PLANETARY SURFACE EXPLORATION USING A NETWORK OF REUSABLE PATHS: A PARADIGM FOR PARALLEL SCIENCE INVESTIGATIONS

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The Mars Exploration Rovers have driven a combined 40 kilometres, visiting many sites of scientific interest along the way. The exploration strategy was serial in the sense that scientific objectives were completed at one site before departing for the next. Here, we advocate for a parallel, rather than series, exploration strategy. We believe this better supports the overarching aims of exploration missions, and in particular, sample return missions, where a methodical down-selection process can be used to identify the key specimens for return to Earth. We present the concept of a network of reusable paths (NRP) [1] to enable a rover to revisit places of scientific interest and thus to study sites in parallel [2]. Our approach was tested through mock lunar sample-return mission scenarios conducted in the Sudbury and Mistastin Lake impact craters in Canada [3].

Visual-teach-and-repeat systems (VT&R) [4] allow robots to drive arbitrarily long distances along previously established routes. In these systems, a chain of small maps is attached along the robot's path during a teaching phase; to repeat the route, the robot simply localizes against each small map as it drives. NRP extends VT&R; instead of a simple chain of local maps, there is an arbitrary network of local maps. With NRP, the robot can return precisely to any previously visited point.

The Sudbury mission was purely robotic. In 43 command cycles, the robot created a network 0.44 km in length and autonomously drove more than 3.9 km. During this mission, NRP enabled nearly twice as many sites to be visited as would a serial exploration strategy.

In the Mistastin Lake mission, the robot travelled over 8.2 km. The network was 1.25 km in length, and of that length, 0.92 km was manually taught by an astronaut. The remaining 0.33 km was added while autonomously seeking waypoints. Of the 8.2 km that were driven, approximately 7.3 km were driven autonomously.

A network of reusable paths offers a game-changing concept for planetary exploration. It allows mission-level improvements by enabling parallel exploration of scientific targets. This capability would be extremely useful for manned or unmanned missions to the Moon and Mars.

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