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Channel modeling for GNSS. A physical-statistical approach

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1. Extended Abstract

GNSS systems present an important challenge to the propagation modeler in that the requirements are different from those in communication systems: we are still interested in wideband modeling but the aim is knowing in much grater detail the arrangement of the near echoes, i.e., those within the excess delay of the ranging code's correlation peak. Also important is achieving a continuous modeling of the channel (preservation of the autocorrelation) as the terminal and the satellites move, as the previous history of the channel is relevant in the current computed position.

Multipath propagation, shadowing and blockage lower the satnav positioning accuracy, especially in built-up areas. The paper will present channel modeling work currently being carried out [1] with the goal of developing a high-fidelity channel model based on real-world measurements to allow for realistic simulation and hardware emulation of wave propagation phenomena in urban, suburban, and rural environments.

The development of multipath-induced error mitigation techniques must rely on the ability to accurately simulate satnav signal propagation. The most comprehensive model for such purposes up to date is that in ITU-R P.681 which stochastically re-creates situations for handheld and vehicle-mounted receivers [2, 3]. This is a model developed from channel sounding measurements performed in and around Munich from a Zeppelin as transmit platform [4].

However, ITU-R P.681 does not model the correlation between house façades and scatterers. In the model, both can exist with or without the other entity. The number of multipath components lies typically in the dozens which imposes a challenge to use ITU-R P.681 for satnav hardware constellation simulators.

Our proposed approach for model design use canonical objects laid out stochastically. A number of diffraction computation methods such as Physical Optics as well as ray-tracing techniques, reverberation effects, and rough surface scattering are taken into account to find the most suitable approach.

Additionally, the model must be fit for its usage with hardware constellation simulators through component count reduction methods. Two MIMO measurement campaigns will be performed which will allow to use distinct datasets for model design, calibration, and validation. During the measurement campaigns, the AltBOC signal broadcast of the Galileo satellites will be recorded. Due to the AltBOC signal's large bandwidth, it should be possible to estimate the characteristics of multipath components, such as amplitude, angle and time of arrival, and life span [5].

The model is a physical, geometrical, statistical one operating on a small number of canonical objects with associated, easy-to-evaluate propagation mechanisms. Each object produces one or various electric field contributions: magnitude, phase and polarization, while limited ray-tracing is carried out mainly to determine delays and angles of arrival. Moreover, cross-correlation of both shadowing and multipath effects are preserved though the same ray tracing performed on full 3D scenario models.

An important issue is that the ray-tracing allows a clear identification of the various interaction points, e.g. the diffraction point or the reflection point, given that delays must be referred to a concrete point in space for calculating distances of flight of the various contributions. This is provided by the ray-tracing algorithm which identifies the points on the surfaces or edges where interactions take place.

Several improvements have been identified with respect to the ITU-R model which include locating the scatterers on the surface of actual scenario features such as building faces, poles, trees, etc. This gives rise to a more accurate angle of arrival reproduction. Moreover, there is no longer the need to use an echo lifetime parameter since the echoes extinguish themselves naturally as the distance to the terminal increases. We also prefer to use physical models for quantifying actual scattering amplitudes.

We also have introduced full polarization analysis at each interaction point in comparison with the simpler scalar approach used in the ITU-R model. We also consider receive antenna co- ad x-polar patterns when assessing the overall received signal. One further advantage over the baseline model is the consideration of the ground giving rise to reflections and combinations of rays, e.g., double reflections.

2. References

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