HALY.ID

HALYomorpha halys IDentification: Innovative ICT tools for targeted monitoring and sustainable management of the brown marmorated stink bug and other pests

Coordinator
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2019 cofunded Call
End-term Project Seminar
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Involved Countries and Partners

UNIMORE – Università degli Studi di Modena e Reggio Emilia

Technische Universität Braunschweig

Tyndall National Institute – Institiúid Náisiúnta

unipg – A.D. 1308 – Department of Mathematics and Computer Science

Universitatea Politehnica din București

OnePlanet Research Center

Duration

36 months

6 months extension

Overall budget

Euro 1.316.576

Objectives

Monitor the Halyomorpha halys (HH)—Brown Marmorated Stink Bug—an invasive alien species, that reached Europe in 2004 and so far, spread in 80% of the European countries.

Propose an autonomous field-monitoring system to detect HH based on drones, and computer vision algorithms.

Extract knowledge from an innovative sticky trap and microclimate stations in order to devise an epidemiological model.

Certify the collected data in a trusted logbook system to be of use in the fruit-production chain.

Investigate non-destructive techniques to increase marketable fruit quality by discarding internally damaged fruits not visible to the naked eye.

Major Results

Achievements

We devised a novel Android application for autonomous data acquisition by using a DJI Matrice 300 drone, equipped with RTK, and a DJI Zenmuse H20 camera.

We trained HH detectors, leveraging YOLO, RetinaNet, and Faster-RCNN, relying on RGB images autonomously collected by the drone with satisfactory results.
2021 Flying in First Person View inside the orchard
2022-23 Flying at a **height** of 10 m above the orchard

We found relevant spectral regions in the SWIR range (1000 to 1600 nm) able to distinguish HH on different backgrounds.

NIR-HSI images of sound and punctured pears (cv. Williams and Abate Fetel) were elaborated using a Machine Learning (ML) algorithm based on image data reduction and feature selection to visualize the pixels ascribable to damaged areas.

Challenges

Hardware selection to strike a balance between off-the-shelf drones and hardware budget;
Image acquisition strategy tailored for the drone-camera system.

Dataset creation with fine samples relevancy and quality;
Lack of HH due to adverse weather conditions;
Large RGB images with a complex and cluttered scenery;
Dealing with a high percentage of images without HH.

Cameras in that SWIR range, e.g., IMEC SNAPSHOTS WIR 9 or 16 bands, have not enough resolution yet;
Other multispectral cameras, e.g., InGaAs, are not com monly used with drones.

Highly dependence on the field condition;
The definition of the ground truth of punctured pixels is challenging since punctures are not visible by the naked eye on unpeeled fruits and only slight spectral differences exist between sound and punctured areas

Major Results

Achievements

We deployed 5 microclimate stations (board sensors and Raspberry Pi), wired connected to a Central Box with LTE to TUBS: humidity, temperature, light-intensity, pressure, and wind are continuously sensed from June 2022.
7 Stationary cameras have been added in June 2023.

We designed and realized a prototype of a novel IoT HH trap that incorporates a sticky panel with pheromone lure, an Open MV board with an MCU and an embedded camera. The MCU extracts ROIs and classifies them using DNN at predefined intervals of time.

We just started to derive a proof-of-concept of an epidemiological model.

We implemented the ContractBox, a framework that offers trusted and accountable data sharing between multiple distrusting parties.

