Surveillance System for *Aedes* Using Multimodal Capture and Detection for Early Dengue Warning

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Session: 2019-20

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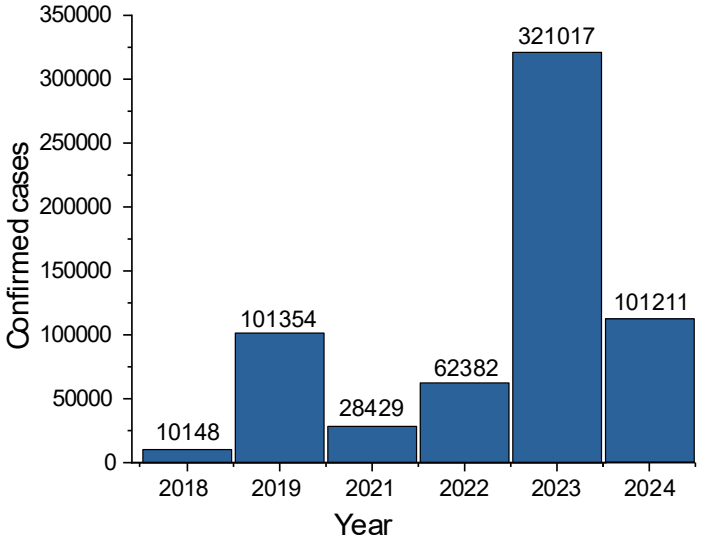
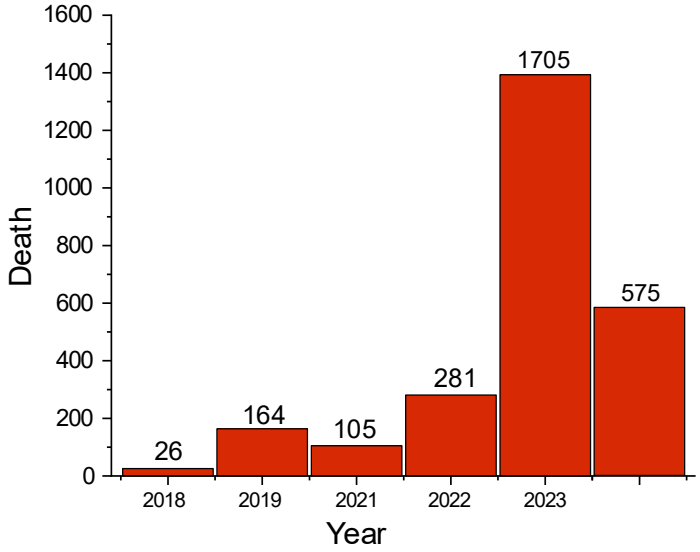
Session: 2019-20

DENGUE: A MAJOR THREAT IN BANGLADESH





- Highest mortality rate (0.57%) in 2024
- Ranked 3rd in dengue-related deaths
- Hemorrhagic Dengue mortality rate of 50%

From January 1st to till date

Confirmed	Death
4120	23

62% higher cases than previous year

*Source: Directorate of General Health Service, Bangladesh

PRESENT STATE OF CONTROL

- Effort to prevent dengue outbreak by eliminating carrier mosquito, *Aedes*

- Indiscriminate use of Chemicals
- Does not reach all affected areas
- Difficult to find the right time
- Increasing chemical resistance

- Tk1288cr project in 2023 yet record number of fatalities (1705)*

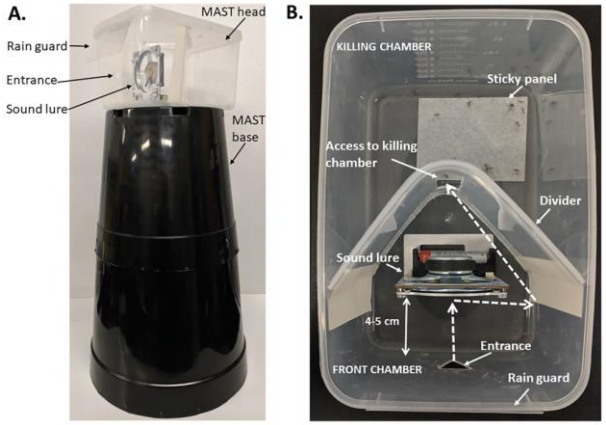
- Delayed
- Wasteful
- Limited

No early warning

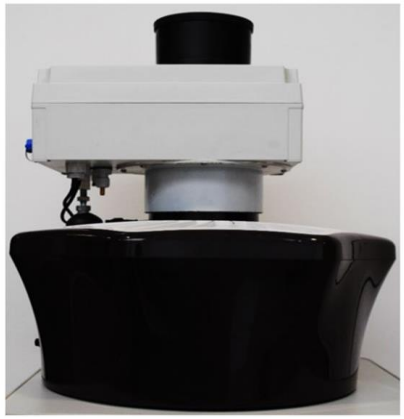
*Source: The Daily Star

RELATED WORK

CO_2 trap
(*Claudel et al*)



Frequency trap
(*Staunton et al*)



