Teleoperated Navigation System based on 3D Occlusion Detection for Lunar Exploration Rovers

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***Abstract*— In this paper, the authors present a system used to calculate the visibility of a given area where a mobile robot is located at and evaluated several different locations in order to enhance the visibility of a local map.**

***Index Terms*—Occlusion, path finding, visibility, 3D mapping**

I. Introduction

DUE to the successful robotic exploration and scientific missions that are still carried out by the Mars Exploration Rovers (MERS), the space exploration community's interest has recently started to shift towards the Moon. Given the topographic characteristics of the lunar polar craters, visibility might become lower as the rover descends. Under these circumstances, handling a rover using conventional stereo cameras at the poorly illuminated walls of the selected crater may put in danger the mission and the robot itself. A possible solution to this problem is the use of LIDAR (Light Detection And Ranging) technology. Laser range sensors are not affected by the lack of illumination in a given area in order to provide the necessary information to generate a very detailed map of the area surrounding the rover.

Given the importance of maximizing the observable area within the space surrounding the vehicle, the authors approach the problem of occlusion by developing a criterion called "visibility index" to evaluate several locations and configurations that would enhance the visibility of the local map. This criterion can be used along with other indexes such as roughness and distance in a path planner algorithm that weights these indexes in order to calculate a candidate path to navigate areas of high scientific interest.

II. Description of the System

Once the mobile robot has left the lander site, it would scan the area surrounding it. This scan would be then translated into a "Local" DEM with higher resolution than a "Global" DEM previously acquired by an in-orbit satellite. The Local DEM will be matched to its corresponding Global DEM's grid. The area to be studied (where the obstacles that might cause occlusion to the LIDAR sensory system) can be reduced to the area given by the newly generated Local DEM which encloses a segment of a Global path within its boundaries. This segment would represent the initial position and goal destination the Local path planner should consider.

A candidate path can now be generated by the Local path planner within the Local DEM considering a calculated visibility index. This local path planner also considers the weight of terrain roughness index and that of the distance to be different from zero, since it is important that the candidate path can be traversed by the mobile robot. Being a teleoperated mission, the candidate path within the Local DEM that includes the visibility index explained previously, is shown as a 3D map to provide a better understanding to the rover driver, and it can help determine which region within the area of the Local DEM (closest to its neighbor cells inside the Global DEM map) would provide a greater coverage area by the laser ranging sensory system.

III. Results

A mobile test bed was taken to an outdoor location in an effort to emulate the conditions of the lunar crater's topography. At this location the laser range sensor gathered the terrain's surface information facing the rover. Multiple scans were taken from a higher ground, which caused the desired simulated occlusion effect. The rover driver benefited from the 3D display of this information, through a graphical user interface (GUI), that differentiates the occluded areas from the non-occluded ones, and provides a visualization of every evaluated configuration and presents the final path recommended by system's algorithm.

IV. Discussion

The authors present a system that calculated the visibility of a given area where a mobile robot is located and evaluated several different locations in order to enhance the visibility of a local map. Developing such system would improve the size of the area that can be mapped with the minimum displacement of the robot. Therefore, it improves the energy usage of the robot when moving towards desired locations rather than spending it by traversing unnecessary paths.

V. Conclusions

A novel occlusion detection system from which a visibility index can be derived has been described. The system can recommend the driver an area from which the effects of the occlusion caused by obstacles are minimized and the results of the system are presented using 3D graphic technology. A simulation using computer generated 3D terrains similar to the topography of the lunar soil and experiments realized in an outdoors location were used to validate the system.