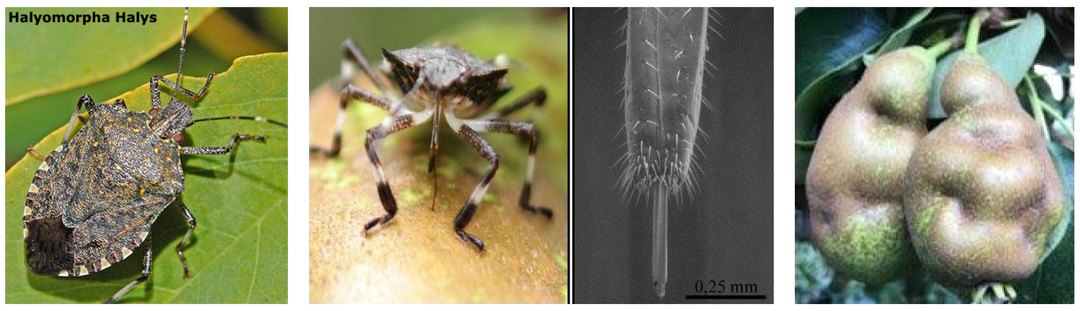
HALYomorpha halys IDentification – HALY.ID

Background



- **Motivations**:
  - **Brown Marmorated Stink Bug (briefly, BMSB)** (scientific name: *Halyomorpha halys*) is an invasive **emerging** pest, native to Asian regions.
    - BMSB reached Europe in early 2000s (probably **hidden** in containers) and is now established in Southern Europe.
  - BMSB has a high reproductive potential with multiple overlapping yearly generations in absence of native predators. In Southern Europe:
    - Overwintering generation survives about one year. They overwinter inside man-made structures and are active in the fields from March–May.
    - There are 2 overlapping generations in July–August that survive 70–80 days.
  - BMSB is **polyphagous** at all development instars and mostly feed on fruits and vegetables
  - To feed, BMSB uses its **stylet** to pierce the plant tissue and extract the plant fluids. Simultaneously, BMSB injects saliva into the plant, creating a dimpling of the fruit's surface and rotting of the pulp underneath. In pears, this causes **suberification**, and this leads to strong deformations and makes the fruits unmarketable.
    - In Northern Italy, in 2017 90% losses in hazelnut, and in 2019 80% losses in fruits: an economic impact of €588 million.

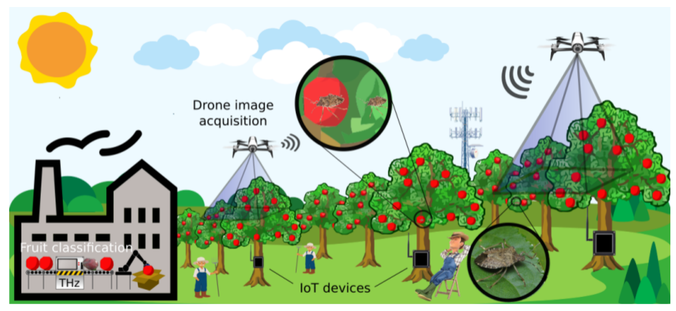
Preliminary conclusions

1. The communication architecture in the field is **fundamental** for any activities (data collection, logbook, support to IoT devices).
2. The drone noise (80dB) at 1 m from the tree does not affect BMSB, the rotor-wind might freeze BMSB.
3. The RGB image resolution required is roughly 0.20 mm for the antennas' dash, 0.40 mm for the dots, and 0.60 mm for the white-black takes of the abdomen.
   - DJI Phantom 4 cannot distinguish BMSB features.
   - DJI Zenmuse H20 can distinguish BMSB features in the interval 8 m to 18 m.
4. Three main spectral regions beyond visible spectrum for discriminating BMSB from different backgrounds (leaves, bark) have been identified: 1220-1295 nm, 1370-1410 nm and 1420-1480 nm.
5. A programmable drone with Real Time Kinematic (RTK) positioning is needed for the automatic collection of the images. Autonomous missions dramatically increase the number of pictures taken.
6. In our experience, some "intelligence" is needed for moving the drone inside the aisles of the orchard. Flying over the trees is easier than moving inside the aisles where there might be branches out-of-shape.
7. The microclimate stations in the canopy of the trees help answer which is the correlation between weather factors and abundance of the pest. The humidity data are of particular interest.
8. The prototyped trap classifies at the edge and sends the BMSB images to the long-term storage. The advantages of automation in trap are evident, like the possibility to query on-demand, regularly, and to remotely receive the info.
9. On the 2021 dataset, the BMSB was detected with 90% precision and 76% recall using the deep-learning Yolov5 algorithms powered by the Transfer learning paradigm. The BMSB's detection algorithms benefit of the bundle of research is going on "computer vision detection".

