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High Accuracy RTK-GNSS/IMU Focusing on Acceleration Error Correction

Aoki Takanose [1)] Kaito Kondo [2)] Yoshiki Atsumi [2)] Junichi Meguro [2)] Kazuya Takeda [2)]

1) The University of Nagoya, Graduate School of Informatics,
Furo-cho, Chikusa-ku, Nagoya, Aichi 464-8601, Japan (E-mail: takanose.aoki@g.sp.m.is.nagoya-u.ac.jp)
2) The University of Meijo, Graduate School of Science and Engineering
1-501 Shiogamaguchi, Tenpaku, Nagoya, Aichi, 468-0073, Japan

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In recent years, research and development in the field of autonomous mobility for mobile vehicles, such as mobile robots and automobiles, has become increasingly active. Autonomous movement of mobile objects is achieved through object recognition, path planning, and vehicle control based on highly accurate location information. In the case of automatic vehicle driving, the required positioning accuracy is about 0.3 m. When using cameras, LiDAR (Light Detection And Ranging), etc., the accuracy is about 1.5 m, which is at the level of lanes.

A method to estimate the position and pose of a vehicle by integrating RTK-GNSS (Real Time Kinematic - Global Navigation Satellite System) and IMU (Inertial Measurement Unit) has been proposed. However, there are several problems with these sensors. Multipath noise can cause GNSS positional accuracy errors of up to several hundred meters. In addition, low-cost IMUs, such as MEMS-based IMUs, include bias noise, which causes a cumulative error in simple integration.

In this paper, a position estimation method for the case where wheel speed sensors are not installed on the moving vehicle and speed information is not available is considered. In contrast to the speed information required by position estimation methods that can estimate at the lane level, the proposed method uses other methods to add a speed estimation function. In the proposed method, we consider the Fix solution by RTK-GNSS and the method to estimate acceleration error using GNSS Doppler as a constraint.

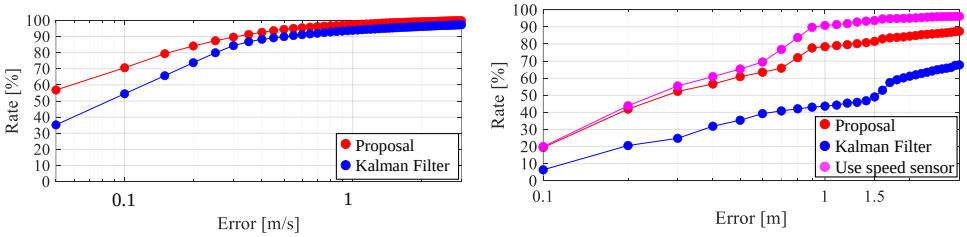
An evaluation test was conducted to confirm the effectiveness of the proposed method. The data used for the test was an open dataset published by Meijo University. The evaluation test was conducted in the Odaiba area of Tokyo, an urban environment where multi-paths frequently occur. Figure 1 shows the route used for the evaluation test. The equipment used for the evaluation test of the proposed method was an Ublox F9P GNSS receiver and an Analog Devices ADIS16475-2 IMU, both of which belong to the low-cost sensor category. For the reference, we used the post-processing results of POSLV220, which is capable of highly accurate position estimation even in urban areas.

Comparative evaluations were conducted for velocity and position estimation. For each item, a comparison is made between the proposed method and a conventional method using the Kalman filter. For position estimation, a dead reckoning method when wheel speed is used is added to the comparison.

Figure 2 shows the cumulative frequency distribution of speed estimation errors. In Figure 2, the horizontal axis shows the velocity error and the vertical axis shows the cumulative frequency of the error converted into a percentage. It can be seen that the percentage of smaller errors is higher for the velocity estimate using the proposed method than for the velocity estimate using the Kalman filter. If a 100-meter run is to be completed in 10 seconds without a fix solution, the velocity error must be at least within 0.1 m/s to be within 1 m error. Therefore, focusing on the 0.1 m/s velocity error, a 16.1% performance improvement can be confirmed.

Figure 3 shows the cumulative frequency distribution of position estimation error for each method. Figure 3 is similar to Figure 2, with the horizontal axis showing the estimation error and the vertical axis showing the cumulative frequency of the error converted to a percentage. Figure 11 shows that for Route A, the proposed method and the Kalman filter improve the percentage of estimation within 1.5 m error by 81.6% and 49.0%, respectively, while the Kalman filter improves the percentage by 32.6%. These results suggest that the proposed method is effective because the improved speed estimation performance improves the position estimation performance.

Fig. 1 Test Course



a) Velocity performance **b) Positional performance**

Fig. 2 Evaluation Results