

Research Article

A Robust Extended Kalman Filter Applied to Ultrawideband Positioning

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Ultrawideband (UWB) is well-suited for indoor positioning due to its high resolution and good penetration through objects. The observation model of UWB positioning is nonlinear. As one of nonlinear filter algorithms, extended Kalman filter (EKF) is widely used to estimate the position. In practical applications, the dynamic estimation is subject to the outliers caused by gross errors. However, the EKF cannot resist the effect of gross errors. The innovation will become abnormally large and the performance and the reliability of the filter algorithm are inevitably influenced. In this study, a robust EKF (REKF) method accompanied by hypothesis test and robust estimation is proposed. To judge the validity of model, the global test based on Mahalanobis distance is implemented to assess whether the test statistical term exceeds the threshold for outlier detection. To reduce and eliminate the effects of the individual outlier, the robust estimation using scheme III of the Institute of Geodesy and Geophysics of China (IGGIII) based on local test of the normalized residual is performed. Meanwhile, three kinds of stochastic models for outliers are expressed by modeling the contaminated distributions. Furthermore, the simulation and measurement experiments are performed to verify the effectiveness and feasibility of the proposed REKF for resisting the outliers. Simulation experiment results are given to demonstrate that the outliers following all the three kinds of contaminated distributions can be detected. The proposed REKF can effectively control the influences of the outliers being treated as systematic errors and large variance random errors. When the outliers come from the thick-tailed distribution, the robust estimation does not play a role, and the REKF are equivalent to the EKF method. The measured experiment results show that the outliers will be generated in the nonline-of-sight environment whose impact is abnormally serious. The robust estimation can provide relatively reliable optimized residuals and control the influences of the outliers caused by gross errors. We can believe that the proposed REKF is effective to resist the effects of outliers and improves the positioning accuracy compared with least-squares (LS) and EKF method. Moreover, the adaptive filter and ranging error model should be considered to compensate the state model errors and ranging systematic errors respectively. Then, the measurement outliers will be detected more correctly, and the robust estimation will be used effectively.

1. Introduction

High accuracy position information is of great importance in location-based service (LBS). Due to a large bandwidth, ultrawideband (UWB) can obtain high-resolution distance estimation and enables reliable distance estimation [1]. Therefore, UWB is well-suited for indoor positioning

applications. The observation model of UWB positioning is nonlinear. The approximate solutions can be obtained iteratively based on Taylor's expansion of nonlinear distance equations [2, 3]. As a standard method for solving general nonlinear equations, the Gauss–Newton iteration is efficient and has a linear convergence rate for points close to the solution [4]. However, in this procedure, only the

