Chapter 13
Despeckling Algorithms for Optical Coherence Tomography Images: A Review

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ABSTRACT

Optical coherence tomography (OCT) is a non-invasive imaging technique widely used in ophthalmology. The presence of speckle affects the quality of OCT images. Despeckling is necessary to improve its visual quality, and it is an integral part of software packages used for the computerized analysis of OCT. Even though a few methods for despeckling OCT are available in the literature, a cross-comparison of their performance is not known to be available. In this chapter, the techniques available in the literature for despeckling the OCT images have been identified. The results of the despeckling algorithms are compared both qualitatively and quantitatively by concerning the noise suppression capability and feature preservation. Among the available techniques, iterative adaptive unbiased (IAUB) filter is found to be superior as far as its performance regarding despeckling on retinal OCT images.

DOI: 10.4018/978-1-5225-7796-6.ch013

INTRODUCTION

Second, to the brain, the eyes are the most complex organ in human body (Gregory, 2015). The eye consists of complex mechanisms and pathways and with the help of several structures like the cornea, retina, iris, pupils, optic nerves and the ciliary muscles. All these parts work together to help the eye function properly and make our vision perfect.

The retina is a thin layered tissue (Gupta et al., 2016). It is situated near to the optic nerve. Retina collects the light focused by the lens and converts the luminance into nerve impulse. Nerve impulses are transmitted through the optic nerve to the visual cortex to establish the vision. The retina contains a layer of photoreceptor cells on its surface. These cells are light-sensitive cells, capable of detecting physical quantities such as color and luminous intensity. The retina processes the information gathered by the photoreceptor cells and sends this information to the visual cortex of the brain through the optic nerve. Due to the retina's critical role in vision, its degradation may cause permanent blindness.

The normal retina comprises retinal pigment epithelium and neuroretina. The neuroretina includes inner and outer segments of photoreceptors (rods and cones), outer nuclear layer, nerve fiber layer, inner nuclear layer, outer plexiform layer, external limiting membrane, ganglion cell layer, inner plexiform layer, and internal limiting membrane. Commonly found retinal pathologies include degenerations (notably age-related macular degeneration), neoplasms, toxicities, inflammatory diseases, congenital abnormalities, retinal detachment, retinal vascular diseases, dystrophies, retinal involvement of systemic diseases and trauma. The thickness of the retina measured from OCT is helpful to characterize many diseases. The retinal layer thickness can be used as a potential biomarker to understand the progression of the diseases and the underlying pathologies (Gupta et al., 2016).

OCT is a non-invasive imaging technology (Drexler et al., 2001), widely used in ophthalmology (Aum et al., 2015; Chiu et al., 2010; Fabritius et al., 2009) for the diagnosis of chronic diseases like macular degeneration (Guillonneau et al., 2017), glaucoma (Khaing & Aimmanee, 2017), cataract (Zhang et al., 2017) and retinal detachment (Wu et al., 2017). As per the report of World Health Organization (WHO) (Blindness and visual impairment, 2018, retrieved from http://www.who.int/news-room/fact-sheets/detail/blindness-and-visual-impairment) 84% of the visual impairments results from the diseases mentioned earlier (Delcourt et al., 2010; Isar; Yorston, 2003; Shah, 2009). Mainly, OCT is helpful to quantify the

Figure 1. (a) Zeiss Cirrus HD OCT machine, (b) The crossectional visualization of the human eye using OCT

(a) (b)