講演番号	014

文献番号	20225014

Autonomous Vehicle Localization Using Magnetic Markers Placed in Grid-Like Patterns

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KEY WORDS: Electronics and Control, Autonomous driving, Control system, Vehicle localization, Extended Kalman Filter [E1]

Vehicle localization is an important technical factor in autonomous driving vehicles. Particularly, accurate and precise information about the vehicle position should be obtained, with robustness towards various weather and road conditions. A method using magnetic road markers as coordinate reference points for vehicle localization (magnetic positioning system; MPS) has proven to achieve the above requirements. However, such method has various limitations. For example, it is unable to localize the vehicle when the vehicle veers off the course of magnetic marker system. This is problematic especially in places where vehicles can take various paths, such as intersections.

In order to resolve the current problems in MPS, we propose to modify on-board and infrastructure system. In terms of on-board system modification, we propose to use only one set of magnetic sensor array. For infrastructure system, we propose a grid-like placement of magnetic markers. However, current system cannot obtain vehicle heading with only 1 sensor array. Also, the coordinate of the detected marker is not defined as of detection.

To overcome the above restraints, extended Kalman filter (EKF) was used to integrate information from inertial measurement unit (IMU) with the information from magnetic markers. Maximum likelihood estimation was used to associate the coordinates of detected markers from a known marker coordinate map. When magnetic markers are not detected, vehicle localization and heading estimation is done by deadreckoning, using the filtering step of EKF. When the sensor array detects a magnetic marker, a coordinate will be chosen from a known magnetic marker map, and the vehicle position and heading is corrected according to the measured coordinate.

The proposed method was validated using simulation and data acquired from experiment using actual vehicle. Fig. 1 shows our test vehicle running on the intersection where markers were placed in a grid pattern. Fig. 2 shows an example of the output of our localization method. In Fig. 2, the line with grey X shows the vehicle position acquired from GNSS signal, the red line indicates the estimated position using dead reckoning, and the blue line indicates the estimated position using the proposed method. The circles indicates the coordinate of the associated markers, the dots indicates the coordinates of each magnetic markers on the test course, and the X indicates the coordinates of observed markers (indicated only at the intersection). The red and blue coloring each shows the N and S pole of each magnetic marker.

The results from simulation and experiment showed that the proposed method is plausible. The proposed localization algorithm was able to correctly associate the marker coordinates and accurately estimate the vehicle position and heading in some condition. It also suggested that the marker placement pattern could affect the precision of marker association algorithm.

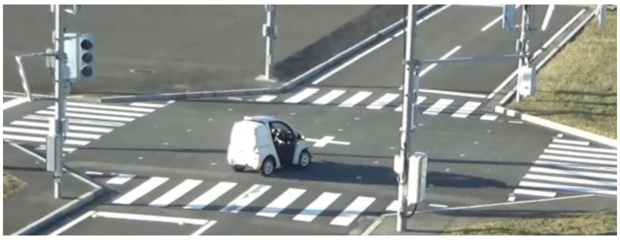

Fig. 1 Test vehicle running on the intersection with additional markers during experiment.

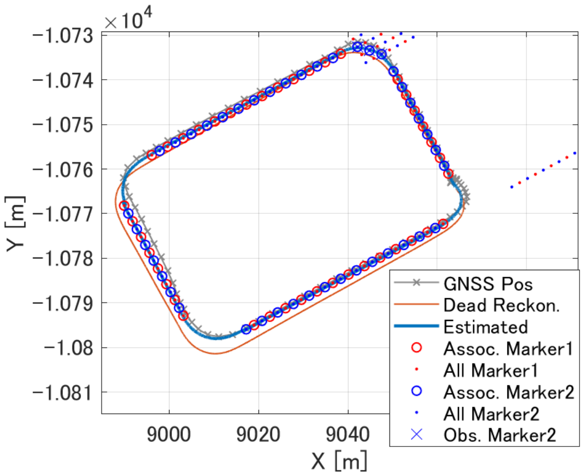

Fig. 2 Example of vehicle position estimation.