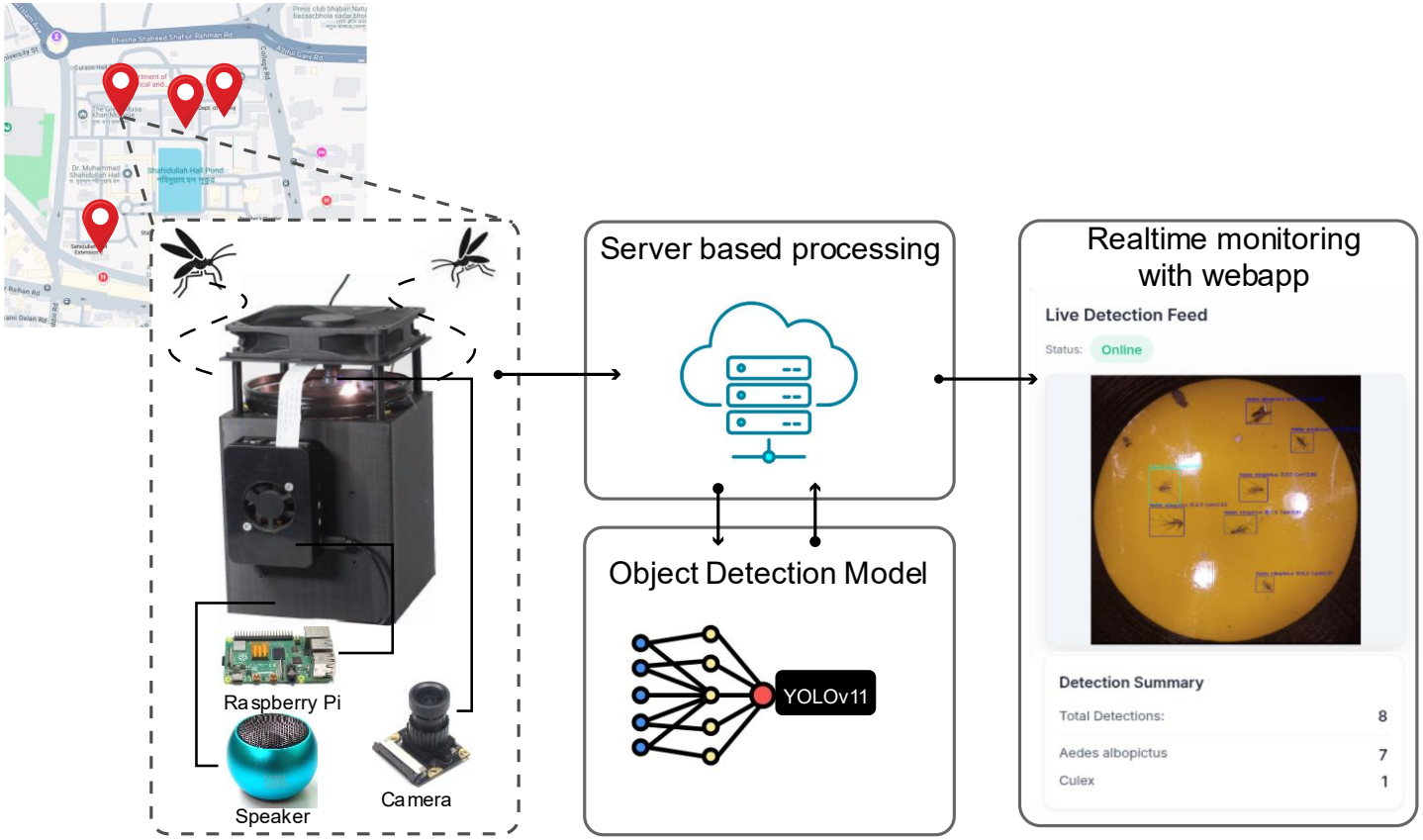
Optical species identifier
(*Faulhaber et al*)

Limitations:

- Lack of **scalability**
- No **automation**
- Unsuitable for **mass-monitoring**

Need for an integrated system capable of providing early warning of local dengue infestation

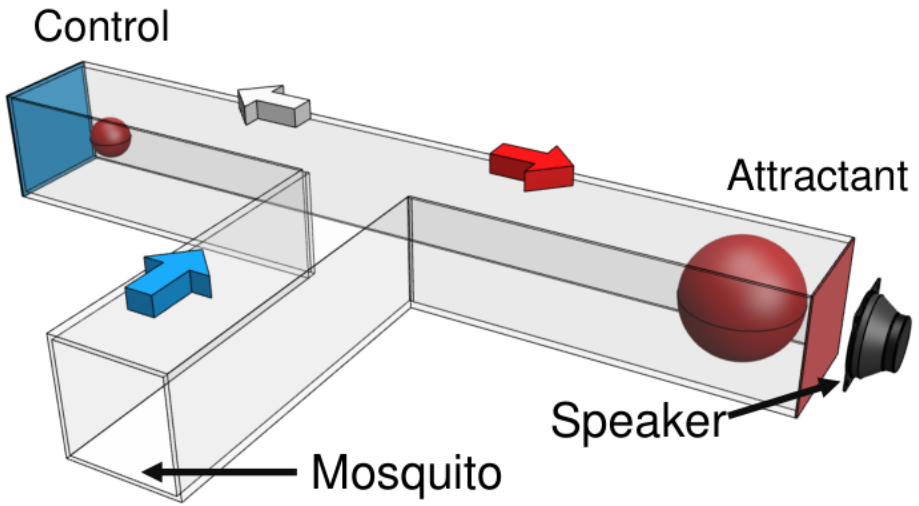
SOLUTION: COMPLETE SURVEILLANCE SYSTEM



- **Scalable system**: Devices distributed across many regions
- **Centralized** data processing
- **Remote monitoring** and management

ATTRACTANT SELECTION

- Aedes cultured locally in *Animal Garden DU* for experiments



Lab-rearing of *Aedes*

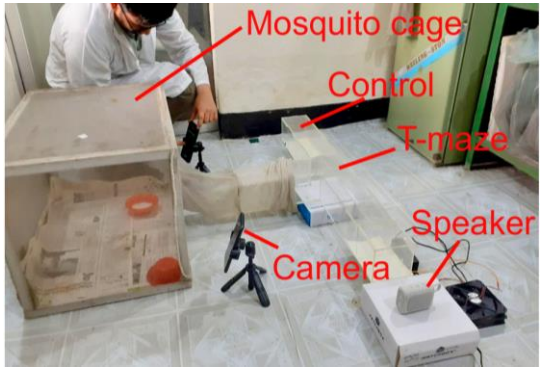
- Egg collection
- Larvae incubation
- Reared into adults

T-maze test

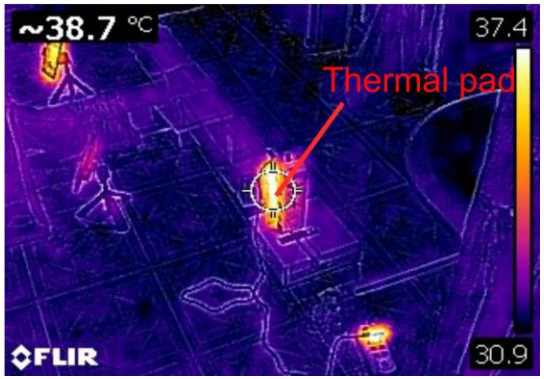
- T shaped structure with 3 arms
- Attractant placed on one side
- Population recorded for 10 minutes

