Paper ID: 53963
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IAF ASTRODYNAMICS SYMPOSIUM (C1)
Guidance, Navigation & Control (3) (9)

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POLARIZED SKYLIGHT-AIDED AUTONOMOUS NAVIGATION METHOD FOR MARS ROVERS

Abstract

Usually, Mars rovers are equipped with Vision-aided Inertial Navigation System (VINS), as they work on the surface of Mars. Biases of gyros in VINS accumulate over time, and VINS works worse. There is no stable global magnetic field on Mars, and Mars rovers can't utilize magnetic field to correct the biases accumulated.

We propose a Polarized skylight-aided Autonomous Navigation method (PAN) for Mars rovers. The new method is based on VINS. We utilize polarized skylight pattern-based information on Mars, to reduce the accumulating error of VINS, just like what desert ants and honeybees do on the Earth. In PAN, the degree of polarization (DP) is calculated by a four areas polarized skylight camera. The variations of DP indicate the change of the Mars rover's orientation. EM-EKF algorithm is designed to calibrate measuring coordinate systems of each sensors in PAN, such as stereo navigation cameras, gyros, accelerometers and polarized skylight camera. A modified Federated Kalman Filter is implemented to estimate the position and orientation of the Mars rover. The principle and the whole algorithm of PAN is presented in this paper in details.

We implemented PAN on a simulated Mars rover to test the performance of the new method. During a tens of kilometers trip, about three and a half hours long, the error of position of the Mars rover, that provided by PAN, did not accumulate almostly, such as the error of orientation. After the long trip, the bias of rover's position was about 1.4 meters. We got similar results after several trips with different distance, range from 5Km to 16Km. At the same time, when polarized skylight camera pointed near the solar point, where the skylight is unpolarized, the DP measured would be very small, and PAN could not get stable orientation of the rover. This means Polarized skylight-aided Autonomous Navigation method could provide accurate position and orientation information of a rover on Mars, during the most time of a long trip.