Honeybee Comb Mapping Using a Robot

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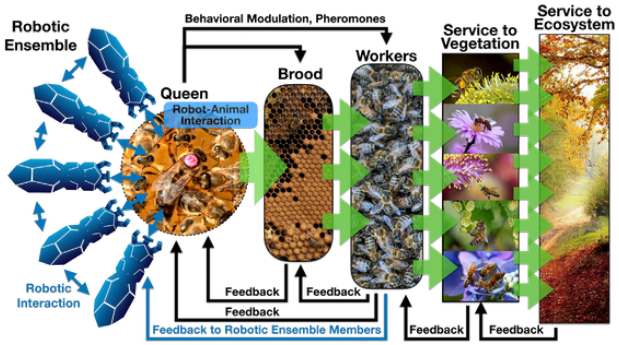
Why? Honeybees are crucial.

Declining pollinator populations threaten ecosystem stability, biodiversity and food production.

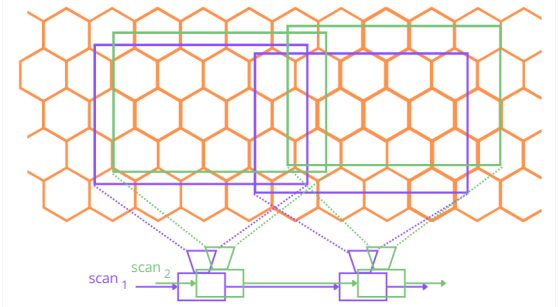


Supporting honeybees with technology requires deep understanding of their behavior [2].

What? Observe the honeycomb.

Honeybee comb encodes all past information about the state of the outside environment and the whole colony.

Using a camera on a robotic gantry system, we want to map the whole comb and observe it over time to get **an unprecedented real-time understanding of the honeybee behavior**.



How? Mapping the comb with a robot over long-term periods.

1. Data and Challenges

Sequential scans using an infra-red camera moving in a 2D plane, recording a living colony in an observational hive.

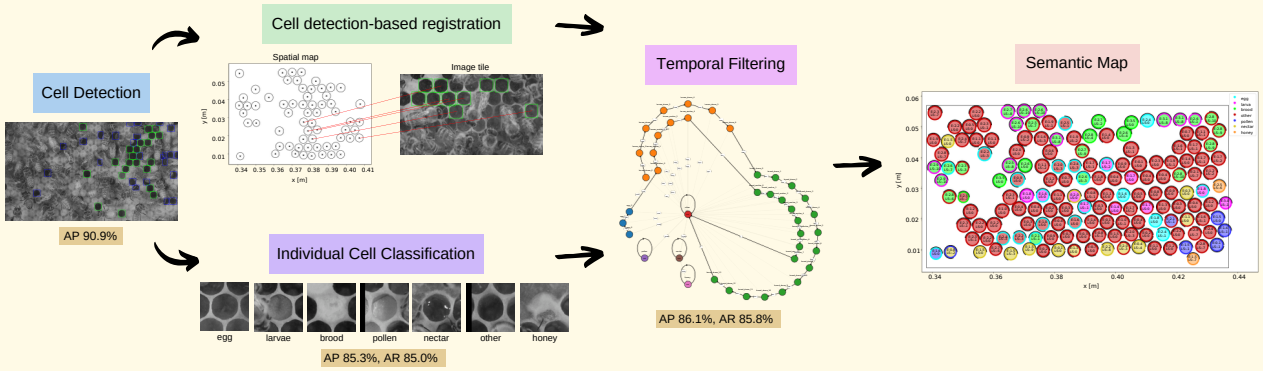
Main challenges are:

- crawling **bees occlude the comb**,
- the comb is very **repetitive in close up**,
- limited time to observe and **irregular observations,**
- **inaccurate odometry** of the robot.

2. Taken Approach

1. open **cell detection** with object detection neural network
2. hand-crafted **registration** method with open cells as features and an image similarity neural network for their visual description
3. neural network for **cell content classification**
4. Bayes filter for **temporal filtering** of cell states

3. Results



4. Outcomes

- The **first** system that enables **continuous colony monitoring** through the state of individual cells.
- We can **classify** individual cell content, **estimate the age and sex** of larvae/brood, and **predict future** states of the cells.
- Detailed comb monitoring allows for **health assessment** of the colony and detection of **parasites** and **diseases** inside the comb, enabling **early treatment**. This is necessary for agriculture and **food security** in the future.
- It presents a step towards **supporting the ecosystem** through the fusion of technology and nature.

Intermediate results were published in [1] and contributed to [3]. The whole mapping system will be submitted to *Computers and Electronics in Agriculture* (Q1).

[1] J. Janota, et al., "Towards Robotic Mapping of a Honeybee Comb," *2024 International Conference on Manipulation, Automation and Robotics at Small Scales (MARSS)*, Delft, Netherlands
[2] M. Stefanec, et al., "A Minimally Invasive Approach Towards "Ecosystem Hacking" With Honeybees," *Frontiers in Robotics and AI*, 2022
[3] J. Ulrich, et al., "Long-term tracking of individual, collective and social behaviors in honeybees by cooperating robots," *Science Robotics*, 2024, to appear.

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For more information visit roboroyale.eu.

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