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NONLINEAR FILTERING METHODS FOR THE INS/GPS IN-MOTION ALIGNMENT AND NAVIGATION

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Abstract. *In this paper we propose algorithms of land-vehicle INS (Inertial Navigation System) / DGPS (Differential Global Positioning System) In-Motion Alignment based on nonlinear filtering techniques (Quasi-Linear Optimal filter* [1]*, Gaussian Sum filter* [2]*, the Extended Kalman filter* [3] *and Monte Carlo filter* [4, 5]*). After briefly reviewing the nonlinear filtering techniques, the algorithms of In-Motion Alignment and navigation are derived. Results of numerical experiments are also shown by using the simulated INS and DGPS data. And the performance of nonlinear filter in the land-vehicle In-Motion Alignment and navigation is evaluated.*
Keywords: INS, GPS, Nonlinear filter, Kalman filter, Itegrated navigation

1. **Introduction.** INS (Inertial Navigation System) is a system that provides navigation information such as position, velocity, attitude relative to the initial condition by integrating acceleration and angular rate of a vehicle. In the conventional INS navigation, the initialization of the INS navigation states such as position, velocity and attitude must be completed prior to vehicle motion. And after the initialization, the INS is often required to be re-aligned by correcting the navigation states data because of the poor initialization or cumulative sensor error. In general, the initialization require the vehicle to stop at the initial position for at least 5 to 10 minutes [6, 7, 8]. It is, however, inconvenient and impractical in case that there is not enough time to stop at the initial position. Therefore In-Motion Alignment algorithm that enables the vehicle to start instantly is motivated.

In the alignment procedure, by assuming that the initial attitude of the vehicle such as heading, roll and pitch angles are zero, the INS data and some independent navigation data, such as position and velocity information obtained from GPS are integrated by estimating and correcting the INS errors. Therefore the INS error equations are required. And it is important to take into account its nonlinearity because the INS error equations are described by nonlinear functions strongly depending on the vehicle's attitude.

When azimuth error is fairly small, the nonlinear equations can be approximated by the linear equations. Therefore, the initial alignment error equation of the INS with the large initial azimuth error has been derived by linearization [9]. However, when the initial azimuth error is large, the nonlinear errors in approximation can not be neglected. In such case, some nonlinear filtering technique are applied [10, 11, 12, 13, 14].