ATTRACTANT EFFICACY ANALYSIS

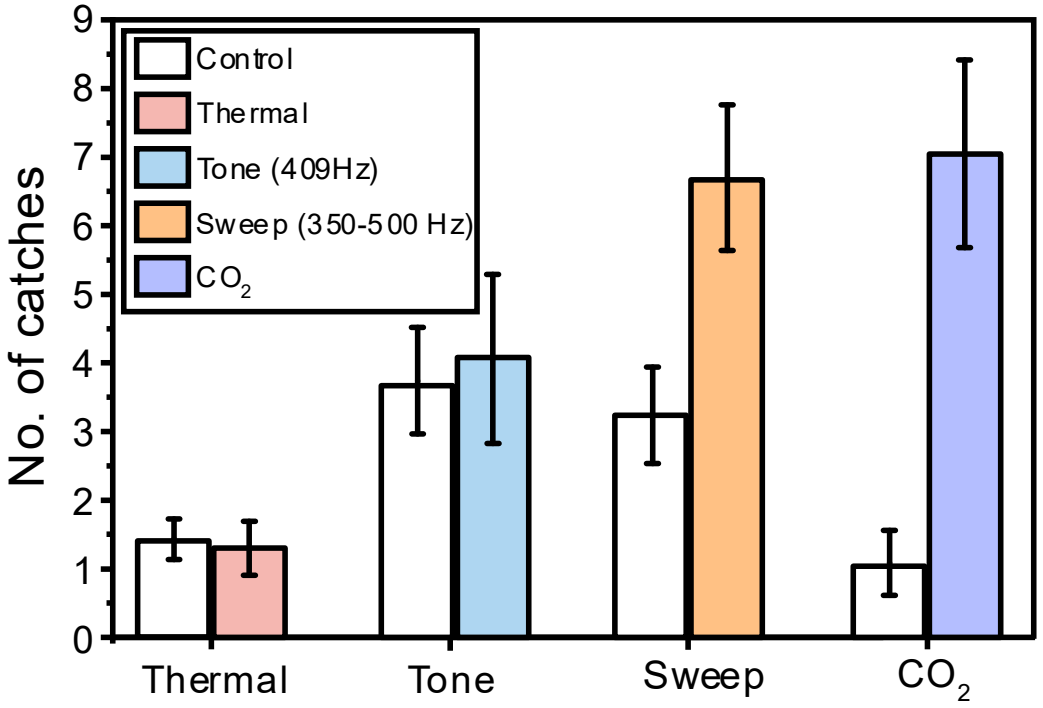
Frequency



Thermal



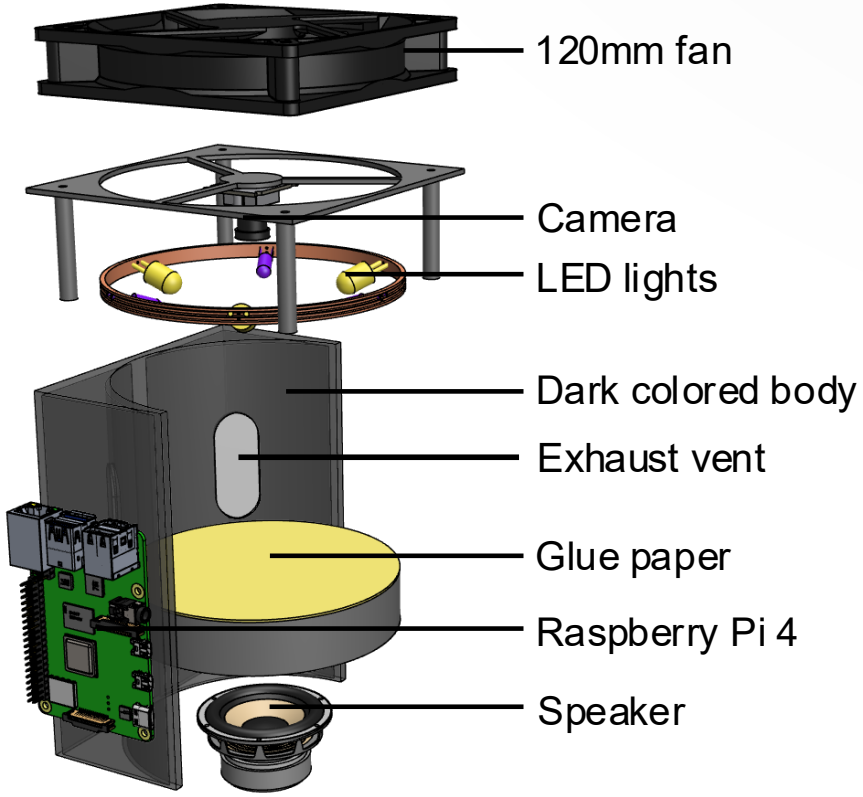
Carbon dioxide

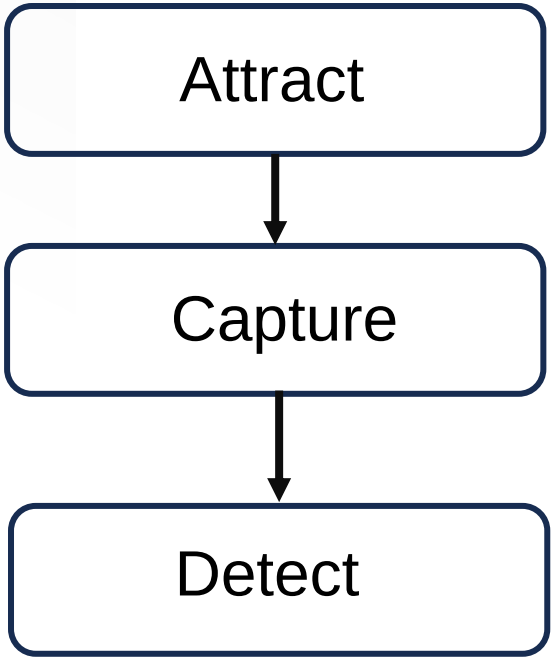


- Frequency sweep (350-500Hz) and CO_2 induced strongest response
- No noticeable response with others

