Quadratic Forward Model for RF Tomography: Preliminary Results

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We propose a novel forward model for Radio Frequency (RF) Tomography.

RF Tomography is formulated around a scattered electric field integral equation, which represents its forward model. Such equation is inherently non-linear, because the unknown scattered electric field can be calculated only from the knowledge of the total field, which includes the unknown scattered field as well. To overcome this problem, the Born approximation is usually employed. The approximation allows to linearize the forward model, by assuming that the scattering field is very small compared to the total field: hence, the total field can be approximated with the incident field, and a linear model is obtained. This is equivalent to considering the Neumann series expansion of the forward model and dropping all but the first term of it.

This approach shows important limitations, such as the assumption that the difference between the dielectric permittivity of the target and the one of the medium where the target is located be small. Even in this scenario, the removal of non-linear effects has detrimental consequences on the quality of the reconstructed image. It can be shown that the Born approximation operates as a spatial low-pass filter on the forward model integral operator. This translates into an overall loss of resolution and sharpness in the target reconstruction.

We propose to overcome these limitations by introducing a forward model based on a quadratic operator. The approach is equivalent to keeping an additional term in the Neumann series expansion of the non-linear integral operator. The advantage of this method is to create a much better model of the forward problem, which translates in turn into a superior image reconstruction. The cost of this approach is mainly computational, since it requires the calculation of both a linear operator (equivalent to the one obtained with the Born approximation) and a quadratic one.