Machine Learning for Polarimetric THz Image Classification for Biomedical Diagnosis

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Spectroscopic Terahertz (THz) imaging has demonstrated utility in several biomedical applications, including identification of tissue malignancies (M.-A. Brun, F. Formanek, A. Yasuda, M. Sekine, N. Ando, and Y. Eishii, "Terahertz imaging applied to cancer diagnosis," *Phys. Med. Biol.*, vol. 55, pp. 4615–4623, 2010), detection of axon demyelination in human brain due to Alzheimer's (W.-G. Yeo, O. Gurel, N. Srinivasan, P.D. King, N.K. Nahar, S. Park, N.L. Lehman, and K. Sertel, "Terahertz Imaging and Electromagnetic Model of Axon Demyelination in Alzheimer's Disease", *IEEE Transactions on Terahertz Science and Technology*, Volume: 7, Issue: 6, pp. 711 – 721, August 2017), and skin burn healing (M. H. Arbab, D. P.Winebrenner, T. C. Dickey, A. Chen, M. B. Klein, and P. D. Mourad, "Terahertz spectroscopy for the assessment of burn injuries in vivo," *J. Biomed. Opt.*, vol. 18, no. 7, 2013, No. 077044), to name a few. Although the state of the art THz instrumentation is effective in capturing the reflection and/or transmission spectral of biomedical samples, the assessment of these images in a diagnostic setting almost always requires concurrent microscopic assessment of sectioned and stained samples of the same tissue conducted by a trained pathologist.

In an effort to break out of this conundrum and demonstrate potential of THz imaging for diagnostic utility, here we propose machine learning as a tool to automatically classify biomedical images and determine the regions of interest. In particular, we present a vector-network-analyzer-based, fully-polarimetric THz imaging setup with 3.4× improved resolution, operating at 1THz to capture images of formalin-fixed, paraffin-embedded human brain tissue samples to identify regions most impacted by the demyelination of the axons. Due to the elongated morphology of the axon bundles, the 4-fold polarimetric reflection image data provides additional information to effectively classify such tissues.