Buried objects and void detection using RF Tomography

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Radio Frequency Tomography (see 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) has been proposed as an attractive ground penetrating radar (GPR) application. RF Tomography uses MIMO sensors to detect targets for relatively wide regions, without requiring human presence on the field, by spreading inexpensive sensors. RF Tomography employs narrowband electrically small antennas and sufficiently low frequency to look into deeply buried objects. Also, RF Tomography is not limited by diffraction limit. However, in order to implement RF tomography in real scenarios, a Green's function must account for irregular terrain and eliminate direct path and reflections from the interface with non-uniform background objects. Our previous simulated results showed the detection of a cubic PEC object inside a duct background. Additionally, our experimental results demonstrated the detection of copper cylinders buried in box filled with sand (T. Negishi et al., "Numerical Green's Function for Radio Frequency Tomography with Complex Geometry," URSI Commission B International Symposium on Electromagnetic Theory, Hiroshima, Japan, May 2013), and the technique is well tested by simulation.

In this work, we show experimental results with several background objects such as sand, gravel, wood etc. The difficulty involves the measurement of weakly scattered signals from void in the presence of scattering at the interface of non-uniformly shaped background objects. We operate background subtraction and numerically compute the Green's function to detect relatively small signal from weak scatterers. Also, a good compromise between the scattered field and clutter noise can be achieved by computing suitable solutions with methods such as Conjugate gradient, Algebraic reconstruction technique and Total variation with constrains to guarantee better contrast (V. Picco et al., "RF Tomography in Free Space: Experimental Validation of the Forward Model and of an Inversion Algorithm based on the Algebraic Reconstruction Technique", International Journal of Antennas and Propagation, 2013).