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

Martin Peniak, Barry Bentley, Davide Marocco and Angelo Cangelosi

Scientific Objectives

- To develop a computer simulation model of a Mars rover robot
- To evolve neural controllers using the evolutionary robotics approach
- To investigate the role of active vision in autonomous navigation and exploration of unknown environments

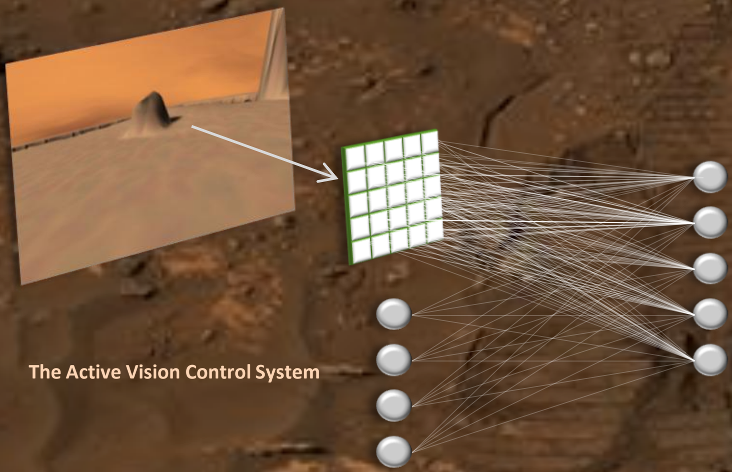
Ongoing Research

Navigation Experiment:

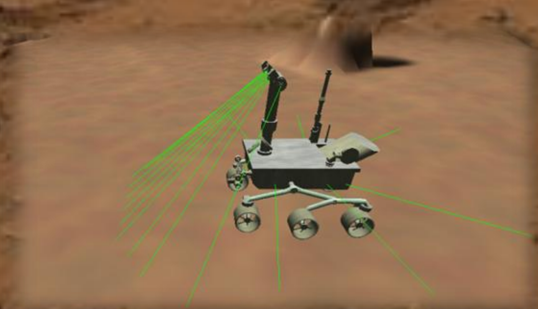
This research aims to investigate the possibility of using an alternative, infrared based sensor system, for planetary rovers required to operate autonomously in environments with challenging terrain. For this research, computer models of a planetary rover and Martian environment have been constructed using the ODE physics engine. The control system for the robot consists of an artificial neural network trained using evolutionary computation techniques. An adaptive threshold for the infrared sensors is 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 are 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 are analysed. These analyses show that different pathways are exploited by the evolutionary process in order to adapt the sensing abilities and control system.

Active Vision Experiment:

Evolved 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. Preliminary experimental results suggest that evolved active vision systems provide a powerful, yet computationally efficient solution to advanced visual processing for navigation.



The Active Vision Control System



Rover Simulation – Showing Sensor Array

Island Experiment:

Current research focuses on investigating simulated `islands' to evolve several populations of robot controllers in parallel. This methodology aims to emulate the observed genetic differentiation that occurs between demes 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.

Publications

M. Peniak, A. Cangelosi and D. Marocco (2008). Autonomous robot Exploration of unknown terrain: A preliminary model of Mars Rover robot. *Proceedings of 10th ESA Workshop on Advanced Space Technologies for Robotics and Automation (ASTRA 2008)*, 11-13 November 2008, Noordwijk, The Netherlands.

M. Peniak, D. Marocco and A. Cangelosi (2009). Co-evolving controller and sensing abilities in a simulated Mars Rover explorer. *Proceedings of IEEE Congress on Evolutionary Computation (CEC) 2009.* Norway, 18-21 May, Trondheim, Norway.

M. Peniak, D. Marocco, S. Ramirez-Contla and A. Cangelosi (2009). An active vision system for navigating unknown environments: An evolutionary robotics approach for space research. In: *Proceedings of IJCAI-09 Workshop on Artificial Intelligence in Space*, 17-18 July 2009. Pasadena, California, USA.

CRNS Centre for Robotics and Neural Systems

in collaboration with the

advanced concepts team

esa