Frequency sweep selected due practicality and environmental concerns

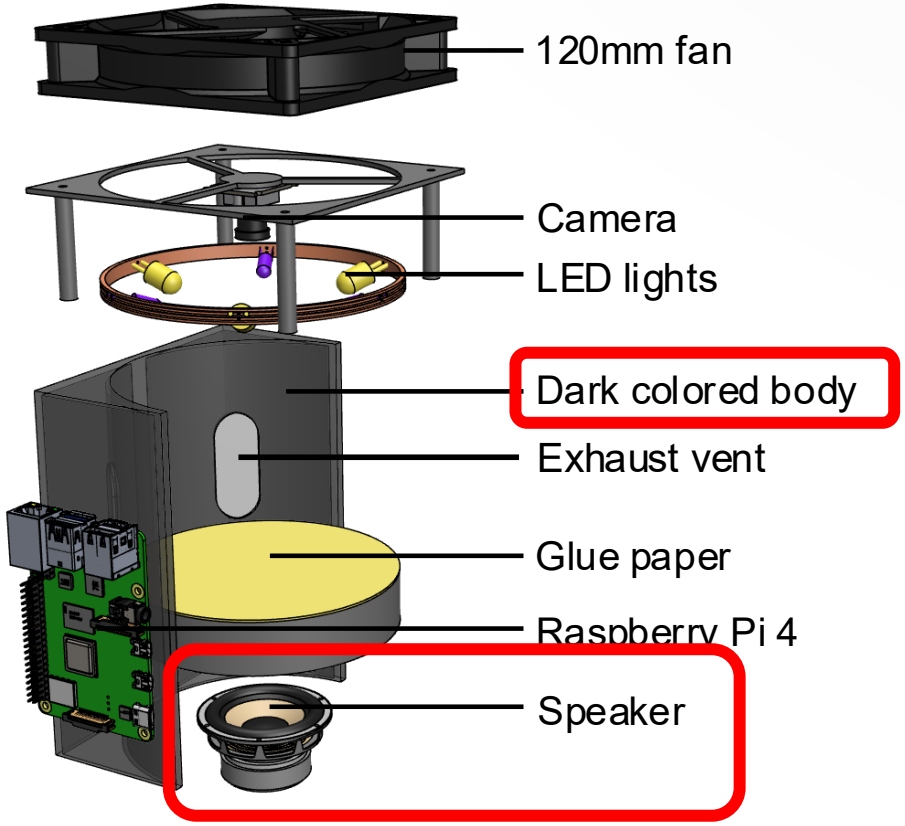
CAPTURE DEVICE DESIGN

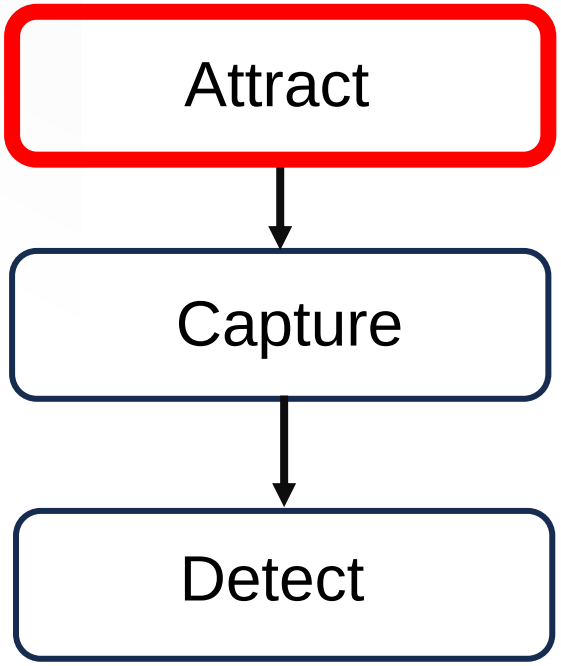




- ❑ Components divided into 3 modules
- ❑ Based on the experiment outcomes and prior studies

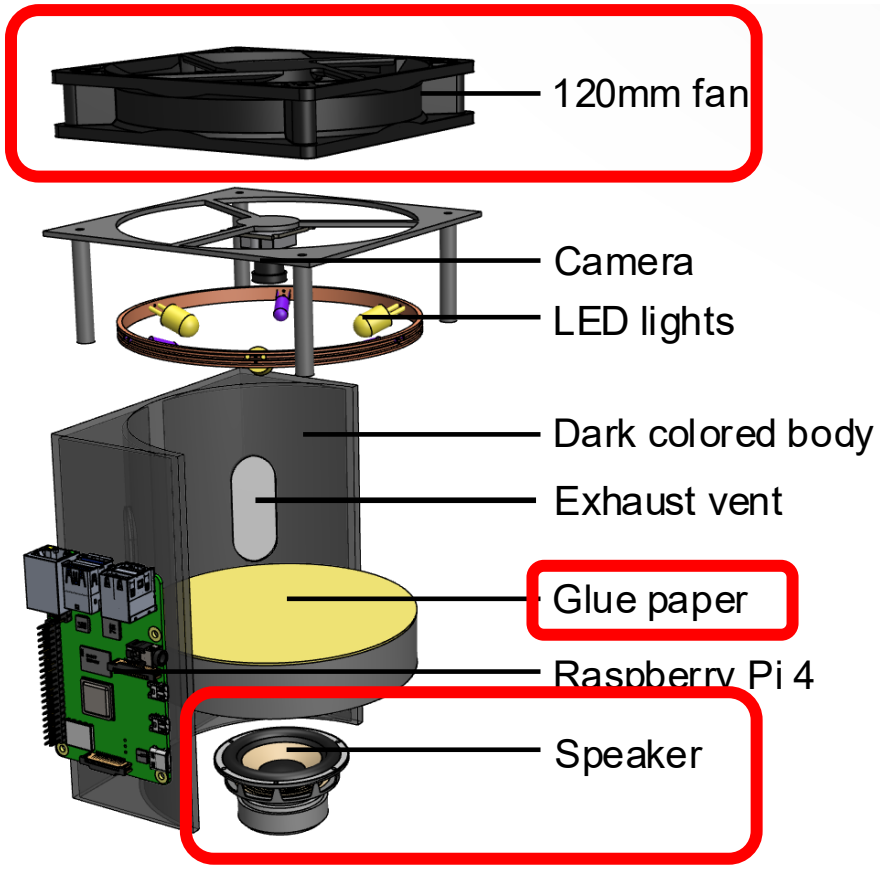
CAPTURE DEVICE DESIGN

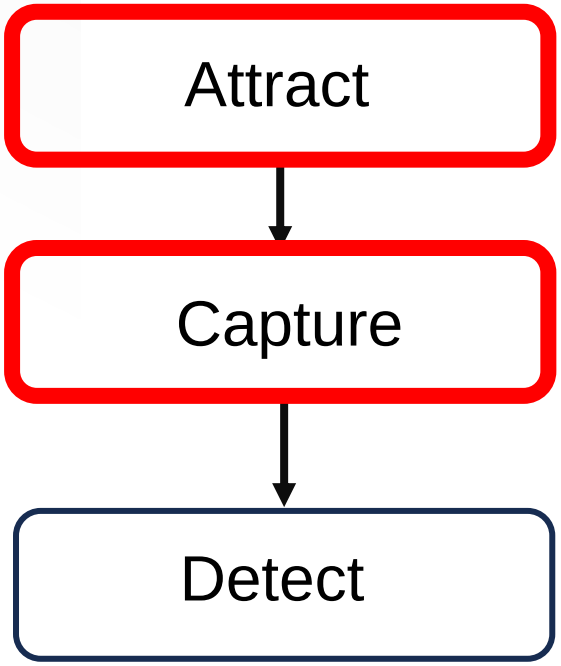




- Frequency sweep selected for attraction
- Speaker plays 350-500Hz sweep
- Black marker acts as visual cue
- Dark colored body enhances attraction

