Technical Programme

The 4th International Colloquium on Signal Processing and its Applications (CSPA 2008)

7-9 March 2008

Kuala Lumpur, Malaysia.

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PREFACE

On behalf of the organizing committee, I would like to welcome you to The 4th International Colloquium on Signal Processing and its Applications (CSPA 2008). This event is a sequel to the previous colloquium with the first held at Pangkor Island in May 2005, the second at Cherating Pahang in March 2006 and the 3rd CSPA was held at the historic city of Melaka in March last year.

As in the previous series, this colloquium also aims to promote R&D activities and to provide a global forum of discussion for academicians, leading technologists, scientists and engineers in various research areas. It is our wish that through this colloquium we will be enriched by the sharing of knowledge, culture and information between individuals, groups, organizations and nations in a variety of contexts.

I wish to thank all participant of CSPA 2008. We highly appreciate your support and participation in this colloquium. Many thanks also to all committee members of CSPA 2008 for their commitment and hard work. Special thanks are due to Associate Professor Dr. Yusof Md. Salleh, Dean of Faculty of Electrical Engineering, UiTM Malaysia, for his kind support in realizing this event. I would also like to express my gratitude to IEEE UiTM Student Branch, IEEE Signal Processing Chapter, Malaysia Section and Institute of Research, Development and Commercialization (IRDC), UiTM for their supports. We gratefully acknowledge contributions from other organizations that are incoming but not finalized at the time of this writing.

Prof. Dr. Mohd Nasir Taib

General Chair
The 4th International Colloquium on Signal Processing and Its Applications (CSPA) 2008,
Kuala Lumpur, Malaysia

Parallel session B3 - DAY 1 – 8th March 2008
Time: 2.00 pm – 4.00 pm
Venue: Room Tiara 2

Early Tests of Low Cost and Simple Optical Tomography Based on a Non-Invasive Detection

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Abstract-Optical tomography technique has been developing rapidly for various applications particularly in medicals. This technique is considerably interesting due to some safety and low cost source and components, respectively such of use of commercialized an infrared Light Emitting Diode (LEDs) and a photodetector. In this research work, the early test has been carried out to the non-invasive objects of the phantom immersed in the liquid filed in the cylinder. These phantoms were placed between a light source of infrared LED and a detector in the home-made tomography apparatus. From the measurement, the image reconstruction was carried out and then followed by a filtered back projection method. From this, the 2D image of phantoms was successfully observed as distinguishable objects. This result was potentially to be used for medical applications which has advantages of low cost and simple in operation.

Keywords : *optical tomography, low cost, infrared LEDs, non-invasive detection.*

I. INTRODUCTION

Optical Tomography (OT) is a technique which is enable to be used for new non-invasive detections particularly for a medical diagnostic technique. It is important to note that optical tomography technique has been developed rapidly for various applications as this technique has introduced some advantages over tomography based X-Ray source. By using X-Ray computed tomography there are some disadvantages such of destructive, impractical and expensive [1,2,3,4]. These problems are being overcome by using optical tomography based on an imaging technique. The technique is considerable low cost and very little side-effect as a low energy of light source radiation is used. Recently, optical tomography techniques using light source of infrared or near infrared spectra are widely used for various applications such of biomedical [5,6,7,8], measurement of the fluids flowing in pipe [9], water analyses [10] and chemical process [11]. The use of diode laser and light emitting diode (LEDs) in that range is considerably interesting for design of optical tomography [12,13,14] because this leads to low energy consumption, low cost, and small size optical of component for portable apparatus. For an example, Sobusiak and Wiczynski [13] have investigated the optical imaging of hand fingers using LED of an infrared light spectrum (880 nm) and PIN photodiode as a sensitive photodetector.

In this paper we will report our computing work of image reconstruction from back projection method through extracted data signal obtained from the measurement set up. This work is as an early test for a simple, portable and low cost of an optical tomography set up using a low cost of commercialized LED for an infrared light spectrum with an operational power less than 1 mW and a PIN photodiode as a detector. From the test using a simple set up of home-made apparatus, it could be used to gathering the projection data of the phantom into 2D imaging. The process of image reconstruction will be carried out using the unfiltered and filtered back projection methods.

