From Self-adaptive Collective Robotics to Artificial Evolutionary Ecology (and back)

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Collective self-adaptive systems (CsAS) are concerned with efficient lifelong learning capabilities to endow a population of (robotic) agents with limited communication (short range, limited bandwidth) to survive in an open environment (a priori unkown, and possibly changing). In Bredeche and Montanier (2010), we have introduced the EDEA approach (aka Environment-driven Distributed Evolutionary Adaptation), as well as a particular implementation termed mEDEA (minimal EDEA). The mEDEA algorithm provides a lightweight component that can easily be embedded in robotic systems, requiring few assumptions on both the robot specificities and the environment at hand. While this algorithm ressembles other embodied evolution algorithms, a major assumption is that *no* fitness function is available at runtime. In this context, the goal is to perform open-ended evolution (long term adaptation in an open environment), guided only by robot-robot and robot-environment local interactions. In earlier works, the mEDEA algorithm was experimentally evaluated as a self-adaptive version of embodied evolution within a group a 20 real e-puck robots (Bredeche and Montanier (2010); Bredeche et al. (2012)) (cf. Figure 1), with an emphasis on robustness and scalability.

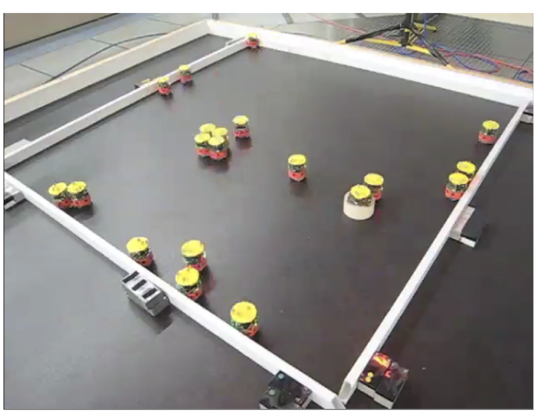

Figure 1: A collective robotic system running mEDEA (collaboration with the Bristol Robotics Lab - details in (Bredeche et al., 2012))

Beyond engineering, the EDEA approach was also shown to be relevant to basic science, as it provides a particular flavor of individual-based modelling method for addressing open questions in evolutionary ecology. Indeed, such a method enables to study the dispersion and mating strategies at work during evolutionary adaptation, which are particularly relevant for the evolution of social behaviours or for speciation. The very same algorithm that was embedded on real robots was also applied to tackle a major open question in evolutionary ecology: the evolution of cooperation with indirect benefits (ie. altruistic cooperation). In recent works, the impact of kin-selection strategies (Montanier and Bredeche (2011)), as well as the interaction between limited dispersal and altruism (Montanier and Bredeche (2013)) have been addressed, and yielded both insights on the evolutionary mechanisms and intuitions for algorithm design.

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