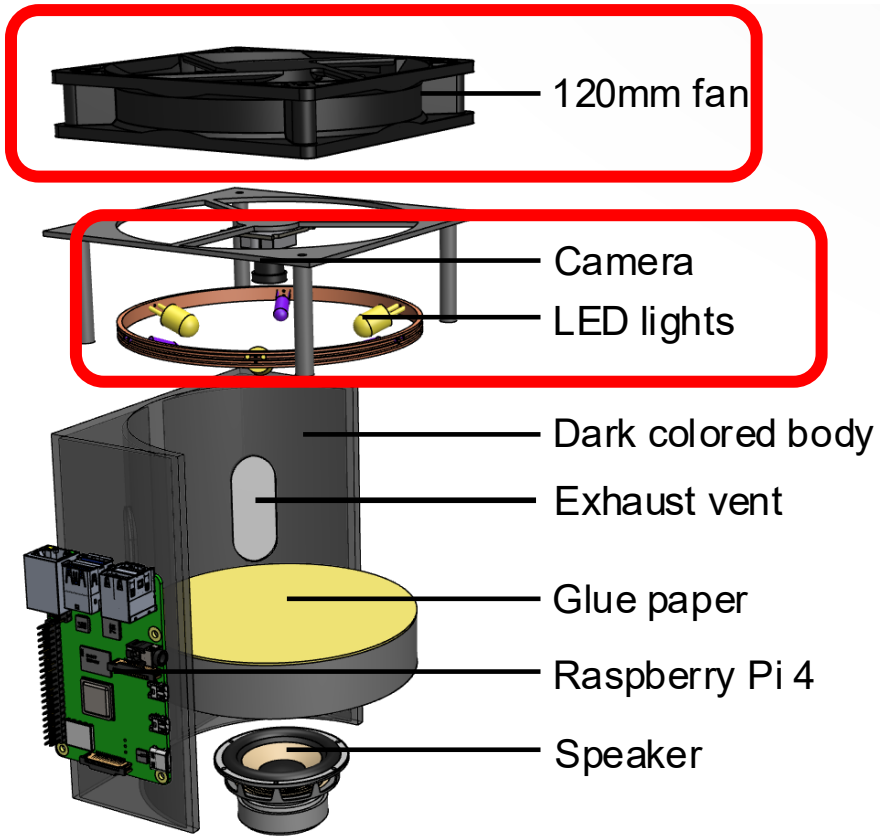
CAPTURE DEVICE DESIGN

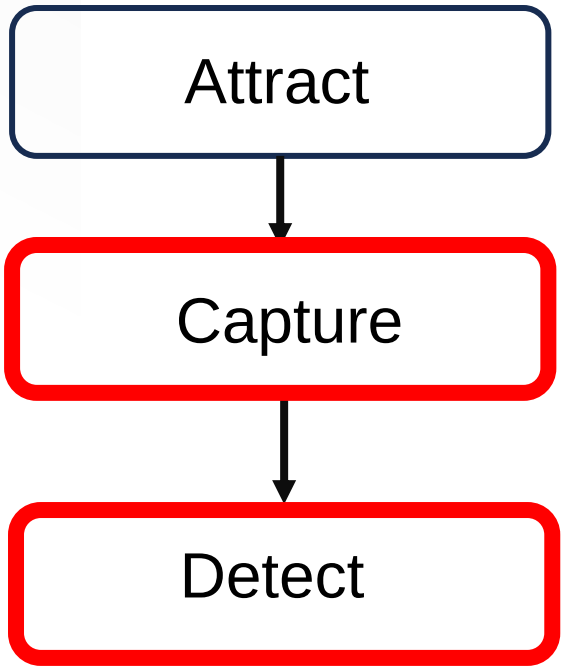




- Chamber provides confinement
- Fan maintains inward airflow
- Mosquitoes sucked in with airflow
- Adhesive paper holds them in place

CAPTURE DEVICE DESIGN

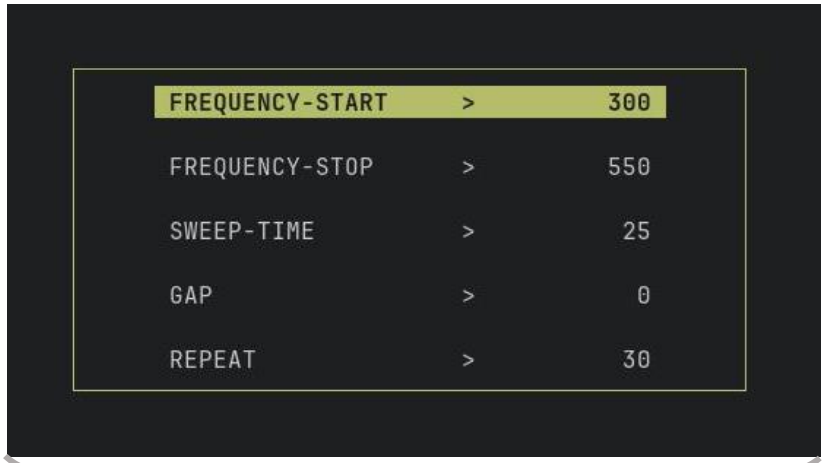




- 5MP camera paired with Raspberry Pi 4B records stream using RTSP protocol
- Three 3W LED used to illuminate the chamber for better imaging

