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Author: Dr. He Yang
School of Aerospace Engineering, Beijing Institute of Technology, China

Prof. Shengying Zhu
Beijing Institute of Technology, China
Dr. Jiateng Long
School of Aerospace Engineering, Beijing Institute of Technology, China
Prof. Rui Xu
Beijing Institute of technology(BIT), China

POTENTIAL FUNCTION GUIDANCE METHOD FOR EXTRATERRESTRIAL BODY LANDING BASED ON TRAJECTORY CURVATURE ADJUSTMENT

Abstract

Future extraterrestrial body exploration missions will seek to land in complex areas with more specialized resources, which often have a complex environment and rugged terrain with more terrain obstacles such as rocks, slopes and craters, posing a threat to the probe safety. In addition, due to the existence of communication delay, the ground command cannot control the motion state of the probe in real time. Therefore, it is necessary to study the autonomous obstacle avoidance guidance method with good real-time performance to reduce the potential collision risk, and to guarantee the successful completion of the exploration mission. In the existing researches, the artificial potential function guidance method is commonly used in the obstacle avoidance task of probe due to low computational complexity. However, this method relies too much on the design of the initial guidance parameters and cannot flexibly adjust the probe trajectory according to the actual terrain, which lacks versatility. Moreover, when the parameters are not reasonably designed, the problem of repeated obstacle avoidance will occur. Aiming at the above problems, this paper designs a potential function guidance method based on trajectory curvature adjustment, which integrates the shape constraints of the trajectory into the artificial potential function design. First, the correspondence between the shape of the trajectory and the real-time state of the probe is investigated, and the shape constraint of the trajectory is transformed into the function of the remaining time required for landing. Secondly, an artificial potential function with the parameter of the remaining time required for landing is designed, which is characterized by positive definiteness. Next, the Lyapunov theory is used to derive the guidance law of the curvature potential function. The guidance law can dynamically adjust the guidance parameters based on the actual terrain conditions, thereby modifying the shape of the probe's landing trajectory to effectively navigate around surface obstacles on the target celestial body. This adaptive approach mitigates the issue of repeated obstacle avoidance. Finally, the designed guidance law is utilized to carry out obstacle avoidance landing simulation tests with Mars as the target celestial body. The simulation results show that the proposed landing curvature potential function guidance method can flexibly adjust the probe trajectory according to the preset terrain obstacles, successfully avoid the terrain obstacles, and accurately arrive at the target landing area within the preset time, which is safe and reliable.