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ANALYSIS OF GNSS LOCALIZATION ACCURACY IN URBAN AREA USING RAY TRACING

Karolis Stankevičius[1], Rimvydas Aleksiejūnas[1]

[1]Institute of Applied Electrodynamics and Telecommunications, Faculty of Physics, Vilnius University
karolis.stankevicius@ff.vu.lt

Rising number of GNSS (Global Navigation Satellite System) enabled devices also comes with an increasing need for higher accuracy positioning. This was addressed to an extent by modernizing navigation systems and introducing new civilian L5 signals. However, higher overall number of available signals does not guarantee better position determination especially in urban environments, where GNSS positioning accuracy suffers from diffraction, multipath and reflections from surrounding buildings[1]. Due to these effects the total sum of GNSS signals at the receiver is comprised from line-of-sight (LOS) direct reception and non-line-of-sight (NLOS) diffracted and reflected signals. This introduces a significant error in position determination, because GNSS receivers operate under the assumption that all received signals are LOS signals[2]. Therefore, it is important to perform environment specific GNSS analysis.

GNSS raw-signal measurements have been conducted in city environment (Fig. 1 right) giving detailed information about carrier to noise ratio (Fig. 1 left), pseudorange, code-phase and carrier-phase. Measurements were performed using automotive grade Quectel LG69T AA GNSS receiver with survey grade Beitian BT-300S GNSS antenna. Measured localization accuracy has been compared against ray tracing simulations using 3D vector building data obtained from OpenStreetMap dataset[3]. The simulation environment is built using Open source ray tracing package Opal: open-source C++ ray tracing library based on NVIDIA OptiX framework which uses 3D ray-launching algorithm[4], and NVIDIA RTX 3060 graphics card.

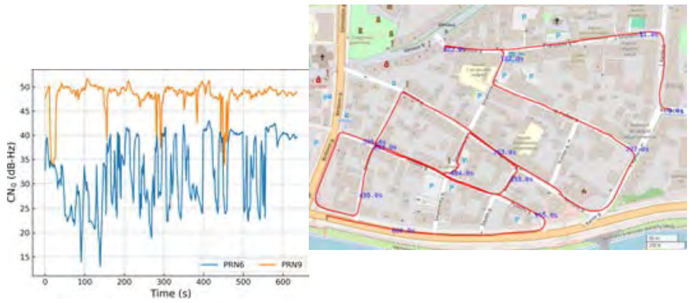

Fig. 1. Carrier to noise ratio of different GPS satellites over time (left) and path taken during raw GNSS measurements (right).

Carrier-phase and code-phase estimations of localization errors have been extracted from ray tracing results. From the results, close correlation between error statistics and NLOS diffracted rays can be observed. This suggests possibility of using ray tracing simulation data to identify areas with high diffraction and multipath probabilities. Based on such spatial information, the correction filters can be applied to GNSS signal prior to using it for location estimation. The results of ray tracing depend on the spatial resolution of building data. Therefore, for future applications, we plan to use LIDAR derived buildings data with decimeter-scale accuracy. For that ray tracing algorithms should be updated to account for more complex mesh-type data structures.

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