Using TD-OCT and Gelatin-based Skin Phantom as a Training Tool for Venipuncture

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Abstract

Optical coherence tomography (OCT) is an imaging modality developed in the early 1990's for retinal imaging. Further modifications allowed OCT's to be used on other parts of the human body, and later on, beyond medicine. In this paper, the researchers will use the TD-OCT system developed by Dr. Shiina which uses a rotating reference mirror. The core of OCT is a Michelson interferometer wherein a low-coherence beam of light is split into a sample arm and a reference arm. Ultimately, this enables the viewing of a cross-sectional image of the sample without the need to cut the sample open.

Using this system in conjunction with a skin phantom to be fabricated in the laboratory, students of venipuncture can practice first on the tissue phantom before moving to actual persons. The skin phantom to be fabricated will be mainly composed of gelatin, thus allowing multiple phantoms to be fabricated at a minimal cost.

Introduction

Optical coherence tomography (OCT) is an imaging modality developed in the early 1990's. The first OCT images were that of the human retina (Huang et al., 1991). The group of Welzel (1997) published in vivo images of the human skin. Colston et al published the first in vivo application of OCT in dental tissue (Colston et al., 1998). Later on, OCT found applications in various fields such as industry (Mauritz, et al., 2010) and agriculture (Meglinski et al., 2010).

OCT is fundamentally based on the technique called low-coherence interferometry (LCI), wherein a broadband light source is used with a Michelson interferometer. The beam of light is split into a sample arm and a reference arm. Reflected light from both arms are combined on the detector to produce interference. This interference pattern is processed to produce an A-scan which contains depth information about the sample at one point. When several A-scans obtained from points along a line of a sample are combined, two-dimensional, cross-sectional image of the sample can be obtained. The first OCT system was time-domain OCT (TD-OCT) which uses a movable reference mirror to provide a periodically varying optical path length.

A newer mechanism has been developed by Shiina et al which utilizes a rotating reference mirror. (Shiina, Moritani, Ito, & Okamura, 2003). The said system is the one to be used in this research.

Venipuncture is the method of accessing superficial veins by puncturing the skin in order to extract blood or introduce fluids into the body. While venipuncture is a mainstay procedure in medical diagnosis and treatment, it can be a painful procedure and might be a cause of hematoma and worse, infection. Hence performance of venipuncture requires training. Beginning students usually perform venipuncture on fellow students. By utilizing a skin phantom in conjunction with TD-OCT, students can first gain experience on venipuncture before moving to actual persons.

Methodology

Food-grade gelatin was used in the experiment. Different concentrations of titanium dioxide was used in order to mimic the extinction coefficient of the epidermis. Extinction coefficient will be determined using the OCT device in the lab (Adili, Shiina, 2018).

The light source is a 1310nm SLD with 53nm spectral halfwidth.

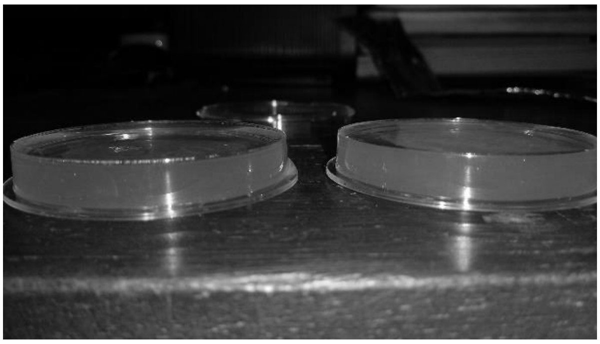

Figure 1. Skin phantom preparation

In the latter phase of the experiment, once the correct gelatin-to-titanium dioxide ratio is achieved, the mixture shall be poured on a tray containing latex tubing. This tubing shall simulate the veins to be punctured.

Results:

Figure 1 is an A-scan showing voltage (mV) versus time (µs) of a 3g gelatin sample without titanium dioxide added. The duration of the voltage spike is 20.64 µs. Figure 2 is an A-scan of 3g gelatin with 0.02g titanium dioxide with a voltage spike duration about 19.66 µs.

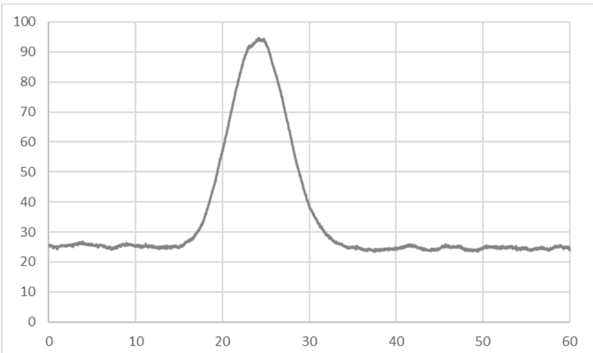

Figure 2. A-scan of mixture containing 3g gelatin and 0g titanium dioxide

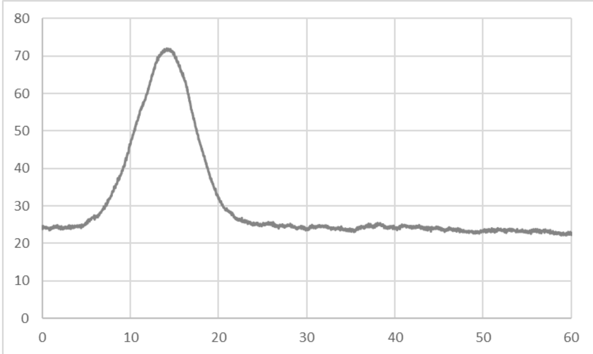

Figure 3. A-scan of mixture containing 3g gelatin and 0.02g titanium dioxide

Based on the A-scans, it appears that only the surface structure of samples can be obtained by the OCT system. This problem might be caused by misalignment of the optics or insufficient power of the light source. As of the moment the device is still being fixed.

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