Abstract

Terahertz (THz) radiation is abundant in the natural world yet very hard to harness in the laboratory. Forming the boundary between 'radio' and 'light', the so called "terahertz gap" results from the failure of optical techniques to operate below a few hundred terahertz, and likewise the failure of electronic methods to operate above a few hundred gigahertz. However, recent advances in opto-electronic and semiconductor technology have enabled bright THz radiation to be coherently generated and detected, and THz imaging systems are now commercially available, if still very expensive. Terahertz pulsed imaging data are unusual in that an entire time series is 'behind' every pixel of the image. While resulting in rich data sets, this high dimensionality necessitates some form of distillation or extraction of pertinent features before images can be formed.

Within this thesis the technology of THz pulsed imaging is examined, together with the imaging modalities that are employed and the type of data that are acquired. The sources of noise are categorised, and it is demonstrated that this noise can be modelled by the family of stable distributions, but that it is neither normally distributed nor distributed according to a simple mixture of Gaussians. Joint time-frequency techniques such as those used in RADAR or ultrasound – windowed Fourier transforms and wavelet transforms – are applied to THz data, and are shown to be appropriate tools to use when analysing and processing THz pulses, particularly in signal compression. Finally, clustering algorithms in time, frequency, and time-frequency based feature spaces demonstrate that such tools have potential application in the segmentation of THz images into their constituent regions.

The analyses herein improve our understanding of the nature of THz data, and the techniques developed are steps along the road to move THz imaging into real world applications, such as dental and medical imaging and diagnosis.