SPACE EXPLORATION SYMPOSIUM (A3)
Mars Exploration – Part 3 (3C)

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NAVIGATION SYSTEM FOR A SEMI-AUTONOMOUS MARS ROVER

Abstract

A semi-autonomous navigation system has been developed to overcome the limitations of manual control of planetary rover prototype developed at IIT Bombay. The system involves inputs in the form of GPS coordinates (relative to that planet) , video feed from 2 on-board cameras one on rover and robotic arm each) and depth (of obstacles) data in the vicinity of the rover. The orientation, speed and acceleration of the rover are approximated using IMU. This data is processed on-board using an embedded Linux based microprocessor to calculate the speed and angle to be given to each wheel. Manual control can override autonomous control.

The algorithm has been developed for a terrain which may include frequent obstacles and trenches of size no more than the diameter of the wheel. The rover defines a line from a reference point to the destination. The default motion of the rover is maintained along this line. A safety alert feedback is incorporated which includes detection of incoming non-negotiable trenches and obstacles using optical distance sensors and preferentially avoids these critical point. This is followed by the algorithm to bring the rover closest to its default line of motion. This uses a combination of GPS and IMU feedback.

Errors in IMU may accumulate in the system. These need to be corrected for from time to time. Also, GPS, although more accurate on a larger timescale, provide lesser spatial resolution. A novel dynamical weighting function for these two sensors has been proposed for extracting the most accurate motion feedback. The weight given for GPS feedback is higher when the rover is farther from its specified destination and corrects for IMU errors during this domain of time. When the rover is in the vicinity of the destination, higher weight is given to IMU feedback in the motion model, since the statistical nature of corrections specific to that terrain is already learnt and thus in smaller timescales, IMU will provide more accurate feedback.

This on-board intelligence is also augmented with extensive base-station capabilities that have been developed such as automatic simulation of delayed-time rover motion in the 3D CAD. This uses angular feedback from specific joints of the rocker-bogie and robotic arm as well as IMU and thus reconfigures the rover CAD to comply. The video feed from 2 on-board cameras are processed at base station to estimate the ground profile and generates a real-time reconstructed picture of rover-ground interaction.