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CONTROL AND NAVIGATION SYSTEM FOR AN AUTONOMOUS MARS ROVER

Abstract

The paper presents a control system developed for an autonomous mars rover prototype. The motivation behind this system is minimisation of human intervention in the functioning of the rover and optimal usage of visual information available in the environment.

A modification of extended Kalman filter is first applied on angular velocity, linear acceleration and yaw data from IMU; velocity data from motor encoders and velocity data from camera (by tracking stationary objects). The measurement covariance matrix of encoder data is continuously recalculated using current feedback from motors.

The GPS position data has a low frequency drift which is corrected using a stationary GPS at the base station. The GPS velocity data and corrected GPS position data are then merged with the odometry frame pose using another extended Kalman filter to get position in map frame.

A stereo camera is used as a depth sensor as it allows correlation of visual texture and depth information, which is quite important for target localisation and obstacle detection. Images acquired from the camera are undistorted to undo non-linear lens effects. Remapping is then done to flat-field image planes for both cameras. A standard block matching algorithm is then used to generate a point cloud.

Given point clouds across frames, 3D feature descriptors are used to match points across the point clouds. A perspective n-point problem is then solved to determine the transformation between the two point clouds. The point clouds are transformed into global coordinates to generate a 3D map of the surrounding. This map is used to generate an obstacle-map, without restriction to a 2D plane as in traditional laser-scanners.

Targets to be reached in the environment are distinguished primarily by their colour difference from the surroundings. In most cases, the approximate position of the target is known but other techniques are needed to accurately narrow it down. In the case of astronaut detection, for instance, the search is for a bright object against a reddish or bluish background. Generally sky is easy to segment out. The difficulty lies in segmenting the astronaut from the ground. To do this, a ground plane is fitted into the point cloud, ground points are removed and a pre-trained classifier is used to determine the astronaut's position.

Using the obstacle map, odometry information and target positions obtained above a standard D* algorithm is employed to navigate to the target.