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"OPTICAL COHERENCE TOMOGRAPHY"

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ABSTRACT

Optical Coherence Tomography (OCT) is a novel, non-invasive, micrometer-scalesolution tomography, which use coherent light to obtain cross-sectional images of specific samples, such as biological tissue. Spectral Domain Optical Coherence Tomography (SD-OCT) is the second generation of Optical Coherence Tomography. In comparison to the first-generation Time Domain Optical Coherence Tomography, SD-OCT is superior in terms of its capturing speed, signal to noise ratio, and sensitivity. The SD-OCT has been widely used in both clinical and research imaging. The primary goal of this research is to design and construct a Spectral Domain Optical Coherence Tomography system which consists of a fiber-based imaging system and a line scan CCD-based high-speed spectrometer, and is capable of imaging and analyzing biological tissue at a wavelength of 1040 nm. Additionally, a NI LabVIEW software for controlling, acquiring and signal processing is developed and implemented. An axial resolution of 16.9 micrometer is achieved, and 2-D greyscale images of various samples have been obtained from our SD-OCT system. The device was initially calibrated using a glass coverslip, and then tested on multiple biological samples, including the distal end of a human fingernail, onion peels, and pancreatic tissues. In each of these images, both tissue and cell structures were observed at depths of up to 0.6 millimeter. The A-scan processing time is 8.445 millisecond. Our SD-OCT system demonstrates tremendous potential in becoming a vital imaging tool for clinicians and researchers.

1. INTRODUCTION

Tomography technology has been developed rapidly over the last 50 years. Among most tomography inventions, Computed Tomography (CT) and Magnetic Resonance Imaging (MRI) have already been applied in radiology and medical diagnosis to investigate anatomy and physiology. Optical Coherence Tomography (OCT) is a relatively new technology which demonstrates better axial resolution (in comparison to other existing tomography technologies). Because of its micrometer resolution and millimeter penetration depth, OCT technology has been applied in biomedical imaging to produce high-resolution cross-sectional images. There are three main types of OCT systems that have been introduced including the Time-Domain OCT (TD-OCT), the Spectrum- Domain OCT (SD OCT) and the SweptSource OCT (SSOCT). The SD-OCT and SSOCT are newer technologies as they use Fourier transform calculations in their analysis and operate at a faster rate than TDOCT.

TD-OCT is characterized by mechanical scanning over the sample, which results in the scan rate being limited to approximately 1 kHz. In addition, due to the limitation of coherence optical path difference (OPD), the signal to noise ratio (SNR) is not comparable to that of the SD-OCT system. SS- OCT has multiple advantages such as reduced noise, better SNR and heterodyne detection ability. these records. In present situation license plate recognition (LPR) scheme plays a vital in the field of vehicle parking system, electronic toll collection, security purpose, speed of the car etc. For the identification of the vehicle individually we can use an RFID tag and IoT based application. But this reader has certain disadvantages such as, operates with in minimum distance, implementation is difficult & time consuming, less reliable, scanning issues etc. Parking is an important component within any transportation system, whereby vehicles must be parked at every destination.

2. TECHNOLOGY

a) Development of current OCT:

Image processing is the process of transforming an image into a digital form and performing certain operations to get some useful information from it. The image processing system usually treats all images as 2D signals when applying certain predetermined signal processing methods.

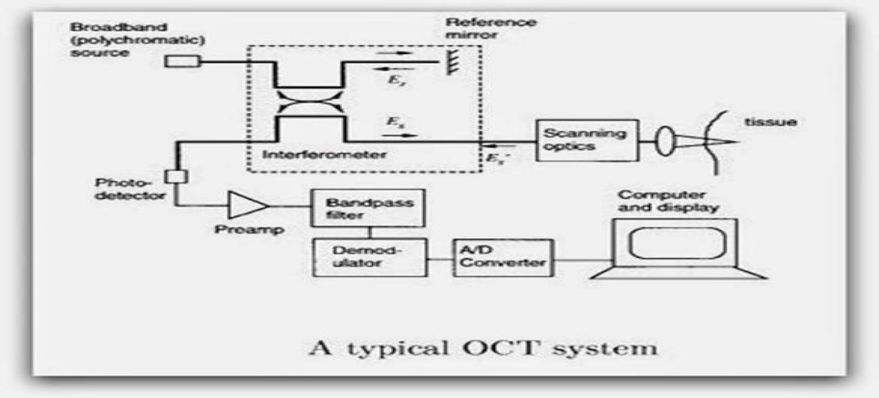

Fig 2.1: Typical OCT system

Fig 2.1 shows the typical OCT system. The main phases of Image processing are: Image acquisition, Image enhancement, mage restoration, Morphology, segmentation, object recognition and representation.

- **Optical character recognition:**

OCR is the electronic or mechanical conversion of images of typed, handwritten or printed text into machine-encoded text, whether from a scanned document, a photo of a document, a scene-photo or from subtitle text superimposed on an image. Widely used as a form of data entry from printed paper data records. OCR software converts the document into a two-color, or black and white, version. The scanned- in image or bitmap is analyzed for light and dark areas, where the dark areas are identified as characters that need to be recognized and light areas are identified as background. The dark areas are then processed further to find alphabetic letters or numeric digits. OCR programs can vary in their techniques, but typically involve targeting one character, word or block of text at a time.

3. METHODOLGY

There are two main OCT methods, time domain (TD)- OCT and spectral domain (SD)-OCT (Drexler & Fujimoto, 2008).SD-OCT is attractive because it eliminates the need for depth scanning, which in TD-OCT is performed usually by mechanical means. SD methods can be implemented in two formats: (i) spectrometer based (SB) or (ii) by using a tunable laser or a swept source (SS).

