Master/Semester project: Modelling emergent thermal dynamics in a robot-bee biohybrid system

Sections targeted: PH, MA, SV, IN or GM.
Master or Semester project, Fall semester 2023

Contact

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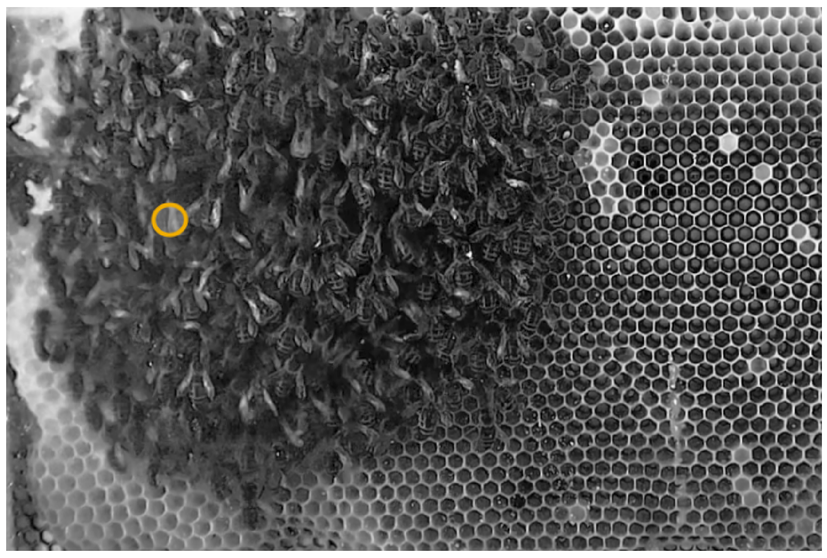
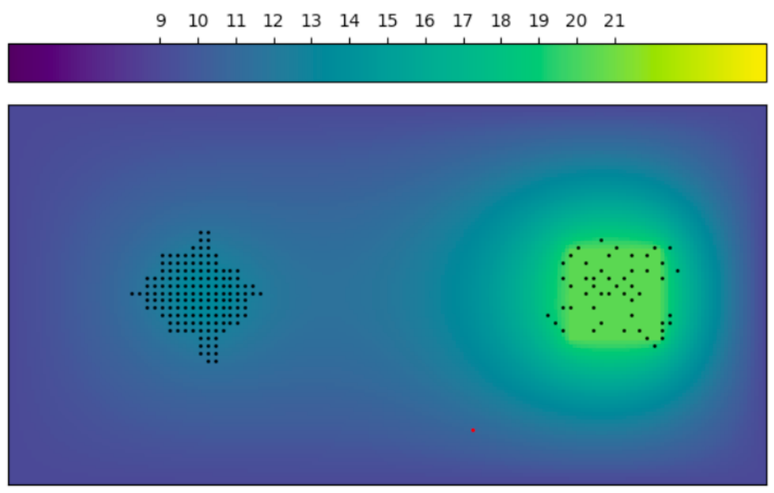
More info:
https://www.epfl.ch/labs/mobots/education/student-projects/

1 Context

Honeybees survive during the winter in a tightly-packed cluster that allows them to efficiently maintain safe temperatures through multiple modes of metabolism. As part of the EU-funded HIVEOPOLIS project, researchers from MOBOTS are using interactive etho-robotics to study **winter cluster dynamics** under the effect of locally heated zones through both open-loop and closed-loop experiments in technology-augmented hives. Precisely how the individuals in the colony arrange themselves in this cluster (metabolically, spatially), especially **in response to localised thermal fields**, is not yet fully understood.
To shed light on how bees function as a super-organism to thrive through the winter season, Artificial Life models can be used as testbed for various **behavioural hypotheses**. This approach aims at explaining the self-organisation observed in honeybee colonies in various conditions including robot-generated thermal fields.



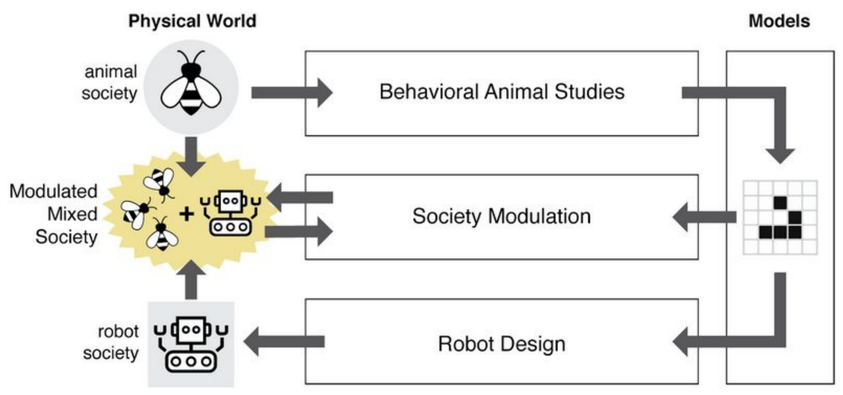


2 Objective

The aim of this project is to build on top of a winter cluster dynamics simulation model. The final model should elaborate on known thermal properties (physical and ethological), and behavioural dynamics should be tested against real experimental data.

3 Methodology

A good understanding of current models will allow for relevant work planning. Agent-based modelling is suggested to express individual honeybees' behaviour. The current model (Python) can be improved or a new model can be established onto an existing C++ framework. Visual and thermal experimental data will be used for model validation.



Left: Method for creating and investigating biohybrid systems (adapted from Mondada et al., 2013. Handbook of Collective Robotics: A General Methodology for the Control of Mixed Natural-Artificial Societies). **Right**: Scientist working on an instrumented beehive.

4 Expected skills

Interest in the subject and strong coding abilities (Python and C++) as well as being comfortable with mathematic equations and representations are the main requirements. Experience in one or more of: system modelling, thermal/heat transfer or collective behaviour are of great value.