INFRA RED (IR) BASED TOMOGRAPHY SYSTEM:
A COMPARISON BETWEEN ORTHOGONAL AND FAN BEAM PROJECTION

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This report is submitted in fulfillment of the requirements for the award of Bachelor of Electronic Engineering (Computer Engineering) With Honors

Faculty of Electronic and Computer Engineering
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UNIVERSTI TEKNIKAL MALAYSIA MELAKA
FAKULTI KEJURUTERAAN ELEKTRONIK DAN KEJURUTERAAN KOMPUTER

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Dedicated for my beloved father and mother…

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ABSTRACT

This project is to design, implement and compare infra red based tomography system which using orthogonal and fan beam projection. Here, the basic concept of orthogonal and fan beam projection must be understood. Infra red will be used as the light emitter and receiver sensor in this project. In terms of hardware, two types of jig/fixture will be designed in order to comparing orthogonal and fan beam projection. The reconstructed images from these two types of projections (orthogonal and fan beam) can be formed by design a signal conditional circuit and fabricate into printed circuit board (PCB) and the data from this circuit will be transferred through Data Acquisition (DAQ). Besides the hardware, this project will include the use of user friendly, Visual Basic 6.0 program to implement voltage linear back projection in order to reconstruct the image by comparing the result between both projections. Through this project, the comparison result of both projections can be obtained.

ABSTRAK

Projek ini adalah untuk mereka bentuk, melaksanakan dan membandingkan inframerah berdasarkan sistem tomografi (kaedah radiografi yang mempamerkan perincian tubuh badan) dengan menggunakan unjuran 90° dan unjuran sinaran kipas. Di sini, konsep asas unjuran 90° dan unjuran sinaran kipas haruslah difahami. Inframerah akan digunakan sebagai cahaya pemancar dan penerima penderia dalam projek ini. Dari segi perkakasan, 2 jenis aci (alat pemegang sesuatu bahan kerja supaya ia tetap) akan direka untuk membandingkan unjuran 90° dan unjuran sinaran kipas. Pembinaan semula imej daripada 2 jenis unjuran ini (unjuran 90° dan unjuran sinaran kipas) akan dibentuk dengan merekabentuk satu litar isyarat dan dibina ke dalam litar tercetak dan data daripada litar ini akan dipindahkan ke dalam sistem perolehan data. Selain daripada perkakasan, projek ini temasuk dengan penggunaan pengguna yang mesra, program visual asas 6.0 untuk melaksanakan unjuran voltan garis lurus belakang dalam pembinaan semula imej dengan membandingkan keputusan di antara 2 jenis unjuran tersebut. Melalui projek ini, keputusan pembandingan di antara 2 jenis unjuran tersebut akan diperoleh.

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CHAPTER 1

INTRODUCTION

1.1 Project Synopsis

The objective of this project is to design, implement and compare infra red based tomography system which using orthogonal and fan beam projection. Infra red will be used as the light emitter and receiver sensor in this project. The reconstructed images from these two types of projections can be formed by reconstructing signal control circuit, jig and fixture design / fabrication. Besides the hardware, this project will include the use of user friendly, Visual Basic 6.0 program to visualize the concentration profile by comparing the result between both projections.

1.2 Project Objectives

1. To design jig/fixture for IR based tomography system using orthogonal and fan beam projection.
2. To design and fabricate PCB of signal conditional circuit.
3. To compare IR based tomography system using orthogonal and fan beam projection.

4. To interface hardware circuit using Visual Basic through Data Acquisition (DAQ).
5. To design a program that can visualize the concentration profile by comparing the result between both projections using Visual Basic 6.0.

1.3 Problem Statements

Process tomography is the method to obtain cross-sectional image over measurement area. There are several methods to array the projection such as:

1. Orthogonal projection.
2. Fan beam projection.
3. Rectilinear projection.
4. Mix all projection.

Most of the researches in process tomography are related on orthogonal projections because it is easy to implement. However, compare to the orthogonal projection, the fan beam projection will give high resolution image, although it used the same number of sensor.

