Erlanger Berichte aus Informations- und Kommunikationstechnik

Band 34

Wei Wang

Channel Measurement and Modeling for Mobile Radio Based Positioning

D 29 (Diss. Universität Erlangen-Nürnberg)

Shaker Verlag
Aachen 2014

Bibliographic information published by the Deutsche Nationalbibliothek
The Deutsche Nationalbibliothek lists this publication in the Deutsche Nationalbibliografie; detailed bibliographic data are available in the Internet at http://dnb.d-nb.de.

Zugl.: Erlangen-Nürnberg, Univ., Diss., 2014

Printed in Germany.

ISBN 978-3-8440-2917-8
ISSN 1619-8506

Shaker Verlag GmbH • P.O. BOX 101818 • D-52018 Aachen
Phone: 0049/2407/9596-0 • Telefax: 0049/2407/9596-9
Internet: www.shaker.de • e-mail: info@shaker.de

Abstract

Global Navigation Satellite Systems (GNSSs) provide an accurate positioning solution as long as line-of-sight (LoS) conditions between satellites and receiver prevail. However, in critical scenarios like urban canyons, the position accuracy by GNSSs deteriorates due to shadowing, diffraction, and reflection of satellite signals. In indoor environment GNSS receivers suffer from severe multipath effects and signal blockage resulting in very low receive power, handicapping the tracking of satellite signals. Augmenting the GNSS based positioning by terrestrial mobile radio signals in critical environments can significantly improve the position accuracy compared to a GNSS-only solution.

The performance of mobile radio based positioning strongly depends on the delay estimation accuracy of the LoS path between transmitter and receiver. Multipath propagation of mobile radio signals may drastically influence the delay estimation of the LoS path and, thus, the performance of the mobile radio based positioning. Furthermore, in none-LoS (NLoS) scenario the delay offset of the first detectable path to the geometrical LoS introduces an additional ranging error. This delay offset is defined as the NLoS bias. For tracking applications, not only the channel at a certain time instant is of interest, but also time evolution of individual multipath components (MPC) plays an important role since it affects tracking performances. For realistic developments of positioning algorithms, the exact knowledge of the channel is of significant importance. The more accurately the channel is known, the more realistic the simulation results are. Thus, the propagation channel model becomes an essential part in simulation tools. However, mobile radio channel models covering the critical scenarios, like the WINNER channel model, have been developed only for communication applications. Therefore, not all requirements for the channel model in positioning applications are satisfied: the NLoS bias and MPC evolution with time are missing.

The primary contribution of this thesis is an outdoor-to-indoor geometry-stochastic based channel model (GSCM) fulfilling the requirements for simulations of mobile radio based positioning algorithms. In the proposed channel model every individual MPC, either received by single-bounce or multiple-bounce propagation, is characterized by a single-bounce equivalent scatterer (ES). A MPC can be characterized by an ES, or particularly by the path from the transmitter to the ES to the receiver, in terms of propagation distance and angle of arrival. While the receiver moves, the location of the ES may change. Within the channel model, the trajectory of an ES is described with help of a fixed point, the so called fixed scatterer (FS). The location of the FS is determined at the path initialization based on on statistics of the ES. In the proposed channel model, three different types of MPCs are individually modeled according to

their characteristics. All necessary statistics to parameterize the channel model are extracted from channel measurement data at S- and C-band. A novel algorithm to estimate the time variant channel parameters is used. As one of the most essential parameters relevant to positioning applications, the time variant absolute delay for each MPC is accurately modeled which implicitly includes the NLoS bias. The time variant number of MPCs is simulated based on a two-step approach: First, the number of disappeared MPCs is determined according to path life or opening angle. Second, the number of appeared MPCs is statistically generated. Another time variant parameter, the amplitude fast fading process of individual MPC, is also considered in the channel model. Finally, a validation shows the reliability of the proposed channel model for mobile radio based positioning algorithms.

Another contribution of this thesis is a channel model for mobile radio based positioning for urban canyon scenarios. In such a scenario for terrestrial mobile radio signals, blockage of the LoS path occurs very often. Thus, the NLoS bias is significant in the channel model. Also exact modeling the MPC is a very important task for the channel model, especially for navigation applications. To fulfill the requirements for channel models in positioning systems, an extension of the WINNER channel model is performed based on a physical-statistical approach. Two components are individually modeled: First, the direct component, consisting of the LoS path and diffracted paths caused by building facades and lampposts, is deterministically calculated in an artificial scenery. Thus, the NLoS bias is obtained in the channel model. Second, MPCs are statistically modeled based on the WINNER channel model. Statistics used to model MPCs are based on the WINNER channel model and, therefore, on a large number of measurement campaigns. By using the same modeling approach as the outdoor-to-indoor channel model, time variant parameters of each MPC are deterministically calculated. Furthermore, a coherent channel model is proposed for positioning applications using both satellite signals and mobile radio signals. The proposed channel model relies on a coherent combination of the extended WINNER channel model and the German Aerospace Center (DLR) land mobile satellite channel model.