

Future 50 Years of Mobile Radio Propagation Research

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Abstract - This paper overviews the latest developments in mobile radio propagation research and presents our views looking to the future. Radio propagation research has high affinity to machine learning such as deep learning since it can deal with copious amounts of measurement data. Deep learning is useful for image recognition and can be applied to modeling of building materials. This modeling achieved through the analysis of building images is needed for radio propagation simulations. Therefore, we believe that the application of deep learning to mobile radio propagation research will emerge as a main topic in the future.

Index Terms — Mobile radio propagation, Radio propagation simulation, Radio propagation model, Deep learning.

1. Introduction

Many technologies have been studied to achieve capacity increases in mobile communication systems using limited radio resources. Moreover, mobile radio propagation characteristics have been actively investigated because the performance of mobile radio communication systems highly depends on these characteristics. For example, characteristics of the departure/arrival angle of radio waves at a base station (BS)/mobile station (MS) have been studied because these characteristics strongly affect Multiple Input Multiple Output (MIMO) performance. Furthermore, the frequency bands utilized for mobile communication systems have become higher because it is relatively easy to acquire wider bandwidths for the systems in these higher bands. Therefore, target frequencies for mobile radio propagation research tend to be higher. In recent years, utilization of the 6 to 100 GHz frequency bands is actively under investigation for the fifth generation mobile communication systems (5G) [1-3]. The targets of mobile radio propagation research have changed as mobile communication systems have evolved and these changes will continue in the future. In this paper, we overview the latest developments in mobile radio propagation research and present our view on future prospects.

2. Latest Developments in Mobile Radio Propagation Research

This section describes the latest developments in mobile radio propagation research that mainly target 5G.

5G assumes the active utilization of the 6 to 100 GHz frequency bands; therefore, clarifying the basic propagation

characteristics such as path loss, delay, and the departure/arrival angles is an important task.

Moreover, since signal blockage due to humans and objects is problematic at higher frequency bands, these characteristics have been investigated and models have been proposed.

To compensate for severe path loss due to higher frequencies, massive MIMO utilizing beamforming that controls the direction of the BS antenna beam toward a moving MS is a promising candidate technology. To evaluate this technology, a channel model for mobility is needed. With this in mind, a mobility model that considers the spatial consistency of scatterers between different MS positions is needed.

Furthermore, Multi-User MIMO (MU-MIMO) has attracted attention since MU-MIMO has affinity to massive MIMO. MU-MIMO performance greatly depends on the correlation of channel conditions, especially the angular information between different MSs. These characteristics are also relative to spatial consistency.

A 5G radio propagation model considering the above mentioned features is investigated in standardization organizations and research projects such as the 3GPP and the Mobile and wireless communications Enablers for the Twenty-twenty Information Society (METIS) [1-3].

3. Future Prospects

This section describes future prospects for radio propagation research.

(1) Future Radio Propagation Measurement and Models

For radio propagation measurement in the future, we consider measurement using commercial mobile communication systems as shown in Fig. 1. More specifically, we envision utilizing a database of radio propagation data measured by BSs and MSs in actual commercial mobile communication environments. In this methodology, the assumed radio propagation data are conventional information such as the received level, delay, and departure/arrival angles. Strictly speaking, the BS and MS equipment should be calibrated before measurement to measure the radio propagation data precisely. However, calibrating all equipment is difficult in a real environment. We believe that measurements will be performed to some degree in the future. Moreover, BSs and MSs should have array antennas to measure the departure/arrival angles.

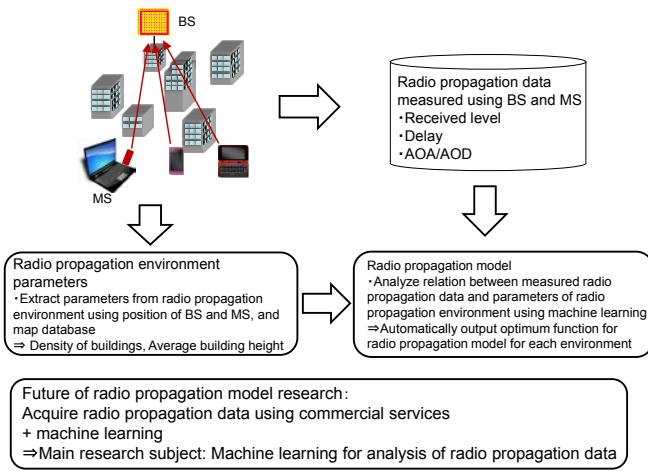


Fig. 1. Future radio propagation measurement and model.

