Radio Frequency Tomography for a Reinforced Concrete Cylinder by Genetic Algorithm

Yangqing Liu, Tadahiro Negishi, and Danilo Erricolo*
University of Illinois at Chicago, Chicago, IL 60607

In the past, reinforced concrete structures have been imaged by directly solving the non-linear systems of equations relating the measured fields to the unknown dielectric parameters based on exact models and regularizations (T. Negishi, V. Picco, L. L. Monte and D. Erricolo, "Dyadic contrast function for the forward model of diffraction tomography of thin cylindrical objects," *IEEE Antennas Wireless Propag. Lett.*, 16, 991-994, 2017). Instead, we propose the quantitative inverse scattering problem as an optimization problem and then utilize stochastic methods to avoid local minimum as an alternative to deterministic ones. This method was previously reported for imaging a multilayer circular cylinder (S. Caorsi and M. Pastorino, "Two-dimensional microwave imaging approach based on a genetic algorithm," *IEEE Trans. Antennas Propag.*, 48, 370-373, 2000).

In this work, we perform the two-dimensional imaging of a circular cylinder with perfect electric conductor pillars and void columns using a tomographic configuration. The TM mode incident wave formulates the electric field integral equation with known Green's function, and the field scattered by the concrete is computed by the Method of Moment with software FEKO. With known body shape, we reconstruct the distribution of dielectric parameters within the cylinder by genetic algorithms (GA), where the unknown dielectric parameters are formulated in the form of a gene of the chromosomes. To apply GA, we define the cost function of this optimization problem as a discretized summation of minimization of residuals over spatial pixels, and multi-static/multi-frequency illuminations. During the iterative minimization process, various genetic operators act on a set of of solutions to the dielectric distribution until the convergence check of the cost function is cleared. Numerical results of the dielectric distribution within the concrete will be presented.