Site-specific wave propagation prediction with improved shooting and bouncing ray tracing method

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The site-specific radio wave propagation prediction in outdoor is increasingly important for electromagnetic interference analysis. Since the outdoor environment is usually very complex and electrically large, the shooting and bouncing ray (SBR) method (one technique of ray tracing) rather than other numerical methods such as finite difference time domain method and finite element method, is often applied in the computation. However, a large amount of rays have to be launched to guarantee the accuracy in conventional ray tracing methods. This, in turn, increases the simulation time significantly. Recently, many acceleration algorithms have been reported including space partitioning and wavefront decomposition. This paper presents a novel adaptive ray launching (ARL) method based on the pattern of transmitting antenna, which reduces the launched ray number significantly while maintaining the computation accuracy

In conventional SBR method, the rays launched from the source are usually uniformly generated in all directions of the three-dimensional space with identical angular separation. In this paper, the new ARL method launches initial rays based on the pattern of source antennas with nonuniform angular separation in the first step. That is, the angles emitting rays in the main lobe of source antenna are assigned finer, while the angles in other directions are roughly assigned. For example, a diploe has 60^0 beamwidth in E plane and is omni-directional in H plane. If 3^0 transmitting angle is applied in the main lobe and 10^0 transmitting angle is applied in other directions, there are only 2832 rays sent out from the source initially. In the second step, to ensure the precision, it tries to find the transmitting angles transporting electromagnetic power with strong possibility to reach the receiver and then trace the rays in those angles with high resolution. Some iterative algorithms in ARL method are applied, which include adaptive reception sphere and transmitting angle. The adaptive reception sphere relates to new ray refinement. In the beginning, the radius of reception sphere is set as half of the distance between transmitter and receiver. Such large radius is to guarantee receiving as many rays as possible and avoid leaving out the rays that contribute to the total electromagnetic field at the receivers. However, when the procedure for new ray generation is completed once, the reception sphere radius is reduced by half. This step is repeated until it reaches the threshold. On the other hand, the transmitting angle is split step by step. As described in the first step, the transmitting angles are roughly assigned based on the antenna pattern, and N rays are launched from these transmitting angles. Then these rays are traced one by one and recorded whether they are received or not. After all these rays are traced, the reception sphere radius is reduced by half. Next these rays are traced according to the new reception sphere radius. The rays which are not received in last iteration would be discarded in this iteration. After determing whether the ray reaches the receiver or not in this iteration, two branches appear: one is to generate new rays for refinement and the other is to generate new rays for narrowing the range. If the ray is received in this iteration, and the neighboring ray is also received, one more ray is launched between them for refinement. On the other hand, if the neighboring ray is not received, one more ray is launched between them for narrowing the range of ray generation. Conversely, if the ray is not received in this iteration, and the neighboring ray is received, one more ray is launched between them for narrowing the range. However, if the neighboring ray is also not received, no more rays are launched between them.

A comparison of the computation time required to predict the electromagnetic distribution in large area using the fixed angular separation ray launching method (FASRL) and ARL method is presented. The electromagnetic distribution of the area with 2041.86 m wide and 1164.7m is calculated under the radiation of two transmitters. FASRL takes 3656 seconds for computation while ARL takes 1202 seconds, and more than 300% speedup is achieved.