Designing Autonomous Robot Controllers for Planetary Exploration: A Model of a Mars Rover

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After the successful mission of the Mars Pathfinder, in which the first semi-autonomous vehicle explored the Martian surface, other missions to Mars have been launched or are under development. Research on Mars robots provides an ideal test platform for the study of autonomous robotics, for example the ability of robots to navigate efficiently within unknown environments. We have developed a computer model of a planetary rover and Martian environment using the ODE physics engine. This simulation model is being used to investigate the design of autonomous neural controllers with different sensor configurations using the evolutionary robotics approach.

In a first study, we investigated the use of an infrared sensor system for planetary rover exploration in rough terrains. The control system for the robot consisted of an artificial neural network trained using evolutionary computation techniques. An adaptive threshold for the infrared sensors was evolved together with the neural control system to allow for the adaptation to various unforeseen environmental conditions. After each evolutionary process, the behavioural properties obtained were tested by measuring the generalisation capabilities of the rover when exposed to new environmental conditions, particularly rough terrain. In addition, the dynamics of the co-evolution between the controller and the threshold were analysed. These analyses showed that different pathways were exploited by the evolutionary process in order to adapt the sensing abilities and control system.

Ongoing work is focusing on the integration of infrared sensors with an active vision camera system. Active vision control systems have the ability to extract salient information from an environment in order to solve specific tasks. The objective of this work is to investigate the use of such systems for obstacle avoidance and navigation in complex environments. Experimental results suggest that evolved active vision systems provide a powerful, yet computationally efficient solution to advanced visual processing for navigation. Other experiments are investigating the use of simulated `islands' to evolve several populations of robot controllers in parallel. This methodology aims to emulate the observed genetic differentiation that occurs in the natural world. The parallel nature of this paradigm enables the utilisation of distributed computational resources, drastically reducing the evolution time required, as confirmed by our preliminary experiments.