An Overview of the Role of Adaptive Polarization-Contrast Techniques in Through-Wall Microwave Imaging Applications

K. M. Yemelyanov[(1)], J. A. McVay [(2)], N Engheta[(1)], A. Hoorfar[(2)]
(1) Department of Electrical and Systems Engineering, University of Pennsylvania, Philadelphia, PA, 19104, USA
(2) Department of Electrical and Computer Enginrring, Villanova University, Villanova, PA 19085, USA

Through-the-wall microwave imaging (TWMI) is an important problem with various applications. We have designed a portable TWMI setup (currently being fabricated) which allows gathering information on the scene behind the walls, processing it, identifying and potentially classifying the objects in the scene as well changes in the positions of those objects. Here we provide an overview of some of the techniques exploiting polarization information for processing the electromagnetic field scattered from the scene for possible identification of the changes in the mutual orientations of objects behind the wall.

The algorithms we present here primarily work by processing polarization statistics of the scene. Electromagnetic waves of specific polarization, scattered from objects inside the room as well as from the walls, and collected in the plane of the receiving antenna, contains both co- and cross- polarization components. Our techniques are based on the analysis of changes in polarization statistics in order to compare and contrast those changes with the actual changes in the scene.

We have been developing the two main algorithms for target detection in through-the-wall environment, i.e., Adaptive Polarization-Difference Imaging (APDI) and Transient Adaptive Polarization-Difference Imaging (TAPDI). Some of the preliminary results of this work were recently reported (K. M. Yemelyanov, J. A. McVay, N. Engheta, A. Hoorfar, "Adaptive Polarization-Difference Imaging Algorithms for Through-the-Wall Microwave Imaging Scenarios," *Digest of the 2005 IEEE AP-S Int. Symposium*, pp. 114–117, July 2005, K. M. Yemelyanov, J. A. McVay, N. Engheta, A. Hoorfar, "Transient Adaptive Polarization Contrast Techniques in Time-Domain Scattering with Applications in Through-Wall Microwave Imaging," XXVIII-th General Assembly of URSI, October 2005). Both of these methods came from the optical polarization imaging, where the original bio-inspired PDI algorithm was introduced and developed (J. S. Tyo, M. Rowe, E. N. Pugh, N. Engheta, Applied Optics, Vol. 35, No. 11, pp. 1855-1870, 1996). The utilization of the polarization of light in many situations provided major enhancement in target detection and feature extraction over non-polarization based methods, since the polarization provides an additional important source of information about the scene. The APDI technique was also developed for optical imaging, and then modified for the microwave domain while preserving the main feature, i.e. comparing the polarization statistics of the "background" and "target" scenes. The initial simulations have shown that APDI has been capable of identifying changes in the scene both in the free space and behind walls. The TAPDI technique may be able to detect changes in the scene in real time and may be successful in reducing the effect of scattered wave from walls thus emphasizing the attention to the signal from the objects behind the wall. Both APDI and TAPDI have shown potentials in target detection for TWMI applications.

This work presents an overview of polarization-based technique for TWMI applications currently developed in our research group.