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A Radiofrequency Based Navigation Method for Cooperative Robotic Communities in Surface Exploration Missions

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Abstract : When considering small robots working in a cooperative community for Moon surface exploration, navigation and inter-nodes communication aspects become a critical issue for the mission success. For this approach to succeed, it is necessary however to deploy the required infrastructure for the robotic community to achieve efficient self-localization as well as relative positioning and communications between nodes. In this paper, an exploration mission concept in which two cooperative robotic systems co-exist is presented. This paradigm hinges on a community of reference agents that provide support in terms of communication and navigation to a second agent community tasked with exploration goals. The work focuses on the role of the agent community in charge of the overall support and, more specifically, will focus on the positioning and navigation methods implemented in RF microwave bands, which are combined with the communication services. An analysis of the different methods for range and position calculation are presented, as well as the main limiting factors for precision and resolution, such as phase and frequency noise in RF reference carriers and drift mechanisms such as thermal drift and random walk. The effects of carrier frequency instability due to phase noise are categorized in different contributing bands, and the impact of these spectrum regions are considered both in terms of the absolute position and the relative speed. A mission scenario is finally proposed, and key metrics in terms of mass and power consumption for the required payload hardware are also assessed. For this purpose, an application case involving an RF communication network in UHF Band is described, in coexistence with a communications network used for the single agents to communicate within the both the exploring agents as well as the community and with the mission support agents. The proposed approach implements a substantial improvement in planetary navigation since it provides self-localization capabilities for robotic agents characterized by very low mass, volume and power budgets, thus enabling precise navigation capabilities to agents of reduced dimensions. Furthermore, a common and shared localization radiofrequency infrastructure enables new interaction mechanisms such as spatial arrangement of agents over the area of interest for distributed sensing.

Keywords : cooperative robotics, localization, robot navigation, surface exploration
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