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Author: Dr. Rene Weller
University of Bremen, Germany

Mr. Max Hofacker
Universität der Bundeswehr München, Germany
Dr. Roland Fischer
University of Bremen, Germany
Mr. Leon Danter
DFKI GmbH, Robotics Innovation Center, Germany
Mr. Navid Jadid
University of Bremen, Germany
Prof. Thomas Pany
Universität der Bundeswehr München, Germany
Mr. Gabriel Zachmann
University of Bremen, Germany

VAMEX-VTB - A COLLABORATIVE MULTI-USER VIRTUAL TESTBED FOR THE SIMULATION, PLANNING AND ANALYSIS OF A ROBOTIC SWARM-BASED MARS MISSION

Abstract

The VaMEx (Valles Marineris Explorer) initiative is an interdisciplinary research program funded by the German Space Agency at DLR aimed at developing new concepts, algorithms, and hardware for swarm exploration of the Valles Marineris on Mars. One of the main goals of VaMEx is the study of collaborative navigation. The mission concept highlights the complementary nature of the heterogeneous team of driving, walking, and flying robots. The goal of the current VaMEx3 development phase is to make the VaMEx swarm available for a field test campaign that is designed to last several months. This long-term demonstration mission shall demonstrate the VaMEx swarm's ability to autonomously and cooperatively explore a terrestrial analog environment. Successful field trials could enable VaMEx to be considered as a payload for future robotic space flights to Mars. To enable a comprehensive evaluation of the entire Mars mission already during the development of the swarm members, we have developed a Virtual Testbed, serving as a testing environment for both the algorithms and systems that underlie the mission. This testbed simulates robotic agents along with their sensors and actuators in a digitally reconstructed terrain of Valles Marineris. Our VTB utilizes cutting-edge rendering and simulation technologies from Unreal Engine 5 to enable high-fidelity simulations of sensor modalities, including but not limited to RGB cameras, LIDAR systems, and IMU. Additionally, the VTB offers interfaces via ROS2, which are identical to the interfaces of real-world sensors. This ensures seamless integration of existing algorithms, such as the developed multi-robot multi-sensor SLAM. Given the high computational demands of real-time sensor simulation, the VTB is designed as a distributed system. This allows the computational workload to be distributed among multiple computers. Furthermore, we have extended our VTB with a sophisticated virtual reality interface with the support of distributed multiple-user environments. This enables a group of engineers to directly experience the simulated swarm very close to the simulated Mars environment. Such immersive experiences can give engineers new insights into the planned mission for instance to better judge distances or understand the importance of surface materials. We also included components

for direct observation and interaction with the robotic agents. Finally, we have conducted a validation for the VTB, where the behavior of robots operating with real sensor data will be compared to those operating within the VTB environment. This serves as an indicator of the accuracy of the simulation and its approximation to real-world conditions.