Future research activities

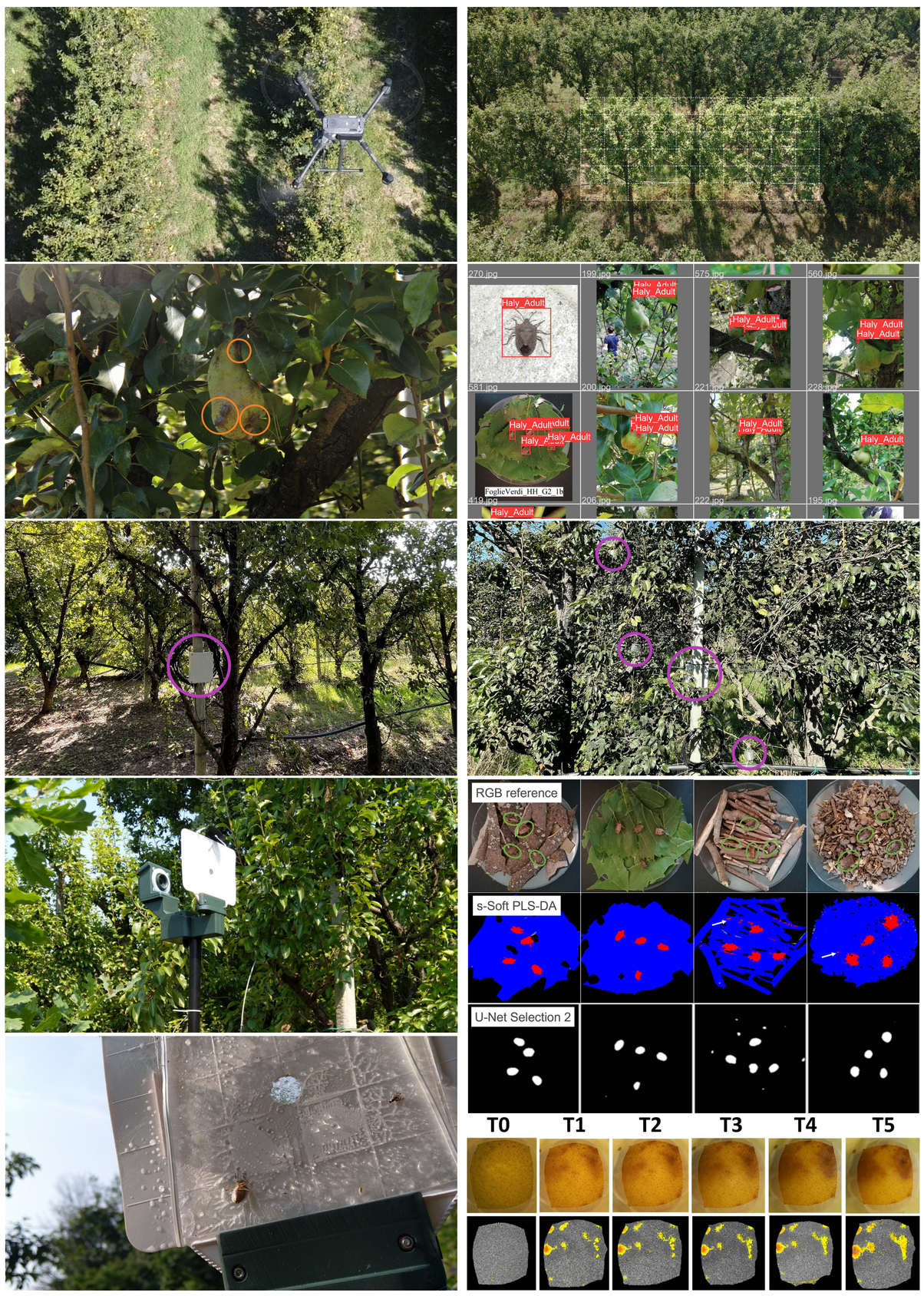
1. Assessment of the efficiency of the automated monitoring activities.
2. Creation of the dataset of season 2022 and the new training of machine learning algorithms.
3. Continuing hyperspectral analysis to detect BMSB.
4. Analysis of the microclimate info (temperature, humidity).
5. Second release of the prototyped trap.
6. Hyperspectral analysis of the punctured fruits not visible at the naked eye from the net-sleeve experiment.
7. Design of protocols for the interaction between drone and sensors.
8. Implementation of the logbook prototype.

Main objectives



- **Automate monitoring** activities by using drones, IoT devices, and communication infrastructures to reduce labor costs and increase monitoring efficiency.
- **Obtain data** (microclimate, pest abundance) for decision making in management actions.
- **Increase marketable fruit quality** via non-destructive techniques to detect defects not visible to the naked eye.
- Propose a **trusted logbook system** for the orchard-system.
- Expand our methodology to other pests, emergent or not.

Preliminary results



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Topic 1: Data-driven ICT platforms and solutions to improve the sustainability of agri-food Systems

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