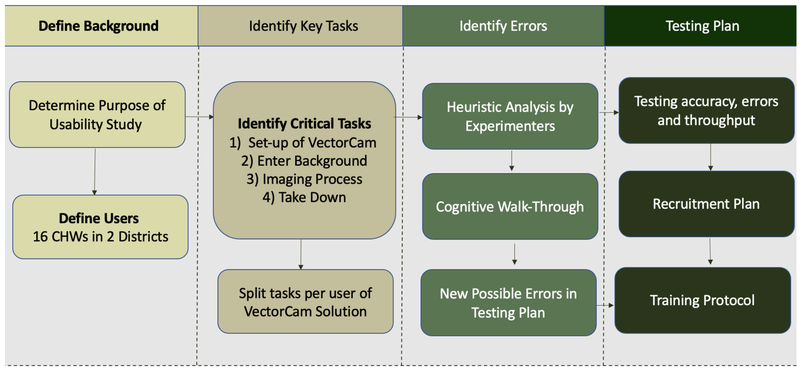


After months of iterations through stakeholder feedback, the current VectorCam hardware and software prototypes developed to be launched in the field are presented. The UX of this system is designed for easy-use by community health workers and rapid image collection. Below are field studies training community health workers.



Summative Usability Study

Pilot Test	Methods	Success Criteria
Accuracy of Algorithm	• Run VectorCam and morphological identification in tandem • Compare accuracy between morph. and app	>90% accuracy against morphological ID
Accuracy of Use	• Identify and quantify errors that impact the binary success of **critical tasks**	0 errors
Throughput of Identification Steps	• Run app identification for **56 mosquitos per VHT pair**, and time how long each task takes	>1 mosquito identified / minute
Usability and VHT Training	• Run VectorCam in one sentinel site, first teaching VCOs (instructional docs) who then teach VHTs • Run summative usability study on system	16 VHTs (8 pairs) and 4+ VCOs trained



Here, we detail a summative usability study, where the success of this team-based approach was evaluated according to four primary characteristics: (1) the accuracy of the algorithm in the hands of intended users (CHWs), (2) error rates of CHWs while using the VectorCam system, (3) the throughput of identifying 48 mosquitos in a team-based fashion, and (4) the comfort of CHWs in using the device, as measured through a system usability scale. This study was conducted in two high-malaria endemic districts in Uganda, as stated by the Ugandan Ministry of Health, Mayuge, and Adjumani.

Conclusion

VectorCam strives to revolutionize the real-time surveillance of vector-borne diseases around the world. It's novel AI technology embedded in smartphones will enable global citizens to observe and monitor the spread of vectors, giving Ministries of Health and non-governmental organizations the upper hand to prevent the next epidemic.

Acknowledgments:
1. Dr. Soumya Acharya (CBID)
2. Dr. Radha Taralekar (CBID)
3. Dr. Neil Lobo (University of Notre Dame)
4. Dr. Douglas Norris (JHSPH)
5. Dr. Rama Chellappa (ECE)

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