TOWARD PRACTICAL TERAHERTZ TIME-DOMAIN SPECTROSCOPY

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ABSTRACT

Terahertz time-domain spectroscopy is a promising technology for the identification of explosive and pharmaceutical substances in adverse conditions. It interacts strongly with intermolecular vibrational and rotational modes. Terahertz also passes through many common dielectric covering materials, allowing for the identification of substances in envelopes, wrapped in opaque plastic, or otherwise hidden. However, there are several challenges preventing the adoption of terahertz spectroscopy outside the laboratory. This dissertation examines the problems preventing widespread adoption of terahertz technology and attempts to resolve them.

In order to use terahertz spectroscopy to identify substances, a spectrum measured of the target sample must be compared to the spectra of various known standard samples. This dissertation examines various methods that can be employed throughout the entire process of acquiring and transforming terahertz waveforms to improve the accuracy of these comparisons. The concepts developed in this dissertation directly apply to terahertz spectroscopy, but also carry implications for other spectroscopy methods, from Raman to mass spectrometry. For example, these techniques could help to lower the rate of false positives at airport security checkpoints.

This dissertation also examines the implementation of several of these methods as a way to realize a fully self-contained, handheld, battery-operated terahertz spectrometer. This device also employs techniques to allow minimally-trained operators use terahertz to detect different substances of interest. It functions as a proof-of-concept of the true benefits of the improvements that have been developed in this dissertation.