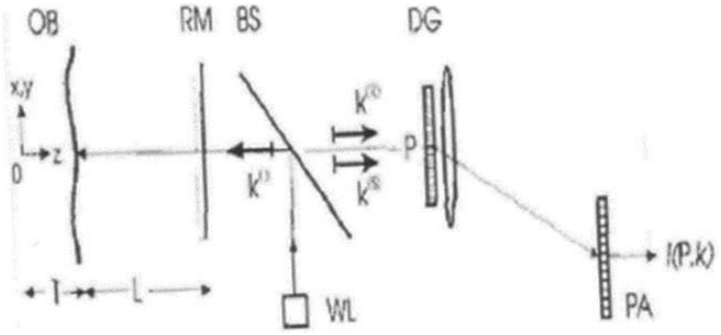

Fig 3.1: Schematic diagram
Fig 3.1 shows the schematic diagram of Optical Coherence Tomography

The technological advances made in the last two decades in regard to interference technologies, optical instrumentation, detectors, speed of data acquisition and processing as well as light sources have facilitated the application of OCT technology in a variety of medical fields such as developmental biology, ophthalmology, interventional cardiology, dentistry, gastrointestinal endoscopy, dermatology, laryngology, gynecology, etc. This past decade has seen OCT evolving from an optical imaging method used mostly in research laboratories into a valuable tool used in various areas of medicine and health sciences.

4. WORKING PRINCIPLE

OCT can image with axial resolutions of 1 to 15 µm, one to two orders of magnitude higher than conventional ultrasound. This resolution approaches that of histopathology, allowing architectural morphology and some cellular features to be resolved.

- **Image of human artery:**

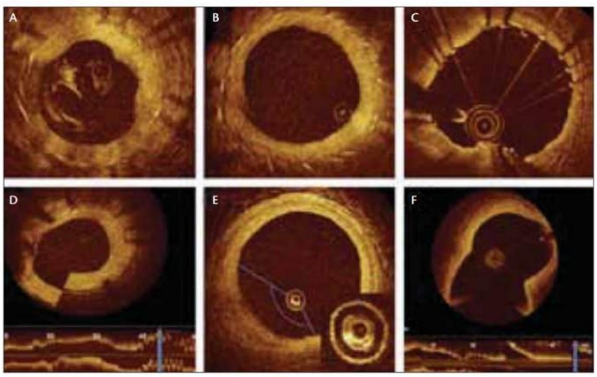

Fig 4.1: Artery Image

Fig 4.1 shows the Image of artery in human eye. The method for choroidal thickness analysis involves manual measurements perpendicularly from the outer edge of the hyperreflective RPE to the inner sclera (choroid–sclera junction) using the respective software within the system.

- **Image of human cornea:**

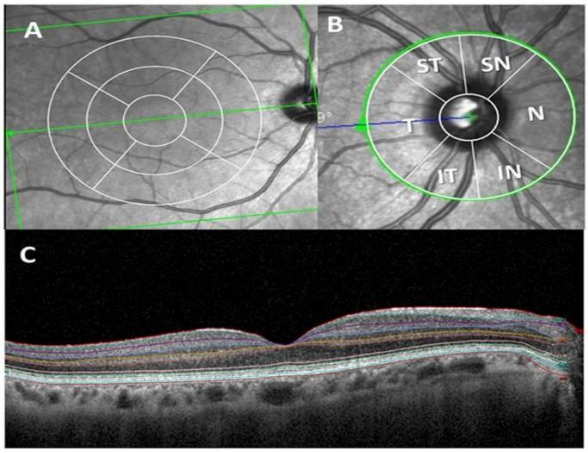

Fig 4.2: Image of human cornea
Fig 4.2 shows the processed gray scale image of captured image. The second image shows

the typical image of the cornea of a human eye to identify any deformation occurred during the formation and the growth of the cornea. The third picture represents the cross-section view of the tissues in the cornea.

- **Image of human nail:**

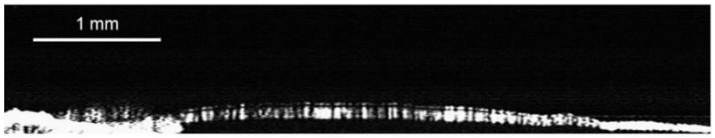

Fig 4.3: Image of human nail

Fig 4.3 shows the image of human nail. The preprocessed image is applied to the edge operator in order to extract the license plate region from them background. Generally, the license plate is in rectangular shape, this region of interest is obtained by comparing with the different dimensionality of the edge. Contour detection method is followed, which extracts all the closed shapes or boundaries from the image.

5. ADVANTAGES

- Broad dynamic range,

- High resolution
- Rapid data acquisition rate,
- Small inexpensive catheter/endoscope design
- Compact portable structure
- (Fiber optically based, making possible the development of small catheters and endoscopes)
- The frame rate for OCT systems are four to eight frames per second. (Assume an image size of 256 by 512 pixels.)

6. APPLICATIONS

- OCT is initially applied for imaging in ophthalmology.
- Other medical fields: OCT biopsy and functional OCT.
- High-resolution OCT in gastroenterology and dermatology.
- Endoscopic OCT in intra-arterial imaging.
- PS-OCT in dentistry.

7. CONCLUSION

OCT can perform a type of optical biopsy, the micron- scale imaging of tissue morphology in situ and in real time. Image information is available immediately without the need for excision and histologic processing of a specimen. The development of high- resolution and high-speed OCT technology as well as OCT compatible catheter/endoscopes and other delivery systems represent enabling steps for many future OCT imaging clinical applications.

More research remains to be done and numerous clinical studies must be performed to determine in which clinical situations OCT can play a role. However, the unique capabilities of OCT imaging suggest that it has the potential to have a significant impact on the diagnosis and clinical management of many diseases.

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