IAF SPACE EXPLORATION SYMPOSIUM (A3)
Interactive Presentations - IAF SPACE EXPLORATION SYMPOSIUM (IPB)

Author: Dr. Riccardo Giubilato
German Aerospace Center (DLR), Germany

Mr. Mallikarjuna Vayugundla
DLR (German Aerospace Center), Germany
Dr. Cedric Le Gentil
University of Technology Sydney (UTS), Australia
Dr. Martin Schuster
German Aerospace Center (DLR), Germany
Mr. William McDonald
University of Technology Sydney (UTS), Australia
Prof. Teresa Vidal-Calleja
University of Technology Sydney (UTS), Australia
Dr. Armin Wedler
German Aerospace Center (DLR), Germany
Dr. Rudolph Triebel
DLR (German Aerospace Center), Germany

ROBUST PLACE RECOGNITION WITH GAUSSIAN PROCESS GRADIENT MAPS FOR TEAMS OF ROBOTIC EXPLORERS IN CHALLENGING LUNAR ENVIRONMENTS

Abstract

Teams of mobile robots will play a key role towards future planetary exploration missions. In fact, plans for upcoming lunar exploration, and other extraterrestrial bodies, foresee an extensive usage of robots for the purposes of in-situ analysis, building infrastructure and realizing maps of the environment for its exploitation.

To enable prolonged robotic autonomy, however, it is critical for the robotic agents, to be able to robustly localize themselves during their motion and, concurrently, to produce maps of the environment. To this end, visual SLAM (Simultaneous Localization and Mapping) techniques have been developed during the years and found successful application in several terrestrial fields, such as autonomous driving, automated construction or agricultural robotics.

To this day, autonomous navigation has been demonstrated in various robotic missions to Mars, e.g., from NASA's Mars Exploration Rover (MER) Missions, to NASA's Mars Science Laboratory (Curiosity) and the current Mars2020 Perseverance, thanks to the implementation of Visual Odometry, using cameras to robustly estimate the rover's ego-motion. While VO techniques enable the traversing large distances from one scientific target to the other, future operations, e.g. for building or maintenance of infrastructure, will require robotic agents to repeatedly revisit the same environment. In this case, the ability to re-localize themselves with respect to previously visited places, and therefore the ability to create consistent maps of the environment, is paramount to achieve localization accuracies, that are far above what is achievable from global localization approaches.

The planetary environment, however, poses significant challenges to this goal, due to extreme lighting conditions, severe visual aliasing and lack of uniquely identifiable natural "features". For this reason, we developed an approach for re-localization and place recognition, that relies on Gaussian Processes, to

efficiently represent portions the local terrain elevation, named "GPGMaps" (Gaussian Process Gradient Maps), and to use its gradient in conjunction with traditional visual matching techniques.

We will demonstrate, analyze and report the performances of our SLAM approach, based on GPGMaps, during the 2022 ARCHES (Autonomous Robotic Networks to Help Modern Societies) demonstration mission, that will take place on the volcanic ash slopes of Mt. Etna, Sicily, a designated planetary analogous environment. The proposed SLAM system will be deployed for real-time usage on a robotic team that includes the LRU (Lightweight Rover Unit), a planetary-like rover with high autonomy, perceptual and locomotion capabilities, to demonstrate enabling technologies for a future lunar application.