Challenges

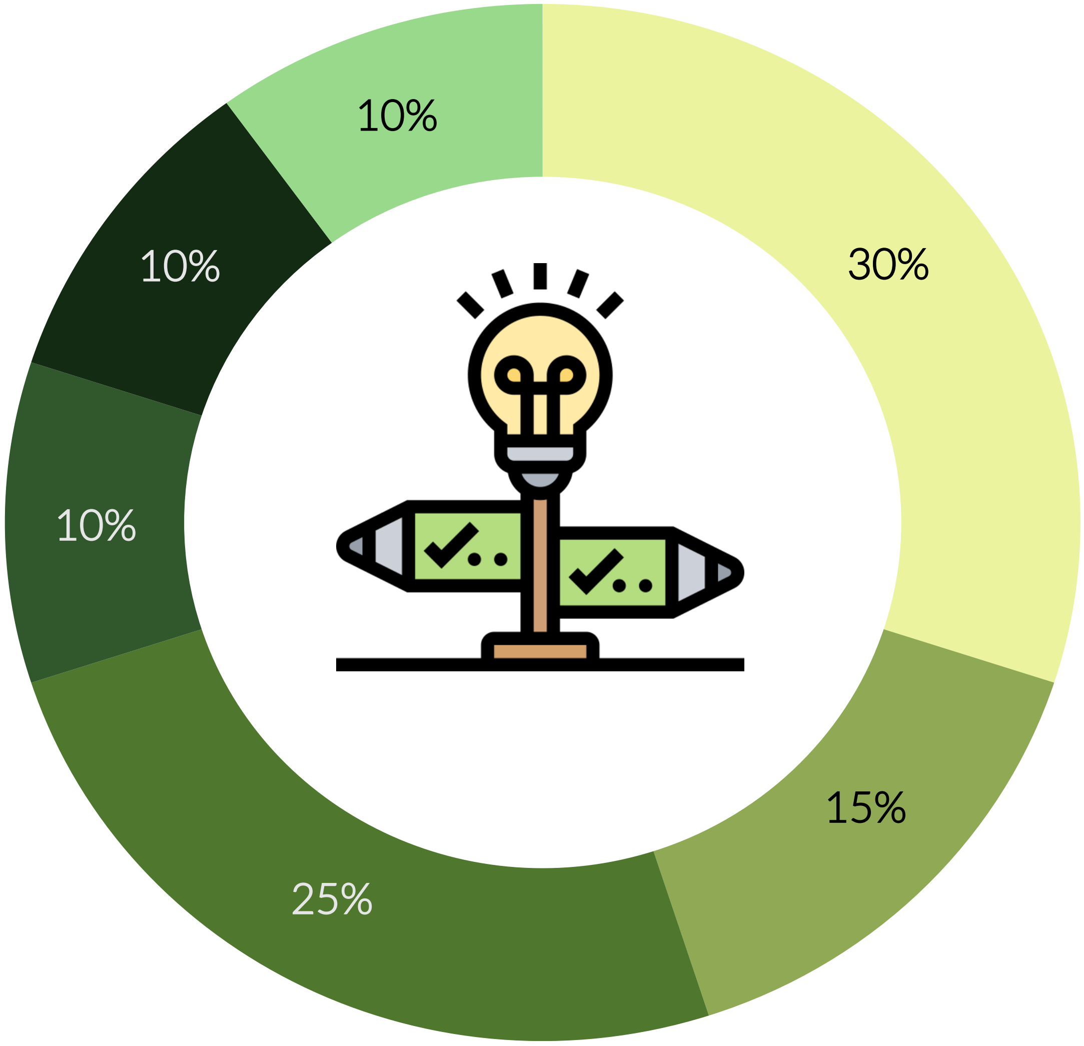
Wired links for reliable and remote monitoring due to Covid Situation and Integrated Circuit Shortage;
Waterproof sensor housing development preserving con nection with the outside environment (air and light).

Finding an optimal trade-off between performance, time and energy;
Stabilize light condition for a reliable detection;
Deal with a two sides sticky trap.

The epidemiological model can only be discussed downstream of environment data acquisition, including data on HH abundance.

Achieving the trustness, accountability, and immutability of a blockchain in a single-node.

Selected research approach, Methodology



- Machine Learning on RGB
- Machine Learning on NIR-HS
- IoT development & deployment
- Android Application & Communication Protocols
- Blockchain techniques adapted to constrained-resource environment
- Entomology support (HH behavior, Data acquisition in the Field, Annotation)

Opportunities and next steps for innovation

SHORT TERM	Complete the porting of HH detectors on a light board carried by the drone and obtain a real-time detection
MEDIUM TERM	Extend the communication part (wireless, sensor-drone) Train HH detectors for the images of the stationary cameras
LONG TERM	Finalize the environment data (microclimate, sticky trap, stationary cameras) towards the epidemiological model Merge SWIR and RGB images in HH detectors Porting of the acquired methodologies to new alien invasive species

Summary and Conclusion

1. The drone does not hurt the HH in terms of **noise** and **airflow**;
2. The success of a computer vision algorithm depends strictly on the **similarity** between the trained and tested images: *the more similar they are, the better the prediction ability*;
3. Computer vision algorithms for bug detection can be trained with **less than thousands** of images;
4. Ad hoc IoT devices can be successfully designed in a **resource-constrained** environment;
5. Based on current results, it will be possible to further optimize a ML classification method to **identify punctured fruits**.

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Thank you for your attention!