Optical Coherence Tomography:
Mitigation of Scattering Using DSP Techniques

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Optical Coherence Tomography (OCT) is a non-invasive method of producing 2-Dimensional images of biological tissues. The practice came into prominence in 1991 from the developments of Huang et al. Since its introduction advancements in laser diode technology and imagery has allowed for micrometer resolution and is widely used in the Ophthalmology.[1] Although OCT produces great resolution there are drawbacks. OCT is notorious for producing a phenomenon called speckle noise. This review will utilize previous work done using imagery filters to reduce speckle noise and as well create our own simulations to confer.

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A. Introduction

Optical Coherence Tomography (OCT) is a non-invasive method of producing 2-Dimensional images of internal tissues in a method comparable to that of ultrasound imaging.[2][4] The practice came into prominence following the developments of Huang et al. at the Massachusetts Institute of Technology in 1991. [2]

FIG. 1. On the left is an image put through a speckle filter in Matlab. On the right is the original image.

I. OCT IDENTIFIED PROBLEM AND SUGGESTED SOLUTION

A. The Problem of Speckle Noise

A problem with using an OCT interferometer is that speckle noise exists, which ultimately reduces the quality of the image. Speckle is a phenomenon that is caused by interference of the reflected wave at the photo-detector. Speckle noise is evident when trying to image non-fluid structures (such as hard tissue). As the wave propagates it becomes distorted due to low-angle multiple forward scattering and diffuse multiple backscattering of coherent photons. [3]

In OCT interferometry imaging, photons are detected after one backscattering event for most relevant information, but when a wave is propagated through a dense biological sample it experiences numerous scattering events (in OCT interferometry). These scattering events increase the likelihood for photons to change their travel distance comparative to their airborne path which results in speckle noise reducing the image quality. [3]

B. Possible Solutions for Speckle Noise

As technology progress in imaging processing, techniques are being developed to help reduces the effects of speckle noise when using OCT. Some of these methods include decreasing spatial and temporal coherence of the laser used. While more trivial techniques such as phase-domain processing and zero-adjustments are used to improve image quality due to speckle noise. [3]

C. Scope of DSP Methods Used

This report will focus on image filtering methods which can be applied using Matlab. (Talk more about types of methods used.)

II. OBTAINING 2D OCT IMAGES

While many published reports contain printed images of OCT captures, getting raw data was necessary to make realistic observations on the effects of using digital filtering. 3D OCT captures of healthy individuals were obtained from a publised proceeding comparing OCT scans of healthy individuals [6]. The scans were provided in .mat file format. The size of each volume provided by these scans was 650 x 512 x 128 voxels. Each voxel had a resolution of 11.72 x 46.88 x 3.54 μm. We were able to extract 2D images from the provided .mat files using a script published on MathWorks file exchange called "3D Volume Visualization" [5].

III. CONCLUSION

[1] Bhende, M., Shetty, S., Parthasarathy, M. K., and Ramya, S. (2018). Optical coherence tomography: A guide to interpretation of common macular diseases. *Indian Journal of Ophthalmology*, 66(1):20–35.

[2] Huang, D., Swanson, E. A., Lin, C. P., Schuman, J. S., Stinson, W. G., Chang, W., Hee, M. R., Flotte, T., Gregory, K., Puliafito, C. A., and Et, A. (1991). Optical coherence tomography. *Science*, 254(5035):1178–1181.

[3] Popescu, D. P., Hewko, M. D., and Sowa, M. G. (2006). Speckle noise attenuation in optical coherence tomography by compounding images acquired at different positions of the sample. *Optics Communications*, 269.

[4] Sander, B. and Li, X. Q. (2011). Optical Coherence Tomography: A review of current technology and its implications for clinical applications. *Scandinavian Journal of Optometry and Visual Science*, 4(2):1–4.

[5] Stough, J. 3d Volume Visualization - File Exchange - MATLAB Central.

[6] Tahereh Mahmudi, Rahele Kafieh, Hossein Rabbani, Alireza Mehri dehnavi, and Mohammadreza Akhlagi (2014). Comparison of macular OCTs in right and left eyes of normal people. volume 9038, pages 90381W–9038–6.