Abstract

The research done in the course of this thesis is located in several scientific fields. On the one hand, this thesis contains methodological advancements in the field of parameter estimation methods, statistical tests and reliability. On the other hand, algorithms specific to pedestrian indoor positioning and especially orientation estimation are developed. Nevertheless, it is possible to transfer these concepts to other fields of research and applications.

The progress in parameter estimation methods is related to the Gauss-Helmert model (GHM), which consists of general condition equations, implicitely containing the parameters or states to be estimated as well as the observations. The measures of inner reliability are derived in the GHM and are generalized, such that they can be used for any kind of systematic deviation parameterized in the observation model. The minimum detectable bias (MDB) and the correlation coefficients between test statistics are identified to be sufficient in order to assess inner reliability. Through a proper analysis of the least-square adjustment (LSA) solutions in the GHM and the corresponding statistical tests, main factors influencing the inner reliability measures are identified. The findings with regard to inner reliability in LSA are consequently transferred to the extended Kalman filter (EKF). The GHM is also applied to the EKF. In the common formulation of the EKF, the system equation unambiguously determines the state vector and the measurement equation exhibits the Gauss-Markov model. Both of the prementioned aspects are not mandatory in the newly formulated EKF update equations. Espically the possibility to use redundant condition equations in the system equation enables the fusion of information from multiple sub-systems in an overall EKF.

Two algorithms are introduced in this thesis, which can be used in indoor positioning applications. On the example of orientation estimation in pedestrian indoor positioning with smartphones, the approach of using an overdetermined system equation in the EKF is applied. It is shown, that this approach leads to a higher precision of the estimated states and improved inner reliability. The approach of fusing the information from multiple pedestrians leads to lower MDBs and greatly reduced correlation coefficients between the corresponding test statistics. The findings regarding inner reliability act as guideline for the development of another algorithm for orientation determination based on the accelerometer, gyroscope and magnetometer contained in a smartphone. Together with some heuristics, an algorithm is introduced, which exhibits robustness to magnetic anomalies affecting the smartphones's magnetometer. The proposed approach is tested in small scale experiments with high accuracy ground truth data. It is compared to three other algorithms introduced in related publications regarding orientation estimation in indoor positioning and outperforms them by at least 40%.