II. DATA ACQUISTION PROCESS

In an optical tomography technique, data acquisition is done by scanning optically using a single beam (such of LED, laser). From that process the projection data are acquired by translating the light beam across the sample and then rotating. The schematized diagram for the apparatus is given in Figure 1. The formulae derived here for the measurement point of view are based on the assumption that there are no diffraction and scattering phenomena during the measurement [15]. For those, we assume that light beam intensities will be attenuated by a phatom (sample) by means of the Beer Lambert's law. Therefore the projection data at a certain angle, $P_\theta(r)$ can be expressed as

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

where

I_0 is the intensity of incident light,

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I_t is the intensity of light attenuation,

$\mu(x,y)$ is the total attenuation coefficient, and

ds is the differential path length along a parallel light beam.

In the translational scanning, change in the position of the incident light beam leads to a change in $\mu(x,y)$. Meanwhile, in the rotational scanning, change in angle θ leads to a change in the position of the sample being illuminated. The above movements could be expressed into the mathematic equations which each ray (parallel light beam) can be written as

$$r = x\cos\theta + y\sin\theta \tag{2}$$

By using the delta function, equation (1) can be rewritten as

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

The function of $P_\theta(r)$ is known as a Radon transform of function $\mu(x,y)$. The Radon transform will map the data from (x,y) to (r,θ). Therefore, the cross-sectional image of test sample can be reconstructed using an inverse Radon transform which the details of the principle of computed tomography can be found in Quinto [16,17].

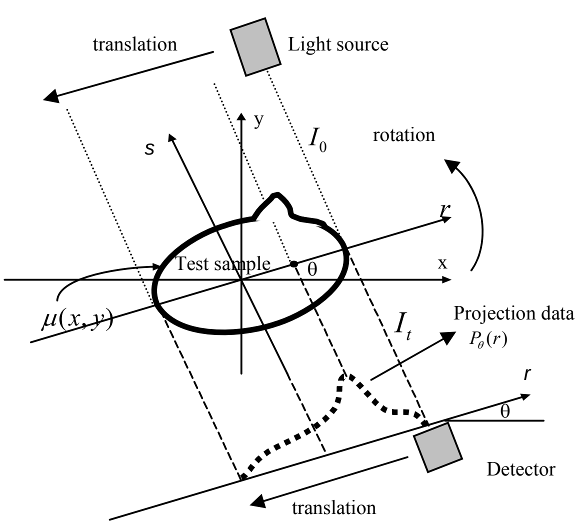

Fig 1. The process of projection data acquisition in a tomography technique.

III. IMAGE RECONSTRUCTION AND BACK PROJECTION METHOD

The method of image reconstruction of the sample used was based on the Filtered Back Projection (FBP) algorithm [18]. This algorithm generates the reconstruction of a single projection following two main steps of filtering and back projecting. The projection $P_\theta(r)$ is Fourier transformed through a relationship of $S_\theta(\omega) = FT\{P_\theta(r)\}$. In the calculation, $S_\theta(\omega)$ is multiplied by a filter parameter $|\omega|$ to apply a weighting to each projection in the Fourier domain before moving back to the spatial domain. The weighted projections then inverse Fourier transformed to give the filtered projection function which can be defined as $Q_\theta(r) = FT^{-1}\{S_\theta(\omega)|\omega|\}$. The values are then inserted into their proper places in the image plane to reconstruct one projection. A summation of the reconstruction of each single projection leads to a final reconstruction of the cross-sectional image. Mathematically, a filtered back projection method can be described by the following equation

$$\mu(x,y) = \int_0^\pi Q_\theta(x\cos\theta + y\sin\theta)d\theta \tag{4}$$

In practice, only a finite number of samples will be taken from a projection, so a discrete approximation of the integral in (4) is applied in practice to be

$$\mu(x,y) = \frac{\pi}{K}\sum_{i=1}^{K} Q_{\theta_i}(x\cos\theta_i + y\sin\theta_i) \tag{5}$$

From (5) there are K numbers of projection $P_\theta(r)$, meanwhile $\frac{\pi}{K}$ is an angle between two projections, meanwhile i is the data point[13].

