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COMMUNICATION AND NAVIGATION ARCHITECTURE FOR PLANETARY EXPLORATION CARRIED-ON BY A SWARM OF MOBILE ROBOTS

Abstract

Planetary exploration is a milestone of future space programs. Continuous evolution in robotics technologies, including improvement in sensors, in miniaturization, in software engineering allows to focus on the concept of unmanned, autonomous exploration carried on by swarm of mobile robots. As taught by several biology's examples, the cooperation among smaller, simpler agents provides effectiveness and ensures a good return even in case of the loss of some – or several – robots. This cooperation is primarily based on the exchange among the swarm's agents of information including payload data and positioning insight. A simple (to keep expandable platforms and their subsystems at a reasonable level in cost and complexity), yet effective communication and navigation architecture is requested to perform the task. The proposed paper aims to first analyse the requirements for this architecture at the general level, and then investigate possible solutions by means of extensive simulations performed with purposely prepared software codes. Performance clearly depends on the mission environment, and in such a concern swarms composed by rovers, drones or low-altitude flying platforms have to be considered, include peculiar motion constraints and issues. Simulations consider radiofrequency links in different bands, with preliminary modelling of the channels characteristics. Obstacles and outages, breaking the connections, are modelled. A specific attention is devoted to the navigation, in order to assess the nature and amount of data required to provide either a relative or absolute positioning capability: this information is crucial for referencing the data collected by the payload as well as for the coordinated guidance of the swarm. Being robustness the crucial asset of the swarm concept, the performance in different mission scenarios are evaluated on the basis of both deterministic and non-deterministic failures. Previous hands-on experience gained from studies and experiments devoted to small fleets of rovers operating in terrestrial, hostile environment is an important input for this research. The final goal of the paper is to provide, through educated analysis and simulation findings, possible guidelines for the communication and navigation architecture of fleets ranging from 3-4 to tens of agents, operating in different scenarios suitable for planetary exploration.