Analysis and Design of Large-format THz Imaging Systems Using Conjugate Field Coupling

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The analysis and design of millimeter wave (mmW) and terahertz (THz) imaging systems require rigorous numerical analysis that accounts for the complex propagation and scattering phenomena. Because of the short wavelengths at these high frequencies, numerical models are electrically very large and become the bottleneck in the design process of an imaging system. For instance, simulating a human phantom at 60 GHz for security imaging systems requires at least a few million elements for a single full wave simulation. Even worse, large-format imaging systems generate multi-pixel images (>1000). For a full-wave simulation, the electrically large numerical problem has to be solved accordingly as many times as the pixels in the acquired image. As a result, such simulations require extremely long time and the rigorous analysis of large-format imaging systems becomes impractical. Alternatively, imaging systems can be simulated using less resource demanding semi-analytical techniques (e.g. Physical Optics), however, in order to reveal all the characteristics of an imaging system, full wave simulations are preferred.

In this study, we propose a numerical algorithm to overcome the aforementioned computational obstacles for large scale imaging problems. Namely, we separate the numerical model into two domains which are simulated individually and then combined appropriately in order to obtain the final reconstructed image. As such, the model is separated into the target and the imaging sensor (e.g. a 2D phased array). Initially, the target is simulated individually, illuminated by an incident wave (e.g. plane wave) and the scattered fields are recorded at the interface between the target and the imaging sensor. Similarly, the radiated fields of the imaging sensor (e.g. antenna array) are computed on the interface. Afterwards, the conjugate field coupling coefficient of the two field distributions is calculated corresponding to the sensor's received signal for a certain incident angle. In order to synthesize the image, the response for all the angles/pixels is calculated. Using the proposed approach, significantly less computational effort is required, since the electrically large target is simulated once.

The proposed algorithm can be exploited to study systems that realize various imaging techniques such as raster scanning, 2D array beam scanning, focal plane array beam scanning, compressive sensing imaging, etc. During the conference the theoretical background of the technique along with the simulated setup for various targets will be presented.