EFFICIENT 2D RAY-TRACING MODEL FOR DIELECTRIC LENSES COMBINED WITH ARRAYS

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Phased array antennas are a good candidate for the new generation of mobile communications (6G) since they can provide highly directive and steerable beams with low loss and wide coverage. In addition, they can be manufactured by cost-effective technology and their mass production is very simple. The performance of a single conventional array may be adapted to different use case scenarios and requirements by using a customized dielectric lens (acting as a radome as well) placed in front of the array. Lenses combined with arrays provide a wide range of advantages in terms of improved radiation performance, reconfigurability in the use case, and reduction in power consumption.

The lens/radome shape optimization process by using commercial full-wave simulators is computationally intensive and very time-consuming. For this purpose, ray-tracing techniques have become of great interest because far-field performance can be evaluated with significantly reduced time and computational resources compared to full-wave tools. Although the status of ray-tracing techniques is very advanced (mainly because of its extensive use in computer graphic tools), the study of dome antennas can be carried out by means of more simplified approaches.

In this work is presented a fast and efficient tool to evaluate the far-field performance of two-dimensional dielectric lenses combined with phased arrays. The proposed tool is based on ray-tracing analysis, but in contrast to other commercial physical-optical approaches, can calculate the effects of internal reflections in a multilayered dielectric dome. Furthermore, this method can estimate the absorption losses caused by the Joule effect. The radiation patters computed with the proposed ray-tracing method are compared with full-wave simulators to validate the effectiveness of the model. The validation has been performed with a 2D simulator, COMSOL, and a 3D full-wave simulator, CST Studio Suite 2022. Evaluating the far-field with ray tracing reduces the computation time by a factor of 150 when computed with COMSOL, and 740 times when obtained with CST.

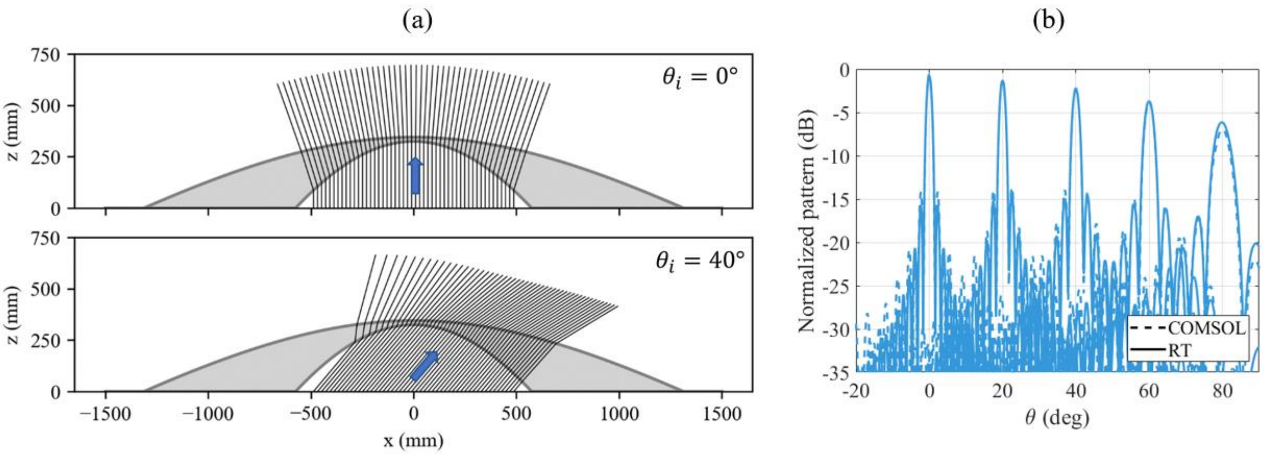

Fig. 1: (a) Ray tracing for a dielectric dome from [1] and (b) radiation patterns computed with COMSOL and our ray tracing tool.

[1] E. Gandini et al., "A Dielectric Dome Antenna With Reduced Profile and Wide Scanning Capability," in IEEE Transactions on Antennas and Propagation, vol. 69, no. 2, pp. 747-759, Feb. 2021, doi: 10.1109/TAP.2020.3022960.

[2] Q. Liao, N. J. G. Fonseca, M. Camacho, Á. Palomares-Caballero, F. Mesa and O. Quevedo-Teruel, "Ray-Tracing Model for Generalized Geodesic-Lens Multiple-Beam Antennas," in IEEE Transactions on Antennas and Propagation, vol. 71, no. 3, pp. 2640-2651, March 2023, doi: 10.1109/TAP.2022.3233643.