Limited Angle THz Computed Tomography for Tissue Imaging

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Due to the low penetration depth of THz waves, research in biomedical THz imaging has been primarily focused on the reflection-mode spectroscopy for the diagnosis of various types of cancer (breast, skin, cervical and colon) as well as the classification of skin burns. However, alternative techniques have been around for many decades. For instance, X-rays provide an inexpensive and high-resolution imaging methodology with excellent tissue penetration. Also, MRI screening offers non-ionizing, high-resolution tomography, and microscopic imaging (biopsy) is a benchmark when it comes to diagnosis reliability. Nevertheless, one of the biggest problems in medical imaging is to combine the microscopic and macroscopic imaging to define cancerous tissue margins more reliably. THz imaging cannot match microscopy in image resolution; however, it can provide unique macroscopic information such as tissue permittivity and absorption. Perhaps more importantly, unlike X-rays, THz waves are non-ionizing and thus considered safe for extended exposure times.

To date, THz imaging has been mostly applied to acquire 2D images of the samples. On the other hand, computed tomography - or 3D imaging - offers much more, including anatomical information by providing measurements through the depth of the examined tissue volume. Recently, we implemented a THz computed tomography system that utilizes a real-time THz camera capable of generating THz-CT images within minutes (G. C. Trichopoulos and K. Sertel, "Large format focal plane array for rapid THz computed tomography" *2013 IEEE Int. Symp. on Antennas and Prop*.).

For a full 3D CT reconstruction, an 180^{o} scan of the sample is necessary. However, for biomedical imaging the excised tissue is placed into thin glass or quartz fixtures that inevitably limit the viewing angle. This effect, which is also known in electron microscopy tomography as the "missing wedge", results in compromised image quality. In this paper, we investigate the utility of limited-angle THz-CT for 3D imaging of biological samples. Using measurements limited to 60^{o} degrees (from normal), an image resolution close to 1.2mm is achievable at 700 GHz. Simulations have indicated that by rotating the object on the vertical axis we can provide more information on the reconstruction process and thus, minimize distortion. We will present phantom measurements that demonstrate the advantages of dual-axis scans for THz-CT reconstruction.