FABRICATION: HARDWARE AND SOFTWARE

Frequency generator software



Electronic components


Raspberry Pi 4


5MP CSI camera

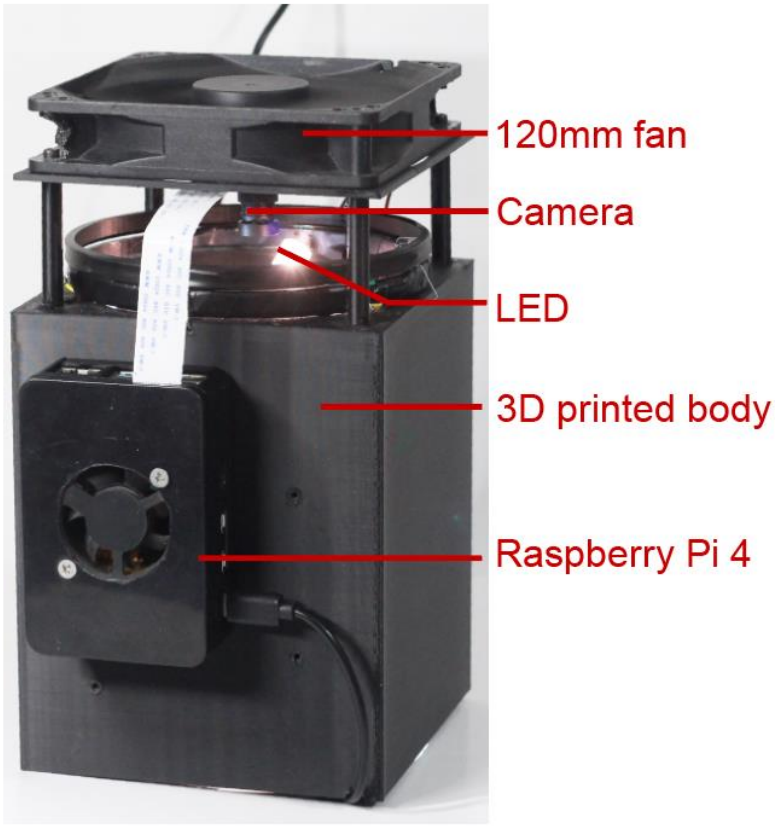

120mm fan


LEDring


Bluetooth speaker

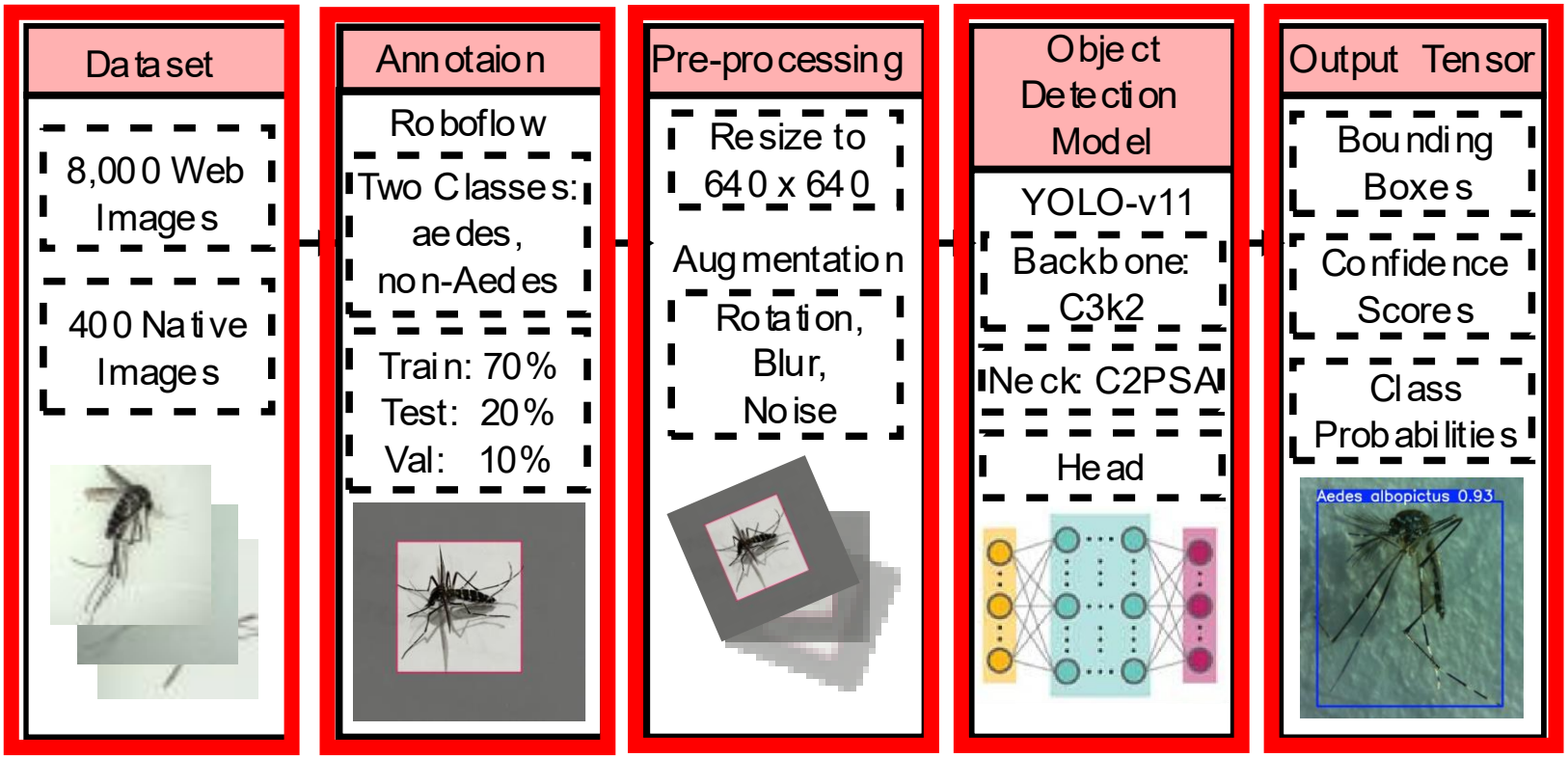

5V 3A power supply

Implementation



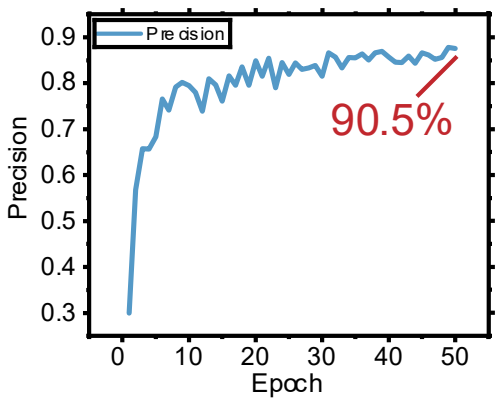
- 3D printed structure
- Integrates attraction, capture and imaging