1.4 Scopes Of Work

The scopes of work for this project including:

1. To understand the concept of orthogonal and fan beam projection.
2. To design, fabricate or build signal conditional circuit.
3. To test the usability of IR sensor for this project.
4. To design, evaluate and manufacture jig/fixture that can produce 2 types of projections (orthogonal and fan beam).
5. To implement voltage linear back projection in order to reconstruct the image using Visual Basic.

1.5 Expected Result

The expected result that student should get from this project is to develop or built several hardware which can compare the infra red based tomography system which using orthogonal and fan beam projection. The images from these two types of projections can be formed by reconstructing signal obtained from signal control circuit, and be process with software (Visual Basic 6.0) to visualize the concentration profile by comparing the result between two projections. Through this project, the comparison result of both projections can be obtained.

CHAPTER 2

LITERATURE RIVIEW

2.1 Process Tomography

Tomography refers to the reconstruction of the internal distribution of 2D and 3D objects from multiple external viewpoints, thus providing cross-sectional slices through the object. The term originates from the Greek words *tomos* (for slice) and *graph* (for image). The term is commonly found in medical diagnostics, where computerized tomography (CT) x-ray scanning systems are well known. The medical applications of tomography provide a useful illustration of the principle, although this review is of course concerned primarily with industrial processes.

In a conventional x-ray imaging system, a cone-shaped beam of x-rays is used to illuminate the subject on one side. In passing through the subject, the radiation is attenuated (either absorbed or scattered) in proportion to the local electronic density; thus, variations in density or composition determine the intensity of the radiation as it leaves the subject. The final intensity pattern is captured as an image on a photographic plate mounted on the opposite side. The pixels of the resulting photograph (radiograph) represent the attenuation integrated through the object along the rays emanating from the source. This integration in effect removes depth information from the image, so if for example a tumor were seen on a radiograph one could not determine (on the basis of one image) which of several overlaying organs was affected.

In contrast, early tomography systems used several different views to build up an image of a slice at a predetermined depth in the subject. Most x-ray tomography systems in recent times have been designed to obtain cross-sectional slice images perpendicular to some axis, around which the sources and detectors are rotated. This process is known as axial tomography. In a first-generation CT system, a narrow x-ray beam is transmitted through the subject, and a collimated detector is placed on the side of the subject. This measures the line-integrated attenuation of the beam through the subject along the path so defined. Figure 2.1 illustrates this arrangement in general form. The example subject has a circular cross-section and contains further contrasting circular features. An x-ray transmission source U and receiver V are shown. A beam is transmitted from the source along the line shown, displaced by length *s* from the origin and at angle *Ø,* creating the line of integration, *l*. The measurement system measures the path integral of the subject's density distribution along this line, and it call this quantity the path density integral (PDI). If the angle is held constant and the beam is displaced across the subject (in direction *s*), a "shadow" of the subject can be seen in the attenuation data. This composite set of data is called the *projection*.

A set of projections can be obtained by repeating this process for a range of values of the angle *Ø,* in effect providing an observation of the subject's shadow from multiple viewpoints. From an intuitive perspective, these projections are the prerequisite for tomographic imaging. In fact, from a mathematical perspective, the individual PDI values are the basic requirement.

Clearly, the measured PDI values will depend on the attenuation distribution, depicted in Figure 2.1 as $f\,(x, y)$. If sufficient PDI data are obtained, these may be used to estimate this distribution. In mathematical terms, this is a classic inverse problem, and the process of solving it to generate the estimated distribution is commonly called *image* *reconstruction*. The quality of the resulting estimate depends on the quality and number of PDI data and on the reconstruction algorithm.

