Master Internship Proposal
Agent-Based Interactive Simulation of a Honeybee Colony

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Duration and date: 5 months starting in February 2017

Location: Lab-STICC, IHSEV research group (Human-Systems Interaction and Virtual Environments), Université de Bretagne Occidentale in Brest, France

Profile and required competencies:

- Master degree in computer science.
- Agent-Based Simulation, object-oriented programming (especially Java), 3D Visualisation.
- Interest in biology, interdisciplinarity and complex systems.
- Proficiency in English communication.

Gratification: according to French laws (around 550 € / month)

Context:

The domestic honeybee, *Apis mellifera L.*, is a social insect that lives in colonies and is used in apiculture for honey production. It is responsible for a large proportion of plant pollinations and is therefore essential to man in agriculture. A great number of factors affect the life of a colony, making it a complex system to comprehend. The numerous, apparently simple, interactions between several tens of thousands of honeybees can create complex phenomena, such as capabilities for auto-adaptation and auto-regulation of the colony in terms of organisation, thermoregulation, the emergence of patterns in the comb, etc.

Over the last 20 years, the scientific community has observed an abnormally high death rate in honeybee colonies. Multiple causes have been suggested to explain these losses: reduction of resources, climatic factors, pathogens and parasites such as *Varroa* destructor, pesticides, some herbicides, or a mixture of these factors.

To study these different causes, the modelling and computer simulation of a honeybee colony, its organisation and function make it possible to evaluate the impact of different factors, better understand the real biological system, and determine appropriate beekeeping practices.

Subject and expected contributions:

This internship aims at designing and implementing a first scalable Agent-Based Model of a honeybee colony. Agent-based (or individual-based) modelling is based on an algorithmic description of behaviour and interactions of individuals making up a complex system. In such a model, the honeybee is defined as an individual, and its biological cycle, behaviour, and the interactions it can have with the other bees and its environment should be described from biological data. From the

interactions between individuals (pheromones, nutrition, communication, etc.), it is expected to reveal complex phenomena such as the auto-regulation and auto-adaptation of the colony.

The simulation environment consists of a 10-frame Dadant hive, a type of hive widely used in apiculture. The ecosystem in which the hive is situated (*e.g.* climate) and its impact on the colony should be simulated following a simplified population-based approach.

Finally, a first 2D/3D visualisation of the simulation is expected. This visualisation should allow the interaction in real-time with the simulation (adding/removing frames, removing the queen, etc.).

The JADE platform based on the Java programming language will be used to implement the ABM. This platform simplifies the implementation of multi-agent systems by providing means of communication between agents, the visualization of their behaviour, and other features that facilitates the development of distributed systems.

Key words: Agent-Based Model (ABM) and simulation, complex systems, biology

Considered collaborations: INRA (French National Institute for Agricultural Research), beekepers, and biologists.

References:

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