IV. EXPERIMENTAL SET UP

The home-made of optical computer tomography (CT) scan constructed of two main parts of mechanics and electronics systems as schematized in Fig 2. The mechanics system will introduce the translational and rotational movements of a pairs of light source and photodetector, meanwhile the sample was fixed on the stage. For those movements, the stepper motors used was controlled by a computer through the interfacing of

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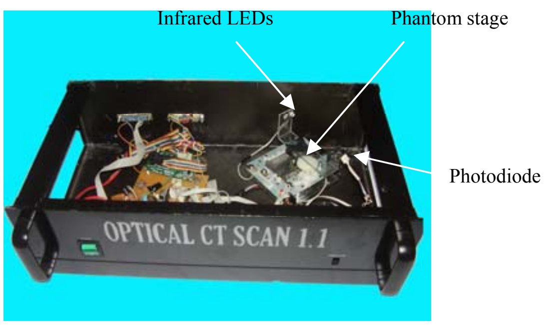
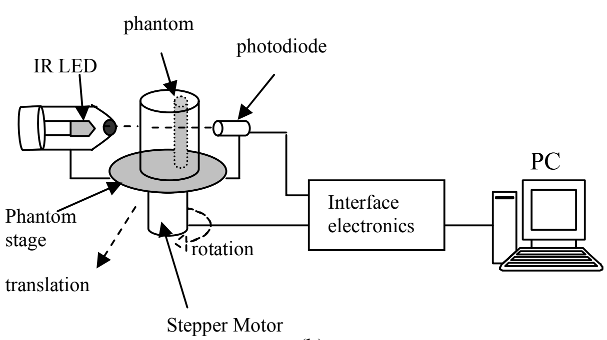
electronics part. With this, the computer will collect the light intensities received by the photodetector from the light source after passed through the sample.

For the probe of optical tomography, the light source of commercialized LEDs of an infrared light spectrum for 720 nm was used with an operational power less than 1 mW. For a photodetector, the commercialized photodiode was used. For a test, the phantom was of metal lids (diameter of 1 cm and 0.5 cm, respectively) immersed in the liquid of benzene filed in the glass silinder of a 4 cm in diameter.



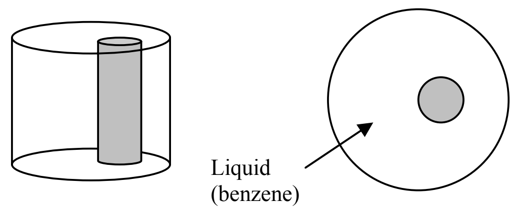
(a)



(b)

Fig. 2. (a) A photograph of a home-made optical tomography apparatus and (b) A schematic diagram of the apparatus system.

A schematised diagram for the phantom are shown in Fig. 3(a and b). The distance between LEDs and photodetector were adjusted for 15 cm, meanwhile the phantom bath (cylinder) was positioned in the center between them. During the experiment, the apparatus introduces the translational and rotational movements for a movement step of 0.22 mm and 1.8°, respectively. This movement allowed the apparatus to collect the data for 200 projections for a complete scanning. Data collected from the detector for different angles (a set of data) were attenuation of light intensities (one dimensional projection profile) after passed through the phantom. A complete scanning was done for about 20 minutes. For the electronics system part, the parallel port of computer was used for an interfacing communication between the apparatus and the computer. Meanwhile, for the analog to a digital converter circuit, the IC of ADC0809 was used.



(a) (b)

Fig. 3. (a) 3D view diagram and (b) a top view of phantom used.

(b)

The data acquisition and also the projection process were carried out using a commercialized software of Delphi 6. Further process for the image reconstruction was done based on the FFT (Fast Fourier Transform) as this command was available in Mathlab. The schematized diagram for the acquisition (gathering) process of projection data is given in Fig. 4.

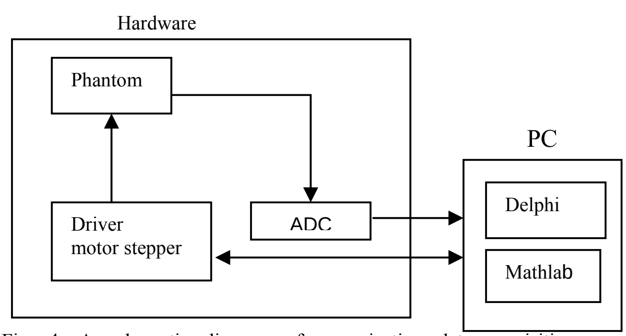


Fig. 4. A schematic diagram of a projection data acquisition (gathering) process.

