Autonomous site selection and instrument positioning for sample acquisition

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The European Space Agency Aurora Exploration Program aims to establish a European long-term programme for the exploration of Space, culminating in a human mission to space in the 2030 timeframe. Two flagship missions, namely Mars Sample Return and ExoMars, have been proposed as recognised steps along the way.

The Exomars Rover is the first of these flagship missions and includes a rover carrying the Pasteur Payload, a mobile exobiology instrumentation package, and the Beagle 2 arm. The primary objective is the search for evidence of past or present life on mars, but the payload will also study the evolution of the planet and the atmosphere, look for evidence of seismological activity and survey the environment in preparation for future missions.

The operation of rovers in unknown environments is complicated, and requires large resources not only on the planet but also in ground based operations. Currently, this can be very labour intensive, and costly, if large teams of scientists and engineers are required to assess mission progress, plan mission scenarios, and construct a sequence of events or goals for uplink. Furthermore, the constraints in communication imposed by the time delay involved over such large distances, and line-of-sight required, make autonomy paramount to mission success, affording the ability to operate in the event of communications outages and be opportunistic with respect to scientific discovery.

As part of this drive to reduce mission costs and increase autonomy the Space Robotics group at the University of Wales, Aberystwyth is researching methods of autonomous site selection and instrument positioning, directly applicable to the ExoMars mission. The site selection technique used builds on the geometric reasoning algorithms used previously for localisation and navigation [Shaw 03].

It is proposed that a digital elevation model (DEM) of the local surface, generated during traverse and without interaction from ground based operators, can be analysed to calculate possible long range trajectories [Weisbin 99] for the rover. Provided the rover is given a predefined "ideal rock" definition, the same DEMs can be used to classify rocks in the surrounding area and identify any which meet the ideal rock criteria, meaning that, during long-range traverses potentially scientifically rich rocks would not be missed. The technique can also be used identify the approach trajectory for the arm given the orientation of the rock surface.

If several ideal rocks have been identified the rover could then use a rock reachability map to prioritise the rocks for sampling, this would consider: rock classification; the amount of energy required to reach the rock; and the number of instruments that can be placed on the surface.

Autonomously identifying ideal rocks and calculating instrument position reduces the rover waiting time and operator input, and increases the scientific return.

1. **Shaw A.J**. and Barnes D.P., Landmark recognition for localisation and navigation of aerial vehicles. *IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*, Las Vegas, October 2003. CD-ROM Proceedings.

2. **Weisbin, Charles R**. Rodriguez Guillermo, Schenker Paul S., Das Hari, Hayati Samad A., Baumgartner Eric T., Maimone Mark, Nesnas Issa A., Volpe Richard A. Autonomous rover technology for mars sample return, Pages 1-10 of: 1999 International Symposium on Artificial Intelligence, Robotics and Automation in Space, ISAIRAS99.