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A Novel Mirror Kirchhoff Approximation for Predicting Shadowing Gain

Xin Du*(1), Kentaro Saito(1), Jun-ichi Takada(1) and Panawit Hanpinitsak(1)
(1) Tokyo Institute of Technology, Tokyo, Japan

With the spread of 5G, millimeter-wave (mmWave) band radio has come to be used for communication. At mmWave, shadowing effects greatly impact cellphone link performance. Conventionally, the full-wave electromagnetism approaches such as the Method of Moment (MoM) are widely used for estimation of those effects. However, the calculation cost of MoM is a significant issue, especially at mmWave. Therefore, the Kirchhoff Approximation (KA) approach is an effective candidate for the simulation in those frequency bands. However, KA has the accuracy issue to predict the shadowing effect by a thick object. In the conventional KA shown in Figure 1, the propagation wave is outstretched between the two planes [1] and the reflection from the shadowing object is neglected which causes the error.

The restrictions of conventional methods have motivated the establishment of an accurate prediction method for evaluating the shadowing effect by a thick object with low calculation time. This research aims to establish an efficient and accurate prediction method based on KA for calculating the shadowing gain by a metal cuboid, which can be approximated by an item of small furniture or a human body. A novel method based on KA called ' Mirror Kirchhoff Approximation ' (MKA) is proposed to achieve the goal. In the proposed MKA shown in Figure 2, the reflection field E^{RE} is introduced into the conventional KA.

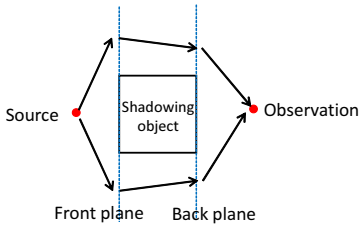


Figure 1. The conventional KA

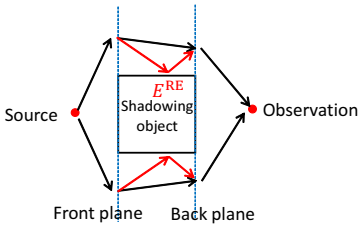
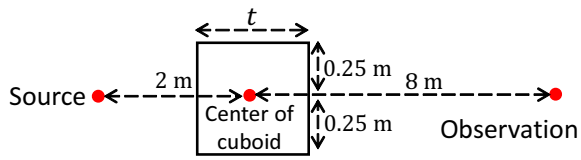


Figure 2. The proposed MKA

The proposed MKA was validated by comparing with MoM and KA in terms of accuracy and calculation time. A line source was simulated at 66.5 GHz frequency band. An infinite height metal cuboid with a changed thickness t was considered as the shadowing object. Figure 3 showed the top view of the environment, parameters of the simulation, and conditions of the calculation computer. Figure 4 showed the plot of the thickness of the cuboid and shadowing gain. Comparing with the conventional KA, the MKA had a maximum 8.3 dB improvement. Comparing with MoM, the calculation time of MKA was improved by 392-915 times. The results implied that the proposed method presented a good accuracy with a low calculation time.



Processor of computer	Intel(R) Core(TM) i7-8750H CPU @ 2.20 GHz
Software	MATLAB

Figure 3. Simulation conditions

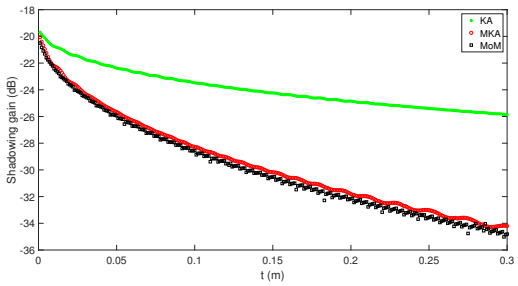


Figure 4. Simulation results

References

[1] A. Osterman et al., "Radio Propagation Calculation: A Technique Using 3D Fresnel Zones for Decimeter Radio Waves on Lidar Data," *IEEE-TAP*, **61**, 6, 2019, pp. 31–43. doi: 10.1109/MAP.2019.2943312.