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Design and Implementation of Projection Data Acquisition for Optical Tomography System

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Abstract

Design and implementation of hardware and software has been made to gather the projection data in process of optical tomography (OT) system. This system use the a pairs of diode laser as parallel light beam source and photodiode as detector. A test sample (phantom) is placed between it. The process of projection data is mechanically acquired by translating and rotating of test sample. Both the mechanical process are controlled by computer. The data collected by detector at different angles are the value of light intensity attenuation after pass through the test sample. A set of data obtained show the a numbers of one dimensional projection profile of test sample at a certain angle. The collection of all projection data is called sinogram. Furthermore, the cross sectional image of test sample is obtained by sinogram reconstructing. In this paper, the process image reconstruction use the iradon function in MATLAB command. The results obtained show that the system is able to gather the projection data as in standard of computed tomography.

Key word: design and intplementation, projection data acquisition , optical tomography

Introduction

Optical tomography is a imaging method of cross sectional objects within media by extracting the light traveling through these media. Recently, optical tomography techniques are widely studied and are currently expected for various applications. Optical tomography has been recognised as an ideal non-invasive technique due to its potential low-cost and very little side-effects. The advantages of using optical tomography over conventional imaging modalities have been well documented in areas such as medical diagnostic, fluid dynamics, flame analysis, atmospheric monitoring, etc. (Watanabe et.al, 2000). The imaged medium or targets in the above mentioned examples were transparent or semi-transparent and image reconstruction techniques were similar to those used in X-ray Computed Tomography (CT). In recent years, however, the advantages of using light for biomedical imaging have been realized and optical tomographic studies

are extended into this promising area of research (Warsito, 2005).

This paper will show the design and implementation of a package of hardware and software for gathering of projection data. As known, taking one dimensional projection is the first step of the whole reconstruction of optical tomography process. The projection is the information derived from the object and it is important for reconstructing the image accurately.

Theory

In the tomography scans using single beam, the projection data are acquired by translating of light beam and rotating of sample, as shown in Fig 1. The theories derived here are based on the assumption that there no diffraction and scattering. Let's assume that light beam follow Beer Lambert's law. The light beam intensity attenuated by test sample can be represented as

$$P_{\theta}(r) = \ln\left(\frac{I_0}{I_t}\right) = \int_{\text{path}(\theta,r)} \mu(x,y) ds \quad (1)$$

where I_0 is the incident light intensity, I_t is the light intensity attenuated, $\mu(x,y)$ is the total attenuation coefficient, $P_{\theta}(r)$ is the projection data at a certain angle θ , and ds is the differential path length along a parallel light beam. In translational scanning, change in the incident light beam position brings about a change in $\mu(x,y)$. In rotational scanning, change in angle θ brings about a change in sample position illuminated.

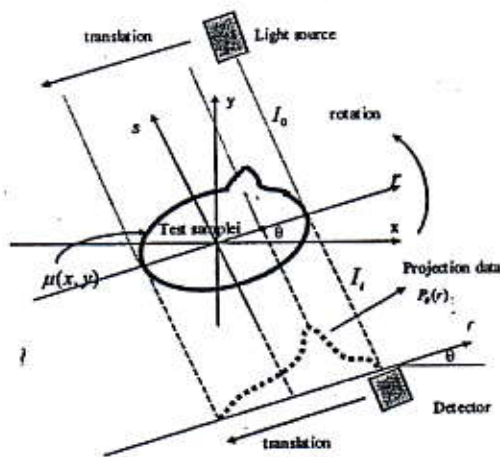


Figure 1. The process of projection data acquisition in tomography technique

Mathematically, the equation of each ray (parallel light beam) can be defined as

$$r = x \cos \theta + y \sin \theta \quad (2)$$

In the delta function, equation (1) can be rewritten to

$$P_{\theta}(r) = \int_{-\infty}^{\infty} \int_{-\infty}^{\infty} \mu(x,y) \delta(x \cos \theta + y \sin \theta - r) dx dy \quad (3)$$

This function $P_{\theta}(r)$ is known as the Radon transform of function $\mu(x,y)$ (Sasono, 2005). The Radon transform maps data from (x,y) to (r,θ) . Such a map is called sinogram. The cross sectional image of

test sample can be reconstructed by inverse Radon transform. The details of the principle of computed tomography can be acquired in Suparta (1999).

Material and methods

Hardware design

The design hardware of optical tomography system can be subdivided into two main sub-system: mechanics and electronics system. The mechanics system consist of the translational and rotational movement of test sample. The specification of diode laser is wavelength 630-680 nm and operational power is less of 1 mW. The translational movement made use of a CD Room. Meanwhile, the rotational movement made use of motor stepper, which the test sample is placed on it. Both the movement are controlled by personal computer via electronics interfacing, as shown in Fig. 2.

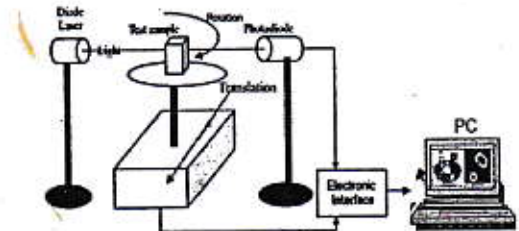
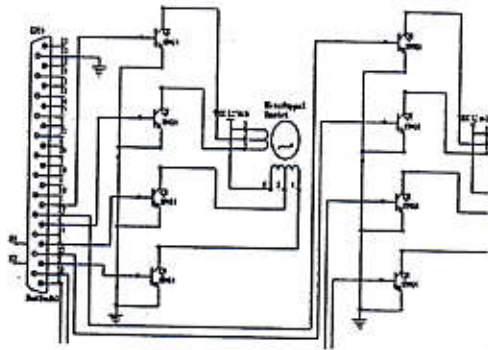