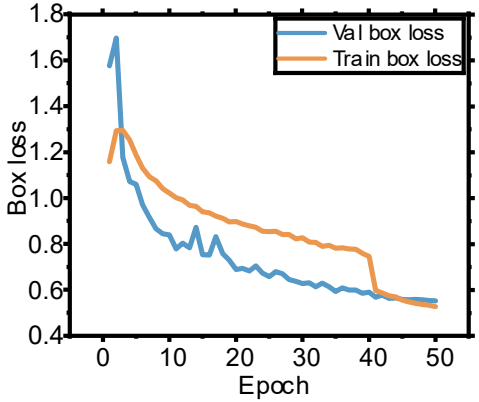
DETECTION: IMAGE PROCESSING

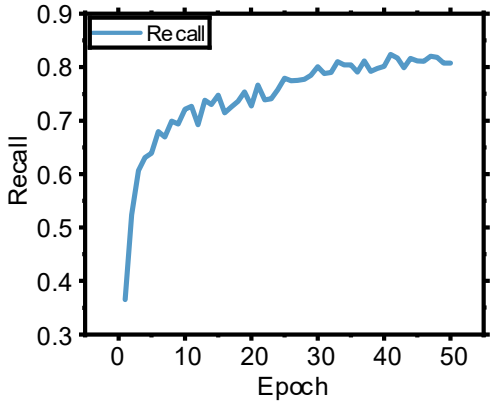


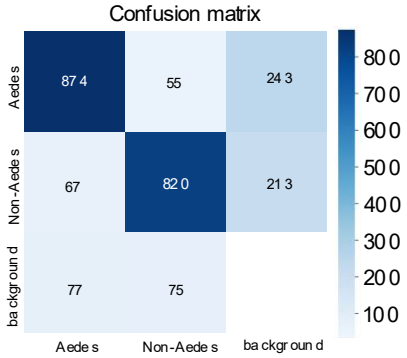
- YOLOv11 model trained in Google Colab Pro (Tesla A1000 GPU)
- Periodic save points to avoid overfitting
- Expanded dataset using image augmentation

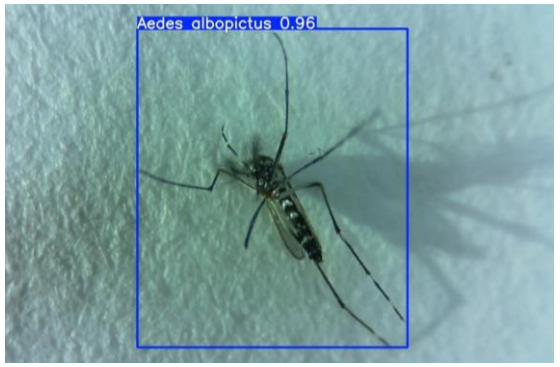
RESULT: Model training and testing

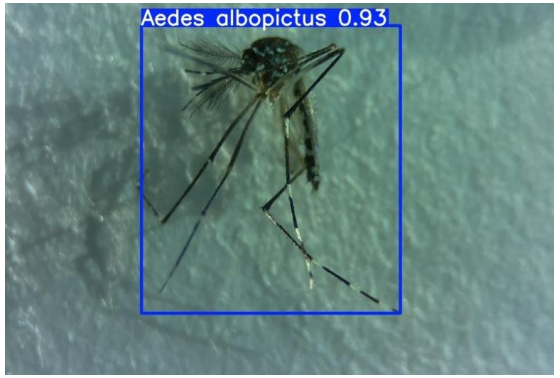


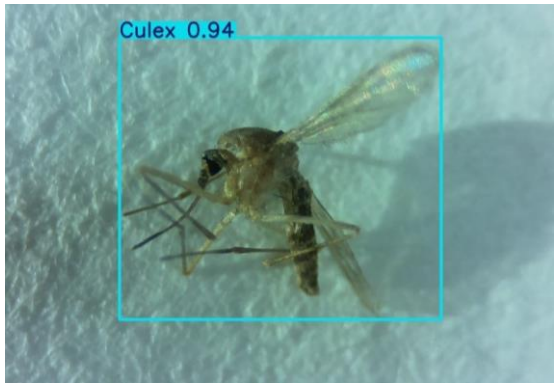








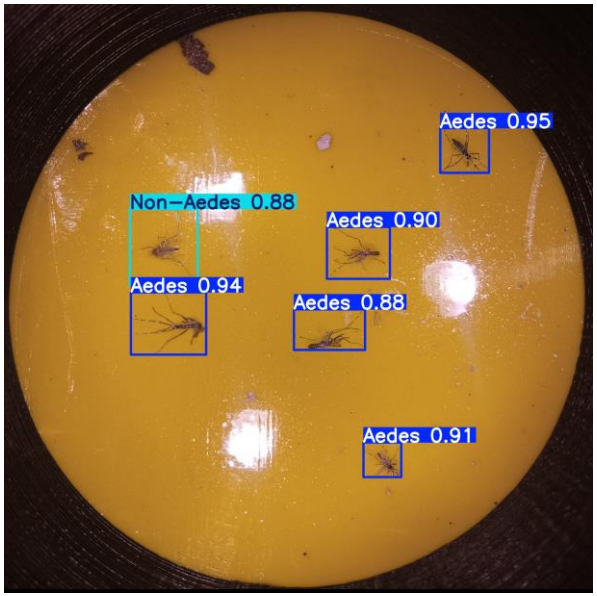




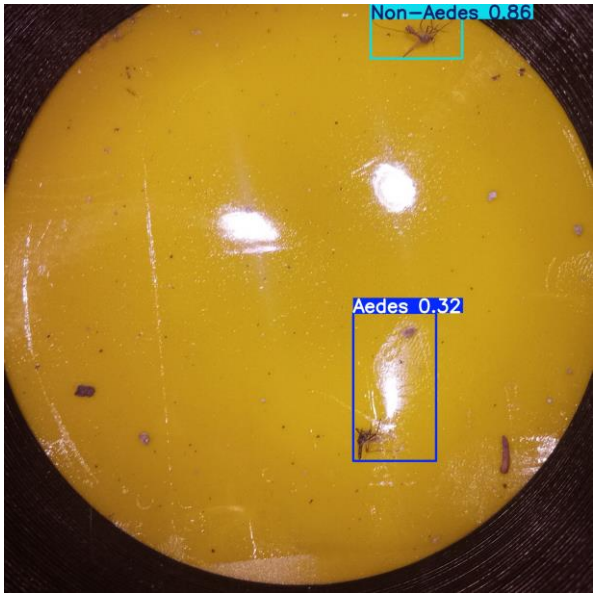
- Precision of 90.5% after 50 epochs
- Validation loss follows training loss
- Model Tested with native mosquito images

