Carleton UNIVERSITY

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Researching the future of robots for exploration in space

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Alex Ellery, PhD

Carleton University's Canada Research Chair in Space Robotics and Space Technology

The future of space robotics: a natural fit

Alex Ellery an associate professor in the Faculty of Engineering and Design at Carleton University, is the Canada Research Chair in Space Robotics and Space Technology. Ellery's field of applied robotics and spacecraft engineering is a vital part of our ongoing exploration and investigation of space and other planets.

According to Ellery, the problem with existing terrestrial robotics—that is to say, robots built for use on planet Earth—is that they simply are not up to the high-stress, long-distance tasks expected of robots used in space exploration. Often, these robots are designed in idealized, controlled environments and are seen as little more than applications of complex algorithms. There are too many unpredictable environmental factors in space for this kind of approach to be effective.

Ellery is very interested in how robots interact with their environments, and sees no better place to draw inspiration for robotic designs than in nature. He thinks of human beings and animals as extremely advanced organic robots, and seeks to learn strategies of environmental adaptation for use in his research. Ellery's research is thus inevitably interdisciplinary, and involves bridging the gaps between all types of engineering, as well as zoology and evolutionary and developmental biology.

Ellery and his graduate students are working on a variety of ways by which space exploration robots can be improved based on biological principles. These include systems for planetary rovers based on such principles as diverse as the navigation of insects, and how we as humans control our eyes to help the rovers navigate rough terrain such as the surface of Mars while maintaining a steady view.

Motor control in robotic arms is also a concern, and Ellery hopes to apply the principles of organic muscles to electronic motors to help robots gauge how much pressure and force to apply in order to mould its grip on that object. Ellery is looking into a highly portable drill concept based on the ovipositor, or egg-laying organ, of certain wasps. Traditional spinning drills are heavy, large and cumbersome, and largely unfit for space travel and exploration. The wasp ovipositor bores by rubbing two body parts back and forth, creating a percussive drill. Ellery suggests that this concept could be applied and made viable for compact storage by using lightweight, rollable parts, like a steel tape.

Additionally, in the long term, Ellery wants to improve the ways in which robots interpret data, map terrain, and 'learn' in unexplored environments. 'Neural networks' are thinking mechanisms—effectively the brains of a robot. Ellery theorizes that these networks are able to 'genetically' evolve, learning as they interact with their environments.

The trick, Ellery says, is to keep control over the learning process. "Robots are much too expensive to be allowed to learn by trial and error, so more sophisticated learning systems need to be implemented in order for the concept to work." For example, he jokes that if a robot comes to a cliff and drives off the edge in order to learn what happens, it wouldn't be much good to anyone. "The key is shaping the learning process."

This may sound like science fiction to some, but for Ellery this represents a very real future of possibilities for robotics and space engineering. For now, however, he is ready to tackle more immediate projects and concerns. Thanks to his research, Canada will continue to play a leading role in space exploration and robotics.

RESEARCH SNAPSHOT

Purpose
The development of greater autonomy, robustness, and adaptability of space and planetary robotic systems.

Scope
To exploit the lessons of biological evolution into space and planetary robotic systems, or 'bio-inspiration'.

Thesis
Evolution by natural selection is premised on the interaction of the agent with its environment – this agent-environment interaction is critical to developing autonomous, robust, and adaptable machines for space exploration where the environments are harsh and uncompromising.

Outcome
We will be closer to the goal of creating intelligent machines to support space activities.

Selected publications

- Ellery (2005) "Robot-environment interaction – the basis for mobility in planetary micro-rovers" Robotics and Autonomous Systems 51, 29-39
- Ellery et al (2005) "Bionics & Space Systems Design 3 – Application of biomimetics to space technology" ESA-ESTEC Technical Note 3 (ESA Contract no 18203/04/NL/PA)
- Ellery (2004) "Space robotics part 3: robotic rovers for planetary exploration" International Journal of Advanced Robotic Systems 1 (4), 303-307

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