V. RESULTS AND DISCUSSION

From the experiment carried out for the phantom, the projection and data reconstruction have been successfully done through a standard of tomography system. From the extracted projection, the cross

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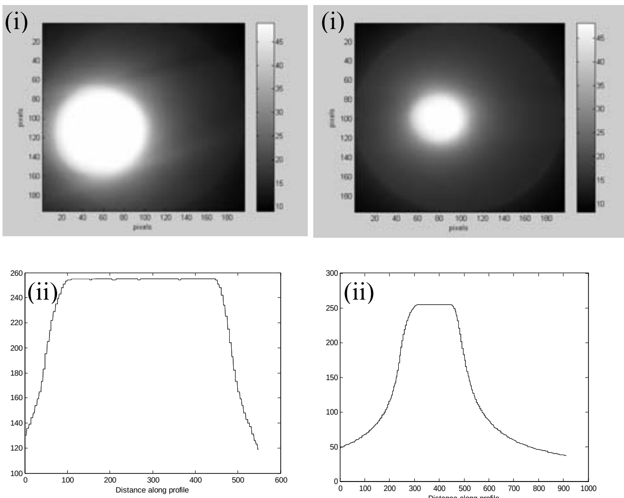
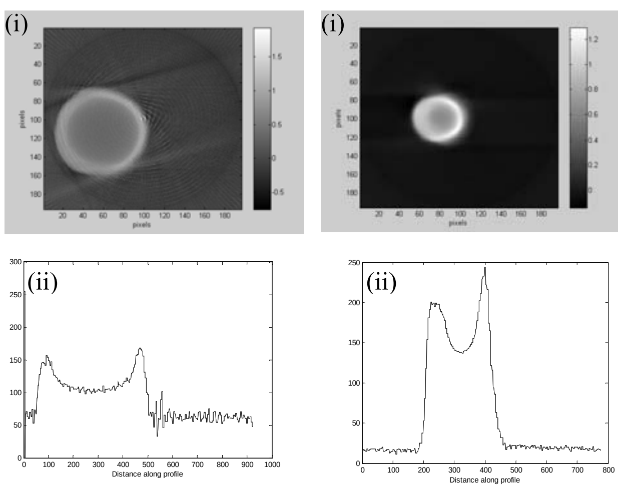
sectional image (test sample) was reconstructed through the unfiltered and filtered back projection methods.



(a) (b)

Fig. 5. The unfiltering of (i) image reconstruction and (ii) image profile for a phantom of metal lid of (a) 1 cm and (b) 0.5 cm in diameter, respectively.



(a) (b)

Fig. 6. The filtering of (i) image reconstruction and (ii) image profile for a phantom of metal lid of (a) 1 cm, and (b) 0.5 cm in diameter, respectively.

The results of the unfiltered 2D image reconstruction and image profile for the phantom with a diameter of 1 cm and 0.5 cm from a top view is shown in Fig. 5a and Fig. 5b, respectively. From that figure, the images, the phantom of cylinder immersed in the liquid benzene are observed more bright for the cross sectional profile rather than the others considered as a background. Nevertheless, from this process the images observed are still blurred by the noise (artifact) which is considered due to the inherent phenomenon in the experiment as also observed by Watanabe *et al*. [19].

This blurred image was then removed using the filtered back projection method which allows us to remove the dc and low-frequency component of the projection in the frequency domain as shown in Fig. 6a and Fig. 6b, respectively. As we can see in that figure, the images of phantom looks much improve in the qualities by reducing the contrast of the images. The phantom of metal cylinder are distinguishable although not perfect yet as this could be studied further by doing some improvement for some components of apparatus such of the detector sensitivity. The image profile for the image reconstructed have shown that after a filtering process, the different magnitude between background and the object is quite large compare than that before filtering.

From the experimental results, it was shown that the home-made of optical tomography system has successfully performed the standard process of computed tomography from the projection data and image reconstruction. Use of the commercialized light source of LED in an infrared spectrum with a low power and a photodiode was considerably interesting for further improvement for a portable and low cost apparatus. This technique is potentially to be used for various applications in petroleum and medical instrument industries.

VI. CONCLUSIONS

From the experiment done through some processes of image reconstruction and back projection method for data extracted from the experiment of optical tomography, the 2D distinguished objects have been succesfuly found. The metal lid immersed in the liquid benzene was distinguishable from the background. This early test from the home-made apparatus was considered to work following the computed tomography technique. Meanwhile, use of a low cost of commercialized LEDs at an infrared light spectrum with a low power for less than 1 mW is considerably interesting and the set up is simple which lead to low cost, portable and potentially being improved for further application such for medicals, oil contamination, etc.

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