Challenge on Dielectric and Metallic Targets Recognition for Radio Frequency Tomography

Tadahiro Negishi*, Vittorio Picco, and Danilo Erricolo
University of Illinois at Chicago,
Department of Electrical and Computer Engineering
851 South Morgan Street, Chicago, IL 60607, USA

In this work, we discuss image reconstruction of metallic and dielectric targets for Radio Frequency (RF) Tomography. RF Tomography for detection of underground targets based on the first order Born approximation is described by L. Lo Monte (L. Lo Monte *et al.*, "Radio Frequency Tomography for Tunnel Detection," *IEEE Trans. Geoscience and Remote Sensing*, Vol. 48, No. 3, Mar. 2010, pp. 1128-1137) and it has been experimentally validated at the University of Illinois at Chicago (S. Nishikata *et al.*, "Imaging of dielectric targets using RF Tomography" *IEEE International Symposium on Antennas and Propagation and USNC-URSI National Radio Science Meeting*, Chicago, IL, July 2012).

RF Tomography is based on MIMO diffraction tomography using extremely narrowband probing signals. RF Tomography involves three main steps: collecting forward transmission scattering data as a way to measure the scattered electric field, creating a matrix representation of the forward model, and finally use an inversion algorithm to find the distribution of the complex dielectric permittivity contrast with respect to the background dielectric permittivity. The inversion of the matrix is a typical regularization problem. In previous work, we have shown that the Algebraic Reconstruction Technique (ART) with constraints has an advantage when reconstructing thin dielectric materials (T. Negishi *et al.*, "The use of the Algebraic Reconstruction Technique (ART) for imaging of dielectric targets in Radio Frequency Tomography," *IEEE International Conference on Wireless Information Technology and Systems*, Maui, Hawaii, Nov. 2012). Also, the modified ART can adequately reconstruct the actual complex dielectric permittivity contrast in terms of being able to differentiate between its real and imaginary components.

In this work, we approach the problem of recognizing metallic and dielectric targets that are present simultaneously in the volume of interest. Since the resulting image vector is complex, we can distinguish between metallic and dielectric targets. In this test, the use of different polarizations significantly helps to reconstruct the image because reflection on a dielectric boundary is different for TE and TM cases while reflection on a metallic boundary is the same for the two polarizations. Therefore, the resulting images for both polarizations tend to be the same for metallic targets and different for dielectric targets.

We present results obtained from both simulations and measurements to support our claims. Although reconstruction is successful, imaging of metallic targets represents a violation of the Born approximation, which assumes weak scatterers only. In future work, we plan to address this issue.