Using Computerized Tomography's Algorithms for Real Time THz Imaging Systems

P.C. Theofanopoulos and G. C. Trichopoulos
School of Electrical, Computer, and Energy Engineering
Arizona State University, Tempe, AZ 85287, USA

Terahertz (THz) waves (0.1-10 THz) have been attractive for several imaging applications due to the small wavelength that allows high spatial resolution as well as the ability to penetrate non-metallic materials. The demand for fast multi pixel imaging systems in security and astronomical applications has led to the development of several THz imaging systems and techniques. Typically, THz imaging systems employ synthetic aperture or raster-scanning techniques to reconstruct images. Specifically, JPL (Jet Propulsion Laboratory, NASA) recently implemented a radar imaging system able to scan 40×40 cm targets at 25±1 meters using a raster-scanning technique (K. Cooper et al., "THz Imaging Radar for Standoff Personnel Screening," in IEEE Transactions on Terahertz Science and Technology, vol. 1, no. 1, pp. 169-182, Sept. 2011). Even though this technique is well established, the reconstruction procedure is fairly slow and the setup is bulky due to the reflectors used to achieve the desired pencil beam.

In this study we propose a novel imaging technique for THz radar systems based on the image reconstruction algorithm used in computerized tomography (CT). In CT, imaging systems record the attenuation of parallel rays (typically X-rays) that propagate through the body of the object. Ray attenuation depends on the material properties of the path and corresponds to the Radon transform of the specific projection angle. After acquiring all the projections of the object, the cross sectional image is reconstructed using the inverse Radon transform. In our proposed system, a monostatic radar produces a fan beam that illuminates only a linear portion of the object's surface. The controlled fan beam is scanned across the object area recording the reflected signal at multiple elevation angles. This corresponds to a single projection of the Radon transform, similar to CT. Afterwards, the fan beam is rotated azimuthally ($0\text{-}180^0$) repeating the parallel beam scanning in multiple azimuth angles. These rotated sets of scans form the Radon projections of the illuminated surface area. Finally, the object's image is reconstructed using the inverse Radon transform of the collected data.

The system, in its simplest form, consists of a rotating linear phased array or a leaky wave antenna that produces a narrow beamwidth fan beam. During the conference the theoretical background of the technique along with the simulated setup for various targets will be presented. Moreover, alternative approaches on the rotating array will be discussed.