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DEVELOPMENT OF A COMPREHENSIVE SIMULATION FOR EVALUATING OPTIMAL LUNAR LANDING AND HAZARD AVOIDANCE TECHNIQUES USING LIDAR

Abstract

The purpose of the research is developing a comprehensive simulation that can be used to evaluate various control, guidance, and navigation aspects of a lunar lander. The primary usage is evaluating landing strategies and hazard avoidance techniques with LIDAR.

The comprehensive simulation includes strategies and algorithms required for safe lunar landing. To serve that purpose, an optimal trajectory and soft vertical landing strategies are developed starting from Apollo's landing methods. Since the lander carries LIDAR, it is possible to use this imagery sensor for terrain reference navigation. This algorithm is also tested using the simulation. The lunar geological data are generated using PANGU. In the terminal stage, the landing spot is evaluated. Nominal slope and roughness are used to test if it is safe to land on the spot. If it is decided not to be safe, the vehicle is controlled to move to another spot.

We investigated and analyzed the previously developed landing scenario such as Apollo project which is directly related to what pursued in this study. And then, based on the Apollo landing scenario we set up highly accurate landing scenario using LIDAR. The landing scenario consists of powered descent phase, final approach and vertical landing phase. In powered descent phase, we perform a reduction in velocity of lunar lander using maximum thrust and open-loop control using pitch history which is result from landing trajectory optimization. In final approach phase, lunar lander land to planed landing site using target guidance of application for optimal guidance law. Also it is performed hazard detection and avoidance using LIDAR, and to change landing site is performed if necessary. The integrated simulation tool is developed using MATLAB Simulink. The simulation consists of 6DOF dynamic model of a lunar lander, hazard detection/avoidance model, guidance, attitude control model and interface with PANGU which generates geologically simulated lunar environment. And then, the landing scenario and design parameters are verified by the integrated simulation tool.

The comprehensive simulation of the lunar lander is highly useful to validate the landing scenario using LIDAR, and verify algorithms for hazard detection/avoidance, terrain reference navigation, optimal guidance, and attitude control. The integrated simulation tool from this study saves time and expense to design of lunar lander and increases the chance of success with improved safety in landing phase.