International Journal of Astrobiology

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Editorial

Cite this article: Ellery A (2018). Editorial for Special Issue on Robotic Astrobiology. *International Journal of Astrobiology* **17**, 201–202. https://doi.org/10.1017/S1473550418000150

Editorial for Special Issue on Robotic Astrobiology

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Robotic astrobiology is an emerging cross-disciplinary activity that interfaces space robotics engineering with astrobiology science, themselves multidisciplinary ventures. Of particular note is the critical importance of coordination between the astrobiologist seeking extraterrestrial life and the roboticist to enable that search technologically but robotic astrobiology is no mere partnership. I hope to present that this is a rich arena of collaborative investigation that more closely resembles a marriage. I am reminded of the tightness of the small JPL Sojourner microrover team of planetary scientists and engineers – in many cases, they swapped roles, so integrated was their work towards a common goal. More's the pity that most science missions are not conducted in such a fashion. However, the astrobiologist and the roboticist do have complementary skills that together can yield more aggressive mission concepts that tackle the challenges of astrobiology directly. This special issue offers a taster of the potential range of activities in robotic astrobiology through six papers. The single thing that threads through them all is the multidisciplinary nature of astrobiology problems and how they can be addressed in a multidisciplinary fashion.

One of the core activities in robotic astrobiology is in roboticizing scientific instruments and their deployment mechanisms to cope with challenging environments to enhance their scientific productivity in the search for extraterrestrial life. So, Ellery begins the special issue with a contextual review of robotic astrobiology-focussed on enhancing Mars rovers with robotic techniques to maximize their scientific productivity. Several approaches are discussed including the use of image processing to autonomously classify rocks, the search for serendipitous geo-targets during rover traverses, the use of online rover terramechanics to search for water ice in the regolith and the adoption of neural-Bayesian expert systems to implement astrobiological knowledge on the rover. These are just a few approaches to robotic astrobiology. In the same spirit, Hay et al have integrated a boom-mounted magnetometer onto an end-to-end micro-rover prototype and conducted a geomagnetic survey along linear parallel transects to generate a magnetic intensity map. The system successfully detected and localized an anomalous source during field trials demonstrating the integration of teleoperated rover navigation with scientific mapping. The obvious application is in the use of magnetic surveys on Mars. Staying on Mars, Nicol et al modelled methane plumes on Mars and, on the basis of concentration measurements from a Mars rover, analysed control algorithms to autonomously drive the rover to localize the source of a methane plume. They found that the turbulent nature of such plumes does not permit the use of gradient-descent-based methods in locating methane plume sources. More sophisticated stochastic techniques requiring considerable computational resources onboard the rover in excess of current capabilities will be required. Thus far, the papers have focussed on robotics exclusively, but robotics can be employed as a supplement to human capabilities. Lupisella & Race were concerned with scientific teleoperations with minimal time delays (low-latency teleoperation) as applicable to human missions around or on Mars in which telerobotic explorers are deployed in special regions to ensure no forward contamination of Mars and prevent astronaut exposure for potential backward contamination of Earth. Short time delays permit near-telepresence projecting sophisticated human-level capabilities remotely enabled by haptic and visual feedback but without the contaminating presence of human astronauts. This capability goes a long way to permitting human exploration of Mars while protecting regions of special astrobiological interest. The giant planet outer moons have not been neglected. Clark et al describe their work on autonomous sampling with the VALKYRIE cryobot representing an analogue of a Europa or Enceladus mission. Such an ice-melting penetrator designed to access the subsurface waters arguably represents the most challenging of planetary mission concepts and will only be enabled through extensive robotics leverage. They tackled the problem of autonomously deploying limited consumable resources in selecting from unique sequences of unknown future sample opportunities. They used a sensor-based score function to select water samples that matched human performance. The final paper is a more speculative venture in which Ellery attempts to explore the nature of life by building parts of a self-replicating machine for the Moon, a barren environment. It encapsulates the notion that only physical construction of life can demonstrate an understanding of life in its most general form. In doing so, he suggests that movement is an under-appreciated capacity of all life as a general property.

This snapshot of selected areas of robotic astrobiology indicates the diverse range of robotic astrobiology. Although from a relatively emergent field, these papers barely scratch the surface of robotic astrobiology activities. Even more importantly, there are many areas of robotic astrobiology that have not been covered but are nevertheless active areas of research such as the employment of viffing to target the tiger stripes of Enceladus by penetrator, the use of robotic algorithms to permit submicron control of formation flying spacecraft for interferometric imaging of exoplanets, analysis of genetic error-detection-and-correction codes for self-replicating machines and others. Robotic astrobiology is an emerging field that is addressing key astrobiologically-important technologies – it is my fervent hope that the astrobiology community will be inspired to engage with roboticists further to address and solve problems that concern them both to permit more pioneering approaches to the search for extraterrestrial life.