EPSC Abstracts
Vol. 12, EPSC2018-1143, 2018
European Planetary Science Congress 2018

FDOA-based method to enhance TOF method for Position Determination of Lunar Exploration Rovers

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Abstract

In this paper, a method for position determination of robotic rovers in a Lunar exploration scenario is presented. A survey on the different position determination methods and techniques for mobile robots is included, based in a number of assumptions, which are defined considering mission, operational and environmental aspects. The advantages of including information about robot velocity to the position determination, calculated by a Multilateration TOF procedure are reported and discussed.

1. Introduction

Although there are different methods and technologies to determine the position of autonomous agents in a given environment [1], the decision about which of these methods to implement is not trivial as it is a key factor to guarantee the success of the mission. For a lunar exploration mission, the advantages of a cooperative multi-robot system over a single robot approach include increasing robustness, reliability, area researched versus rover mass and power budget etc. Nevertheless, effective mapping and navigation mechanisms must be implemented.

Previous to navigation and other high-level functionalities, a precise and efficient method for mobile robots location is necessary to support local navigation processes as well as the organization of the robotic system as a whole. For this, Frequency Difference of Arrival (FDOA) methods based in Doppler shift for velocity determination can contribute to improve the position estimation [2], in combination with absolute (i.e. non incremental) position determination by, for instance, multilateration Time-of-Flight (TOF) procedures. This work proposes a system to implement such functionality with minimum hardware and software requirements.

2. Materials and Methods

The next figure shows the system proposed. The exploration system consists in a hybrid robotic system formed by large robots providing the communications and navigation infrastructure (Tracking stations) and a number of smaller robots carrying instrumentation (mobile nodes) intended to travel across the research area.

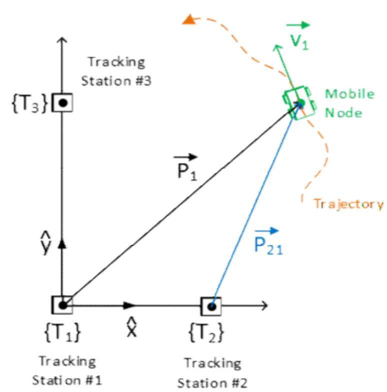

Figure 1: Multirobot system proposed for Lunar Exploration.

The system is configured as a hybrid heterogenous robotic system in order to comply with complex mission requirements and to be scalable and reusable (the large tracking station could be used by future robotic missions or enhanced by further missions). Therefore, a concept of upgradeable robotic exploration infrastructure is presented, making possible the enhancement of the system functionalities with successive missions.

The exploration area is assumed to be 1000 x 1000m, limited and small enough to assume a flat non-geodetic surface [3]. Numerical formulation of the multilateration and velocity determination from the range via Time-Of-Flight measurements and Doppler frequency shifts respectively is presented and discussed, including analysis of computational load yielding to the solving of the resulting algebraic equations systems, generally inconsistent and overdetermined.

3. Summary and Conclusions

The advantages of an heterogeneous robotic system for lunar exploration were explained, and the combination of Doppler shift-based velocity estimation with Time-of-Flight absolute position determination of exploration rovers was demonstrated to enhance position information, necessary for effective navigation across the exploration scenario.

Acknowledgements

We want to express our acknowledgments to the Aerospace Sciences Department of the University of Glasgow for their support.

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