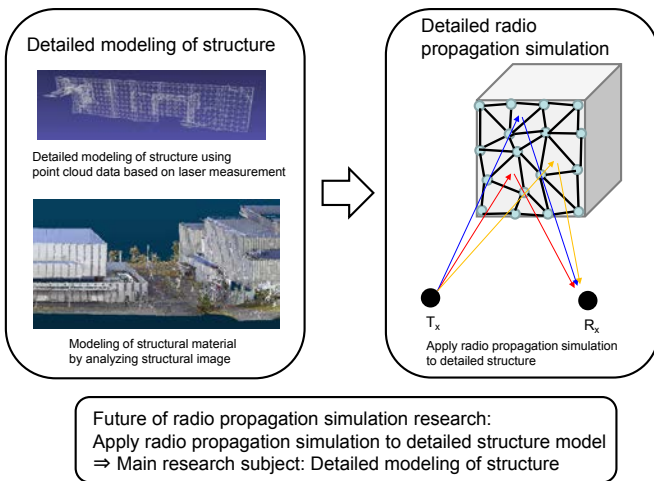


Fig. 2. Future radio propagation simulations.

Performing measurements at all BSs and MSs is difficult; however, we believe that these measurements will be possible to some degree in the future. In addition to the above-mentioned measurements, we envision utilizing the position data of BSs and MSs in the analysis of radio propagation data. Specifically, we consider extracting and utilizing radio propagation environment parameters of the area around the BS and MS that affect the radio propagation characteristics using the position data and a map database. Radio propagation environment parameters considered here are the density and average height of buildings around the BS and MS.

Next, we consider future radio propagation models utilizing the above-mentioned radio propagation data. Most current studies mainly analyze the relation between measurement data and the environment parameters for radio propagation models. When studying radio propagation models in the future, utilizing machine learning such as deep learning can be considered [4]. As shown in Fig. 1, radio propagation data and radio propagation environment parameters measured using commercial mobile communication systems are input into an analysis system

using machine learning and the system automatically analyzes the data. Finally, the system outputs the optimum function for the radio propagation model. The amount of data that is obtained using commercial mobile communication systems is very large. Machine learning is well suited to analyzing these copious amounts of data.

(2) Future Radio Propagation Simulation

In current radio propagation simulations, we often use the ray-tracing method using a building model that is constructed based on a commercial map database. In the future, radio propagation simulations using detailed building models might be performed, as shown in Fig. 2. In the current situation, it is possible to construct a detailed structural model of a building using laser measurement equipment such as that in the upper right in Fig. 2. These data are called point cloud data [5]. Currently, building structures are mainly modeled. The building materials are also important in the simulation; however, manually setting building material parameters for each building is very time consuming in the simulation. Therefore, an automatic process is needed to perform large-scale simulations such as in a city-level simulation. Automatic modeling of material might be performed in the future using the strength of lasers obtained through measurement of point cloud data and by analyzing the image of buildings such as depicted in the lower left in Fig. 2. Machine learning such as deep learning is useful for the above-mentioned image analysis since it is utilized in the area of image recognition. Conventional simulation methods such as ray-tracing and physical optics can be applied to simulations in the future. Therefore, detailed modeling of buildings will become a main research subject in the future.

4. Conclusion

We overviewed the latest developments of mobile radio propagation research and presented our view of future prospects. Radio propagation research has a high affinity to machine learning such as deep learning since it deals with large amounts of measurement data. Moreover, deep learning is useful in image recognition and can be applied to modeling of building materials, which is needed in radio propagation simulations. Therefore, application of deep learning to mobile radio propagation research will emerge as a main topic in the future.

References

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