Imaging and detection of hidden objects behind obscuring random media

Akira Ishimaru, Sermsak Jaruwatanadilok, and Yasuo Kuga
Department of Electrical Engineering, Box 352500,University of Washington,
Seattle, Washington, 98195

Detection of an object behind obscuring layers is one of the important problems today as it is applicable to numerous practical problems such as detection of hidden objects, mine detection, and imaging through scattering biological media. It has been noted that a short pulse which penetrates through obscuring layers may be scattered by the layers and the object. Then, the received signal scattered from the object and from the layers can be separated in time and therefore, detection of the object hidden behind the scattering layer may be possible.

However, this requires the study of the interaction of a short pulse with random media. Theoretically, this requires the study of pulse wave scattering and propagation in random media, and the development of the generalized two-frequency mutual coherence function. In this paper, we investigate this detection and imaging problem. The formulation is based on the use of the forward and backward stochastic Green's functions from a square array of transmitter and receiver elements. The second moments of the received signal include the fourth moments which are reduced to the second moments by the use of the circular complex Gaussian assumption. We make use of a focused aperture or an array of antennas, which emits a short pulse and receives it with focusing. This analysis is a generalization of OCT (optical coherence tomography), SAR, and confocal imaging.

We discuss two imaging techniques. One is the fixed focus imaging which gives the spatial imaging of objects at different times. The other is the variable space-time focusing similar to SAR, OCT and confocal imaging. We clarify the relationship among transverse and longitudinal resolutions, the coherence length, the shower-curtain effects, and the backscattering enhancement. The pulse spread, pulse delay, resolutions, and the effects of aperture size and the bandwidth are discussed, and it is shown that it is possible to distinguish the target scattering from the medium scattering.