Vito Trianni

Evolutionary Swarm Robotics

Studies in Computational Intelligence, Volume 108

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Evolutionary Swarm Robotics

Evolving Self-Organising Behaviours in Groups of Autonomous Robots

With 55 Figures and 12 Tables

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Summary. According to Hölldobler and Wilson, ants are the "dominatrices of the insect fauna", thanks to the fundamental role they play in the different ecosystems in which they live (Hölldobler and Wilson, 1990). Moreover, ants feature a very complex colony organisation, which contrasts with the limited cognitive abilities that characterise the single individual. Not surprisingly, the principles that lay behind the organisation of an ant colony have been so far exploited by scientists and engineers in multiple domains, resulting in the development of robust optimisation algorithms (see, for example, (Dorigo and Stützle, 2004)), and giving birth to the *swarm intelligence* research domain (Beni and Wang, 1989; Bonabeau et al., 1999). Also robotics could benefit from this biologically-inspired approach, as demonstrated by the continuously growing interest for *swarm robotics* (Dorigo and Şahin, 2004). The subject of our studies concerns exactly a swarm robotic system, that is, a system composed of a number of autonomous robots, which need to interact and to cooperate to achieve a common goal. In such a context, it is useful to allow for *self-organisation* while designing the different parts of the robotic system. Self-organisation can be defined as the emergence of order in a system as the result of interactions among the system components. It is often observed in biology, and in particular in animal societies, not limited to social insects like ants, bees or termites (see (Camazine et al., 2001) for a review). From an engineering perspective, there are multiple advantages in designing a self-organising robotic system. Among these, it is worth mentioning that such a system is inherently robust to individual failures, as it is normally redundant in its constituent parts. It can adapt to varying environmental conditions and it can maintain its organisation notwithstanding certain external perturbations.

However, designing a self-organising behaviour for a group of simulated and/or real robots is not a trivial task. In this book, we propose the use of ER techniques for the design of self-organising group behaviours, for both simulated and real robots. This research has a twofold value. From an engineering perspective, we propose an automatic methodology for synthesising complex behaviours in a robotic system. We believe that ER techniques should be used in order to obtain robust and efficient group behaviours based on self-organisation. From a more theoretical point of view, the second important contribution brought forth by our experiments concerns the understanding of the basic principles underlying self-organising behaviours and collective intelligence. In our experimental work, the evolved behaviours are analysed in order to uncover the mechanisms that have led to a certain organisation. In summary, this book tries to mediate between two apparently opposed perspectives: engineering and cognitive science. The experiments presented and the results obtained contribute to the assessment of ER not only as a design tool, but also as a methodology for modelling and understanding intelligent adaptive behaviours.

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