Workshop: Swarm Intelligence in AI and ALife

The 3rd International Symposium on Swarm Behavior and Bio-Inspired Robotics (SWARM2019) will bring together a diverse community interested in the engineering of living things, from biomechanics to swarm intelligence, and the perpetuation of research at the intersection of biology and engineering.

Swarm intelligence is not just the result of self-organization. Component agents differentiate, communicate with each other, and create super-organisms. Using various model simulations and social animals and insects as examples, we will discuss the swarm intelligence of natural and artificial systems and their complexity. In this workshop, we invite presentations by **Prof. Marco Dorigo** and other interesting researchers in the fields of AI and ALife.

Location:
Room B (Meeting Room #1), Conference Center, OIST [Google Maps : https://goo.gl/maps/SsJ8RBKsYz7uaPxC7]

Workshop Leaders:
Takashi Ikegami (University of Tokyo), Hemma Philamore (Kyoto University)

Workshop program :

13:00 Introduction

13:15 Matthew Turner, University of Warwick

Intrinsically motivated collective motion

We study a simple model of information-processing (living) agents. These agents seek maximal control of their environment via "future state maximisation" (FSM), a principle that may connects fitness with information processing more generally. We study moving, re-orientable agents. The action of each agent is (re)established by exhaustive enumeration of its future decision tree at each time step - each agent chooses the branch of its tree leading from the present to the richest future state space. Cohesive swarm-like motion emerges that is similar to that observed in animal systems, such as bird flocks. We develop heuristics that mimic computationally intensive FSM but that could operate in real time under animal cognition. This offers a philosophically attractive, bottom-up mechanism for the emergence of swarming.

13:45 Olaf Witkowski, Cross Labs

Open-ended swarms: the layered evolution of collective intelligence

Since life originated on Earth, it seems to have indefinitely been increasing in levels of intelligence and complexity. Simple organisms had to self-organize into dynamical networks to gather, internalize, compress and reorganize relevant information about their own persistence, from perpetually changing environments. The learning process undergone by all life can be understood as a long series of self-maintaining information flows through time and space, which enabled organisms to make increasingly better predictions, eventually reaching much faster learning timescales than Darwinian evolution, and achieving impressively generalized knowledge about the universe. In this talk, I will present an approach to the study of this open-ended evolution via the simulation of collective dynamics in autonomous agents, giving rise to layer after layer of dynamics. The model highlights three important factors in the creation of novelty and diversity: (a) communication generates combinatorial cooperative dynamics, (b) concurrency allows for separation of time scales, and (c) complexity and size increases push the system towards transitions in innovation. These three components are illustrated in a model computing the continuous evolution of a swarm of agents, thus contributing to our understanding of the characteristics and layered structure of collective intelligence.

14:15 BREAK

14:30 Giovanni Reina, University of Sheffield

Collective decision making: search, vote, and agree

I will give an overview of my studies on collective decision making in distributed systems of the last eight years. Such systems, found in biology, sociology, and engineering, are composed of a large number of interacting individuals that coordinate in order to reach a consensus. The main phases of the collective decision making process consist of identifying the available options, estimating their quality, and selecting the best option or any of them. I will present the main results of my research in understanding and designing each of these phases. Collective systems are inherently difficult to analyse as the stochastic nonlinear interactions between individuals can give rise to complex emergent dynamics. Therefore, I employ a collection of advanced techniques, commonly defined as multiscale modelling. Relying on a set of methods, rather than a single one, gives the benefit of having complementary techniques addressing one another's limitations. In fact, through multiscale modelling, it is possible to analyse the systems at various levels of complexity and detail, from macroscopic group-level dynamics to microscopic individual-level behaviour, and from noise-free deterministic models to stochastic spatial descriptions. I finally shed a light on the recently developed opensource software for automated multiscale modelling.

15:00 Hiroyuki Iizuka, Hokkaido University

AI applications to swarm behaviors

In this talk, I will introduce AI application studies toward swarm behaviors. One is a machine learning method to obtain the sensorimotor mapping of individuals directly from data captured in a real fish swarm. The individual positions are detected and the sensory inputs and motor outputs are estimated and used as training data. A simple feedforward neural network is trained to learn the sensorimotor mapping of individuals. As a result, our trained neural network could reproduce the swarm

behavior better than the Boids model. Another example is to establish a real-time interaction between real and virtual fish. The computer display is attached on the tank and the
fish can see the virtual fish. The real fish movements are captured by a camera and the virtual fish can decide the movements in response to the real fish. The behaviors of the real fish are evaluated and compared with the condition with virtual playback fish. I will discuss about the further possibilities to apply AI to swarm.

15:30 Marco Dorigo, Université Libre de Bruxelles

Collective Decision Making: The Best-of-n Problem in Robot Swarms

Achieving fast and accurate collective decisions with a large number of simple agents without relying on a central planning unit or on global communication is essential for developing complex collective behaviours.
In this talk, I will present recent research done in my lab on collective decision making in robot swarms. In particular, I will present opinion-based methods for the solution of a few variants of the best-of-n problem using a swarm of real robots.

16:15 Closing remarks

16:30 END