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題目(和文)	SHF帯の屋内環境における幾何学に基づくクラスターの周波数依存性解析
Title(English)	Frequency Dependency Analysis of Geometry-Based Clusters in Indoor Environments at SHF Bands
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種別(和文)	論文要旨
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（博士課程）
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論 文 要 旨

THESIS SUMMARY

系・コース： Department of, Graduate major in	環境・社会理工学院 融合理工学 地球環境共創	系 コース	申請学位（専攻分野）： Academic Degree Requested	博士 Doctor of (Engineering)
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要旨（英文 800 語程度）
Thesis Summary (approx.800 English Words)

Chapter 1, “Introduction”, provides a detailed explanation regarding the background of wireless communication research and the main motivation of this study. The study of channel frequency dependency across wide frequency ranges is necessary for the deployment of the next-generation wireless system. Thus, the extensive literature review is provided, which conclude that most studies focus on the dependency of large-scale parameters, and the dependency of clusters for the improvement of the channel model is scarce. Hence, the main objective is to analyze the cluster frequency dependency of the radio channel in indoor environments, where the clustering algorithm from the master's work is enhanced and utilized to estimate the clusters, as well as propose the modification and improvement of the standardized channel model. Moreover, the electromagnetic simulation tool called physical optics (PO) is also exploited to physically interpret the cluster frequency characteristics.

Chapter 2, “Radio Propagation Mechanisms and Channel Models”, explains the basics of the radio propagation channel and channel models. The fundamentals of radio propagation mechanisms, which are free space, reflection, diffraction and scattering, and their effects on the channel frequency characteristics, as well as the scattering intensity calculation, are described in details. Then, the general structure and concept of channel models, both deterministic and stochastic models, are explained.

Chapter 3, “Indoor Radio Channel Measurement using Virtual Array Channel Sounder”, presents the concept of channel sounding and the channel sounder used in this thesis. The channel sounder is based on the virtual uniform circular array (UCA), where a single antenna is mounted on a robot arm, which is then rotated and measured the channel in a circular fashion to emulate the antenna array system. After that, two indoor environments where the measurement campaigns were carried out, which are hall and classroom, and their major scattering objects are explained.

Chapter 4, “Geometry-based Dynamic SIMO Multipath Clustering Algorithm”, describes the geometry-based clustering algorithm applied to estimate the clusters. In Section 4.2, the single-directional measurement-based ray tracer (MBRT) is proposed, where the multipath component (MPC) parameters and the geometric map of the environment are used to estimate the scattering points (SP) of each MPC. Then in Section 4.3, the clustering algorithm utilizing these SPs, which is enhanced from the master's work, is proposed and explained, where the SPs are grouped based on minimizing the physical distance among them. Then, the cluster tracking algorithm is provided to track the clusters from different spatial snapshots. Finally, in Section 4.4, the SI calculation from the clustering results is provided.

Chapter 5, “Physical Optics Algorithm”, explains the PO algorithm implemented in this work to assist the interpretation of clusters. Firstly, the object model based on triangular meshes is described. Then, in Section 5.4, the single bounce PO algorithm without shadowing is explained, where the windowing function is utilized to reduce the computational complexity and truncate the integral area. Then, the mesh fields and field at the observation calculation method is provided. After that, the single bounce PO algorithm with shadowing case is described in Section 5.5. Finally, the SI calculation is explained and the algorithm interpretations using simple scenarios are provided in Section 5.7. The interpretation results indicate that there are three main groups of clusters with different frequency characteristics: 1. Reflection, 2. Scattering/Diffraction/Shadowing, 3. Fading.

Chapter 6, "Frequency Dependency Analysis of Clusters in SHF Bands and Standardized Channel Model Modification Proposal", explains the algorithm parameters and provides the analysis results in both hall and classroom environments, as well as proposes the modification of the frequency-dependent cluster generation of the 3GPP channel model. The MBRT, clustering, and tracking results in Section 6.3 implied that the algorithm worked well in terms of detecting the SPs and clusters on the object which were actually presented in the environment. Moreover, there were fewer clusters in the hall environment where line-of-sight (LOS) and single bounce clusters were prominent. On the other hand, there was more cluster richness in the classroom environment but the single bounce clusters were still significant. In Section 6.4, the frequency dependency analysis showed that group 1, which comprises mainly of reflection and is frequency independent, dominated the hall environment due to a large amount of large and smooth surface objects. Group 2, which mainly consists of brick scattering, elevator shadowing, and metal stud diffraction, also contributed greatly to the hall environment channels. In contrast, group 3, which consists of fading due to shadowing of different Fresnel zones and phase addition or cancellation of two or more signals, was the major group in the classroom environment because of the multi-layer structure of plasterboard. In Section 6.5, the two types of cluster generation were proposed to improve the frequency dependence of the 3GPP channel model, and their properties were compared with that of the conventional 3GPP channel model. The results revealed that although the distributions were mostly the same as the conventional 3GPP, the statistics of each type and all of clusters varied greatly. This implied that, to realistically capture the channel characteristics, it is necessary to generate two types of clusters independently due to their dissimilar properties, which is totally ignored in the conventional 3GPP.

Chapter 7, "Conclusion and Future Work", summarizes this thesis and the important contributions. The possible research topics for future work are also provided.