REAL-TIME SURVAILLENCE

With Frequency

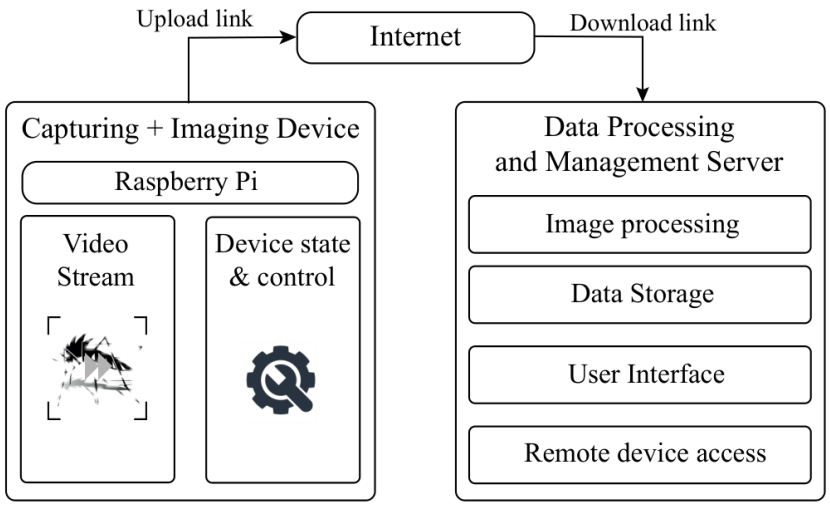


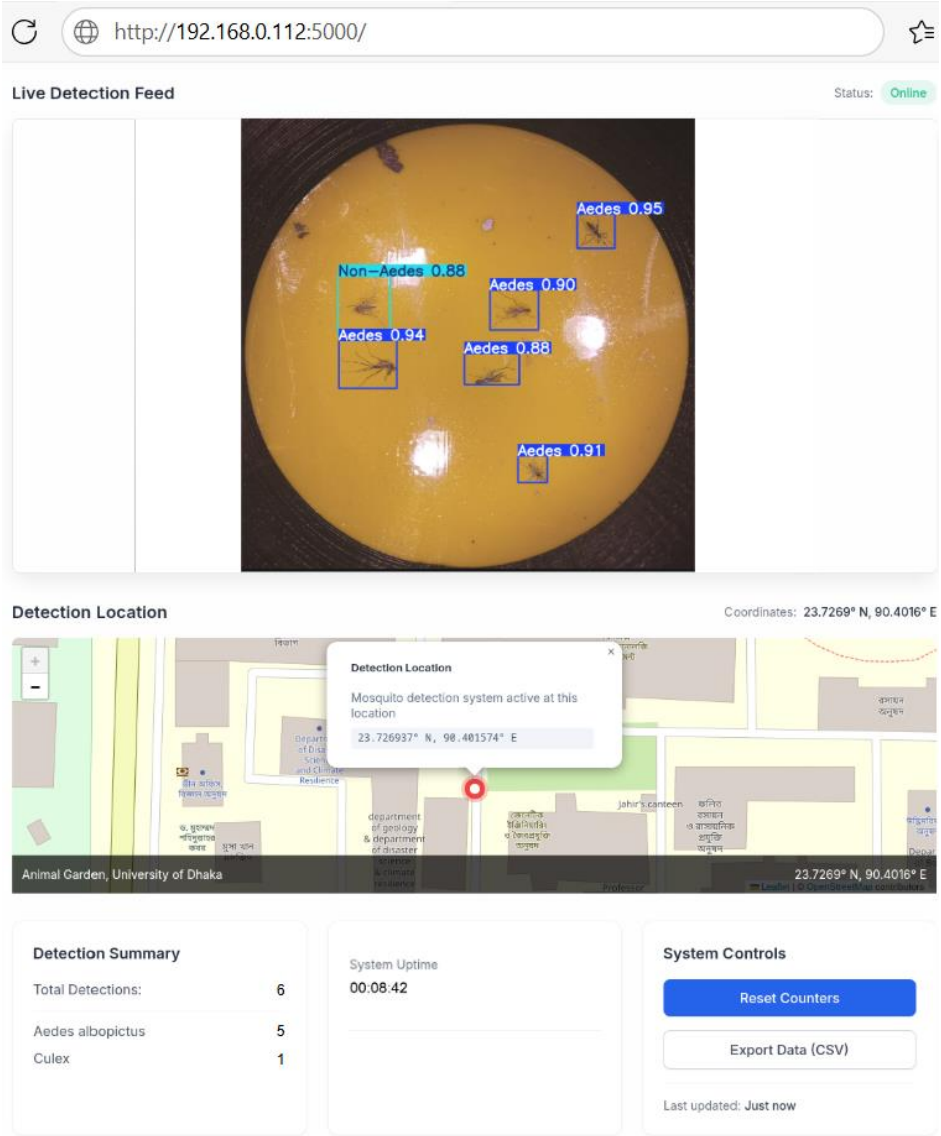
Without Frequency



- A mixed population of *Aedes* and Culex mosquitoes grown in a mosquito cage
- The capture device placed inside this cage
- System tested both with and without wingbeat-frequency audio
- Trials conducted for 10 minutes, total number of detected mosquitoes monitored afterwards
- The device with frequency captured 5 *Aedes* and 1 Culex mosquito
- All but one detection had confidence scores above 88%

SERVER BASED PROCESSING SYSTEM





- Web application obtains data, runs inference and displays results
- Enhances data management & accessibility
- Enables remote access to a large network of devices.

FUTURE SCOPE IN DEVELOPMENT

- Adding wingbeat frequency-based detection
- Expanding native image database
- Further optimizing object detection model
- Field testing in various environments
- Host server

ACKNOWLEDGEMENTS

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