Detection of Targets in a Forest Medium Using a DORT Based Method

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We have developed a model of propagation of electromagnetic waves in the forest media in a frequency range of 100 – 300MHz. The trees are modelled by dielectric vertical and tilted parallelepipeds representing the trunks and the branches. Other elements of the trees are not modelled because of their negligible effects on the propagation (F.T. Ulaby, A. Tavakoli, T. Senior, IEEE trans. on Geoscience and Remote Sensing, pp. 714-724, November 1987). The method is based on the volume integral representation of the electric field. It allows the computation of the electric field everywhere in the medium. Comparison between results given by the model and the measurements in anechoic chamber are given in (Y. Ziade, H. Roussel, M. Lesturgie, W. Tabbara, 'A Theoretical Model of Propagation in Forest Compared with Experimental Results', IGARSS05).

In this paper, we use a method based on the decomposition of the time reversal operator (*DORT*) to study the detection and the localisation of hidden targets in the forest medium. The configuration of a classical DORT algorithm is composed of an array of N transmitting/ receiving antennas. Each antenna transmits a wave at a fixed frequency and the scattered field from the medium is measured and registered on each element of the array to obtain the $N \times N$ transfer matrix of the medium, noted K. The time reversal operator (*TRO*) is defined as K^*K, where * means complex conjugate. It was shown (A..J. Devaney, IEEE trans. on Antennas and Propagation, pp. 1600-1610, may 2005) that the TRO can be diagonalized and, in the case of well resolved targets, each of its eigenvectors of nonzero eigenvalue provides the phase law to be applied to the antennas in order to focus on one of the scatterers in the medium. The limitation of this method is the necessity of considering multiple positions of the transmitter and the receiver to form the matrix K, which is not always easy to realize in practice. We propose to reduce the number of positions of the transmitting antenna, the reception remains over N antennas, by transmitting several frequencies and considering the received field on the array for each frequency. We apply this method to measurements made in an anechoic chamber in order to detect and locate a metallic object embedded in a cluttered medium. We show that for horizontal polarisation the effect of the cluttered medium is less important than for vertical polarisation, and the target is better localised.