Constitutive Effective Ray-Tracing Parameters for Mobile Propagation Prediction

Miyuki Hirose
Department of Electrical and Electronic Engineering
Kyushu Institute of Technology
1-1 Sensuicho Tobata, Kitakyushu-city, Fukuoka 804-8550, Japan
Email: miyuki@ele.kyutech.ac.jp

Ray tracing (RT) method is used to predict radio propagation characteristics, such as propagation losses, delay spreads, and angular spreads. This method finds the dominant ray paths between a transmitting and the receiving antenna, depending on the geometry of the environment. Through ray tracing scheme and multipath channel model, it is possible to design and, theoretically, evaluate wireless channels for 5G/6G communication systems [1]. A recent paper proposed deep learning approaches for estimating radio maps [2]. The neural network is a function that returns an estimate of the pathloss for each input Tx-Rx locations. Ray tracing parameters, that affect propagation characteristics, are a great concern to improve the mobile propagation prediction in ray tracing simulation. An optimization system using a genetic algorithm was proposed [3], and in this paper, RT parameters were evaluated based on measurements.

A parameter optimization system for ray tracing simulation was constructed. Our system consists of 4 steps as follows: (1) **Setup** of input data of our system including the occupied frequency, locations of the transmitting and receiving points, antenna information, and materials of the structure. (2) **Calculation** of propagation characteristics, such as propagation losses, delay spreads, and angle spreads. (3) **Evaluation** of results of RT calculation compared with measured data. (4) **Output** as optimized values or **Update** the parameters and go back to the calculation. A method of updating the parameters was a genetic algorithm.

The measured data of the urban environment around at Yokohama city in Japan was used to evaluate our optimization system. The setup of the ray tracing simulations is shown in Tables 1. Searching for the optimized parameters, RMSE of the propagation losses between the ray tracing simulation and measurements converged to 3.77 dB in our system. The permittivity and conductivity of the buildings were 15.29 and 40 respectively. The maximum number of reflections and diffractions were 5 and 1, and the ray spacing was 0.05 degrees. The propagation losses of ray tracing simulation with the optimized parameters and the measured data are shown in Fig. 1.

Table 1. Setup of ray tracing simulation.

Map data	Yokohama city
Frequency	922 MHz
Antenna	Omni antenna
Antenna gain	2 dBi
Transmitting antenna height	66.2 m
Receiving antenna height	1.1 m
Number of receiving points	1795

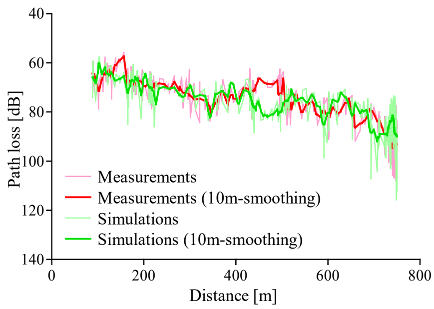

Figure 1. Comparison between measurements and ray tracing calculation results.

Acknowledgment

This research has been conducted under the contract "R&D for the realization of high-precision radio wave emulator in cyberspace" (JPJ000254) made with the Ministry of Internal Affairs and Communications of Japan.

References

1. D. He *et al.*, “The design and applications of high-performance ray-tracing simulation platform for 5G and beyond wireless communications: A tutorial,” *IEEE Commun. Surveys Tuts*., vol. 21, no. 1, pp. 10-27, 2019.
2. T. Imai, K. Kitao, and M. Inomata, “Radio propagation prediction model using convolutional neural networks by deep learning,” European Conference on Antennas and Propagation, Mar. 2019.
3. M. Hirose, T. Imai, S. Wu, S. Iwasaki, G. S. Ching, and Y. Kishiki, “A Ray Tracing Parameter Optimization System in Mobile Radio Propagation Prediction,” International Workshop on Antenna Technology, May 2022.