Investigation of Time Reversal Effects in Random Scattering Media on Super-Resolution by FDTD Monte Carlo Simulations

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This paper presents numerical simulations that analyze the time reversal effects in random scattering media on super-resolution. Results were previously reported on the first and second moments of the time reversed pulse, obtained using second and fourth order moments of stochastic Green's function in random media [Ishimaru, A., S. Jaruwatanadilok, and Y. Kuga (2007). "Time Reversal Effects in Random Scattering Media on Super-Resolution, Shower Curtain Effects and Backscattering Enhancement." *Accepted for Publication Radio Science*]. In free space environment, the transverse spot size resolution depends on the size of the receiving array. However, in multiple scattering environments, time reversal can provide super-resolution as the spot size decreases. This is due to the coherence length, which can be smaller than the free space spot size. Although analytical solutions provide confirmation on the spot size reduction and also explanation of the shower curtain effect and backscattering enhancement, they are still based on several assumptions. These include parabolic approximation and circular complex Gaussian random function. Therefore, validation of analytical results against realistic scattering events is necessary. Two-dimensional Finite Difference Time Domain (FDTD) Monte Carlo simulations are employed for this investigation to simulate wave propagation and scattering in random scattering environments. The scattering environments are created by randomly locating cylindrical rods with different dielectric constants in the background media. Simulations include a point source that emits a Gaussian pulse wave and propagates through the scattering media. Then, each element of the receiving array collects the signal, time reverses it, and then emits the time reversed signal back into the same scattering media. By analyzing the area near the original point source location, specific spot size behaviors can be retrieved. These retrieved behaviors include the location of the spot size, its transverse and lateral resolution as a function of signal bandwidth, and its scattering media parameters, such as the optical depth and anisotropic factor.

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