Figure 2. Schematic diagram of acquisition process design for optical tomography system

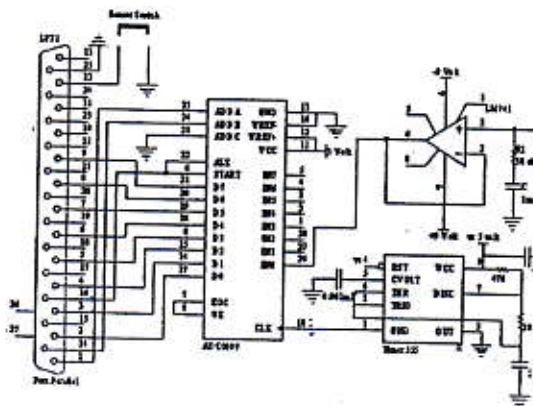
The electronics system consist of parallel port computer as interface, analog to digital converter using IC ADC0809, a couples of diode laser-photodetector, and motor stepper driver. The scheme of whole circuits are shown in Fig. 3.

Software design

In order to the whole of acquisition process are controlled by personal computer, then the software program needed. The program made use of Delphi 6. The projection data is automatically measured by the software, and then the data obtained is saved in file form.



(a)

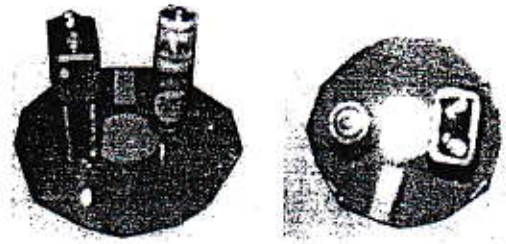


(b)

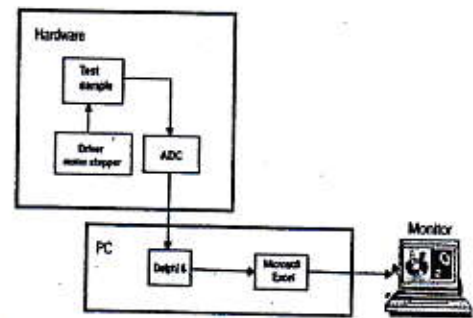
Figure 3. The whole of electronics circuits of projection data acquisition: (a) the driver motor stepper, (b) the ADC and sensor

The acquisition process

Firstly, performance of system designed were tested. The sample tested is the a AAA in measurement of 1.5 volt (oval) and 12 volt battery (box), as shown in Fig. 4a. The block of schematic diagram of projection data process is shown in Fig. 4b.



(a)



(b)

Figure 4. (a)The test sample, (b) blocks schematic diagram of projection data acquisition process

Results and Discussion

Fig. 5 show the results designed of hardware and software for projection data acquisition of optical tomography system. In this experiment, the translational and rotational steps were set up $25 \mu m$ and 1.8° (100 projections), respectively. Fig.6a show the sinogram obtained of projection data acquisition. Meanwhile, the one dimensional projection of test sample profile obtained were shown in Fig.6b. The samples of projection profile graphical are angles at 0° , 45° , 90° and 135° , respectively. The results obtained show that it according to the profile of test sample at different angles. It is also according to standard of computed tomography system, for example, as the simulation carried out by Sasono (2005).

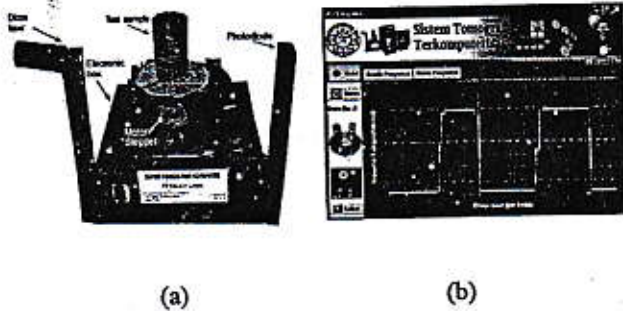


Figure 5. The system obtained of projection data acquisition for optical tomography system : hardware system (a) software system (b)

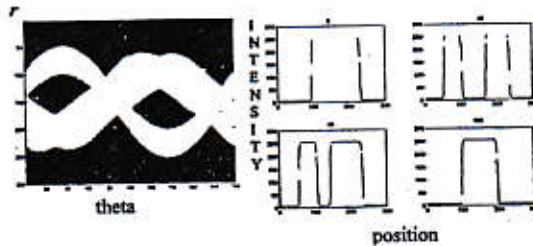


Figure 6. The results of experiment : Sinogram (a) The samples of one dimensional projection graphical at angles of 0, 45°, 90° and 135°, respectively

In this paper, it is also attempted to reconstruct the cross sectional image of test sample using the iradon function in standard MATLAB command. The result of image reconstructed is shown as Fig.7. The image is clearly according to the cross sectional profile of original test sample. Unfortunately, the image reconstructed is blurred by the noise (artifact) that it is inherent in experiment process (Watanabe et.al, 2000). The image blurred will be removed by the next of research project. The image blurred can be removed, for axample, by the filtering process of projection data (Suparta, 1999).



Figure 7. The 300 x 300 pixels of image reconstructed from sinogram use iradon function in MATLAB command

Conclusion

A package of hardware and software for projection data acquisition of optical tomography system has been successfully designed and an initial testing of its performance made. The system is suitable for producing the one dimensional projection profile graphical and optical tomographic image of test sample. The system designed is also according to the standard computed tomography.

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