Evolution of Collective Behaviors by Minimizing Surprisal and by Micro-Macro Links

Heiko Hamann
Department of Computer Science, University of Paderborn, Germany
heiko.hamann@uni-paderborn.de

Evolving collective robot behaviors is more challenging than the evolution of controllers for single robots due to multiple interactions between agents [8, 1]. However, the collective system with its microscopic (individual) level and its macroscopic (swarm) level also creates new opportunities to generate the desired behaviors. I present two of these opportunities here.

First, we can leverage the robot-robot interactions to basically bootstrap the system and to trigger the emergence of complex behaviors. This is an idea based on minimizing surprisal of the agents about their perceptions [9, 2]. The advantage of a collective system is that an agent's actions create input for another agent. That way the system is typically forced to stay active and to react to the new input. Each agent is equipped with two independent artificial neural networks (ANN) – an action network and a prediction network. Direct selective pressure is only on making correct predictions while the behavior itself is only indirectly influenced. I present results for simple swarm behaviors (aggregation, flocking, dispersion) [4].

Second, we can leverage macroscopic swarm effects by making use of swarm models. Models of collective systems can help either a human designer to anticipate the resulting swarm-level behavior (macroscopic) for a given individual behavior (microscopic) or they can be used to simplify the evolution of desired collective behaviors. Hence, if it is possible to establish a so-called micro-macro link [3, 7], then we can evolve the desired swarm behavior simply as the sum of its parts. Instead of applying ANN, the robot controllers are modeled as finite state machines and population models of the collective system determine the expected swarm behavior [5]. I present options for a collective decision-making scenario [6].

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