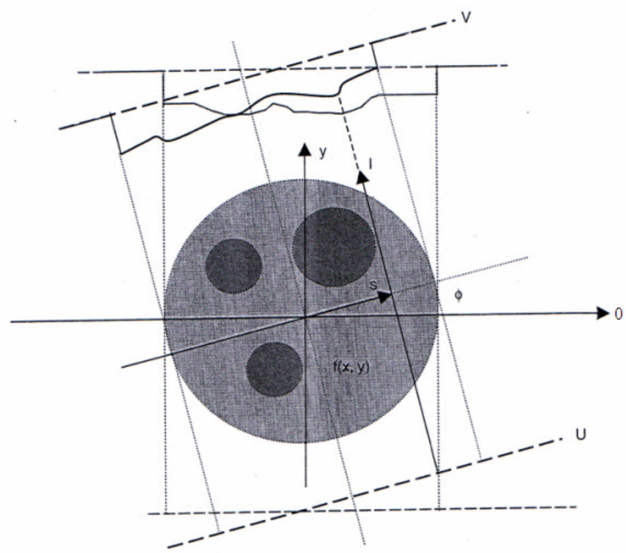

Figure 2.1 X-ray tomographic projection

2.2 Types Of Projection

Tomographic techniques vary widely in their instrumentation and applications, all of them can be characterized by a common two-step approach to the imaging process; firstly gather projection data based on some physical sensing mechanism, then reconstruct a cross sectional image from the projections. The term "projection" has a specific meaning in tomography which a projection can be visualized as type of radiography of the process vessel.

In tomography, many projections are needed to reconstruct the interior volume or cross-section of an object. Projections actually can be referred as sensor arrangement. In practical systems, there are two types of projection that have been investigated and applied to measure gas / solid flow, which are:

1. Parallel projection (Orthogonal Projection).
2. Fan beam projection

For parallel projection, the number of emitter and receiver are the same. Each pair of trans-receiver is arranged in a straight line and the received signal only corresponds to its emitter source, while for fan beam projection, the number of emitter and receivers can be unequal. The fan beam projection technique provides a higher resolution system compared to the same number of sensors used in parallel projection due to high obtaining information several projections are needed to reduce aliasing which occurs when two particles intercept the same view.

However from both methods, it can be illustrated into a various techniques of arrangement which all of that has been widely investigated to implement into flow imaging of conveying system. The various arrangements can be illustrated into six types of projection, which are:

1. Parallel beam projection. (Figure 2.2)
2. Two orthogonal projections. (Figure 2.3)
3. Two rectilinear projections. (Figure 2.4)
4. Three rectilinear projections. (Figure 2.5)
5. A combination of two orthogonal and two rectilinear projections. (Figure 2.6)
6. Three fan-beam projections. (Figure 2.7)
7. Four fan-beam projections. (Figure 2.8)

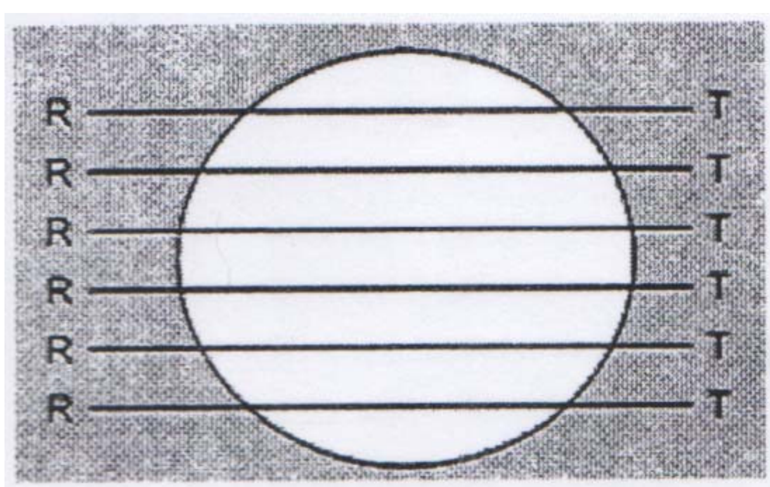

Figure 2.2 Parallel beam projections