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Special Issue on Evolutionary and Developmental Robotics

Biological evolution and development have received increasing attention in intelligent robotics, giving birth to two popular sub-fields, namely, evolutionary robotics and developmental robotics. So far, developmental robotics has been often known as epigenetic robotics, concentrating on the cognitive development of robotic systems, including language, emotion and social skills, through sensorimotor adaptation, self-exploration, imitation, prediction, and social interactions. Most recently, it has been emphasized that developmental robotics should cover both physical and mental development, where a new emerging sub-field termed morphogenetic robotics deals with the physical development, including the development of nervous systems and body plan. Working mechanisms for neural and body plan development employed in morphogenetic robotics are mainly inspired from biological morphogenesis and metamorphosis as well as chemical, physical and social systems that result in robust and emerging patterns in a self-organizing manner.

This special issue aims at presenting the state-of-the-art research work on evolutionary and developmental robotics. All the contributions were invited, yet have been subject to a peer-review process before they are accepted. As a result, we are now able to include four papers, embracing the morphogenetic, developmental and evolutionary aspects in robotics.

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Evolutionary design of a neural controller is the main topic of the paper by Dürr et al, where the authors aim to evolve a neural controller that is able to simultaneously solve multiple problems. To this end, a modular genetic representation is employed to evolve modular neural controllers in a more robust manner for a mobile robot to navigate a T-maze. It has been shown that the evolved modular neural controller performs significantly better than a non-modular neural controller.

Spröwitz et al describes a fascinating application of reconfigurable modular robots—adaptive furniture—in their paper. Both hardware and control mechanisms for realizing such adaptive furniture built from meta-modules are discussed. Stochastic optimization algorithms, such as evolutionary algorithms and particle swarm optimization, are used to tune the parameters of a central pattern generator to produce coupled oscillations for gait control of the locomotion of meta-modules.

In the paper by Massera et al, a neural network-based controller is evolved for object grasping in a simulated robotic hand. Their results demonstrate that linguistic information makes it easier for the robot to acquire complex behaviors for object manipulation, such as object reaching, grasping and lifting. The work presents a convincing case study where robots can autonomously develop their skills through interactions with other robots and the environment.

The fourth paper, by Sayama, presents a great example of how self-organizing and self-repairing robotic swarms can be achieved by making use of local interactions. Simple kinetic rules are employed to design spatio-temporal patterns without a centralized control. These patterns are adaptable to environmental changes and robust to partial damages. In addition to swarm robots, morphogenetic robotics also deals with self-organized reconfiguration of modular robots.

The four papers collected in this special issue represent a few fascinating research efforts in evolutionary and developmental robotics. Meanwhile, they are also touching upon and opening up a research direction that puts evolutionary and developmental aspects in one framework, namely, evolutionary developmental robotics. We are confident that in the near future, we will see more work on evolutionary developmental robotics that integrates evolution, learning and development in a systematic framework.

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