IMAGING CONCENTRATION PROFILE OF MULTIPHASE FLOW USING LASER BASED TOMOGRAPHY

ROSHITA BINTI AHMAD

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Faculty of Electronic and Computer Engineering
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Signature	: ……………………….………
Supervisor's Name	: ADIE BIN MOHD KHAFE
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For my beloved father and mother, thank you for giving full commitment.

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ABSTRACT

This project describes the use of Laser based tomography in the measurement of concentration profile of Multiphase Flow. It use an optical tomography method which a laser as emitter and photodiode as receiver (sensor). The array of sensor will be installed at the jig/fixture which the laser will emit the light to the photodiode. The data of the sensor will be converted to the suitable digital form for computer processing. The computer is used to reconstruct a tomography image of the cross-section by the sensor. This system used an orthogonal projection which both the number of emitter (laser) and receiver (photodiode) are the same and each pair of transmitter and receiver is arranged in a straight line and the received signal only correspond to its emitter source. Beside that, this project also uses the Visual Basic (VB) software to reconstruct the image.

ABSTRAK

Projek ini bertujuan mengkaji penggunaan laser untuk mengesan banyak fasa bagi sesuatu pengaliran dengan menggunakan proses tomografi. Ia menggunakan kaedah tomografi optik iaitu menggunakan laser sebagai pemancar dan photodiod sebagai penerima (*sensor*). Jujukan s*ensor* ini akan diletakkan di bahagia luar jig/fixture, dimana cahaya laser akan dipancarkan kepada photodiode. Hasil daripada data yang diperolehi daripada *sensor* akan ditukarkan kepada bentuk digital yang sesuai supaya dapat diproses oleh komputer. Dengan menggunakan data yang diperolehi daripada sensor, imej keratan rentas akan terbentuk. Sistem ini menggunakan orthogonal projeksi, dimana bilangan pemancar (laser) dan penerima (photodiode) yang digunakan adalah sama dan diletakkan bersudut tepat. Selain daripada itu, projek ini juga menggunakan perisian Visual Basic (VB) bagi tujuan penghasilan imej.

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$V_{LBP}(x, y)$ = Voltage distribution obtained using LBP algorithm concentration profile in unit (volt) an *n x m* matrix where *n* equals to dimension of sensitivity matrix.

$S_{Rx,Tx}$ = Signal loss amplitude of receiver Rx-th for projection Tx-th in unit of volt.

$\overline{M}_{Tx,Rx}(x, y)$ = The normalized sensitivity matrices for the view of Tx-Rx.

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CHAPTER 1

INTRODUCTION

1.1 Tomography Overview

Tomography is a branch of imaging which produces an image called a tomogram which shows a single plane of an object in very specific detail. Originated from the Greek words *'tomos'* which means slice and *'graph'* meaning picture, tomography can be defined as a picture of a slice [3]. In simple terms, tomography is an imaging technique that enables one to determine the contents of a closed system without physically looking inside it.

Process Tomography provides several real time methods of viewing the cross-section of a process to provide information relating to the material distribution. This involves by taking numerous measurement from sensor which places around the section of the process being investigated and processing the data to reconstruct an image. The process involves the use of non-invasive sensor to acquire vital information in order to produce two or three dimensional images of the dynamic internal characteristics of process systems. Process tomography refers to any method used to measure the internal state of a chemical process. In a tomography system several sensor are installed around the pipe to be imaged. A computer is used to reconstruct a tomography image of the cross-section being interrogated by the sensor [4].

Basically, in a tomography system several sensors are installed around the pipe or vessel to be imaged. A computer is used to reconstruct a tomography image of the cross section being interrogated by the sensors. The specific subsystem for flow imaging are shown in Figure 1.1 and described as follows [1]:

1. The sensor and sensor electronics. The field sensing pattern of the sensors is also important, as it is related to the choice of image reconstruction algorithm.
2. The flow fields, which is assumed to be composed of two or more separate components. Since the flow pattern can change rapidly, fast data processing of the measured information at an acceptable cost is required.
3. Image reconstruction, which includes extraction of image characteristics and reconstruction of the image.
4. Image interpretation, to give the desired information on the flow, such as the instantaneous concentration of components from which volume flow rates can be calculated.

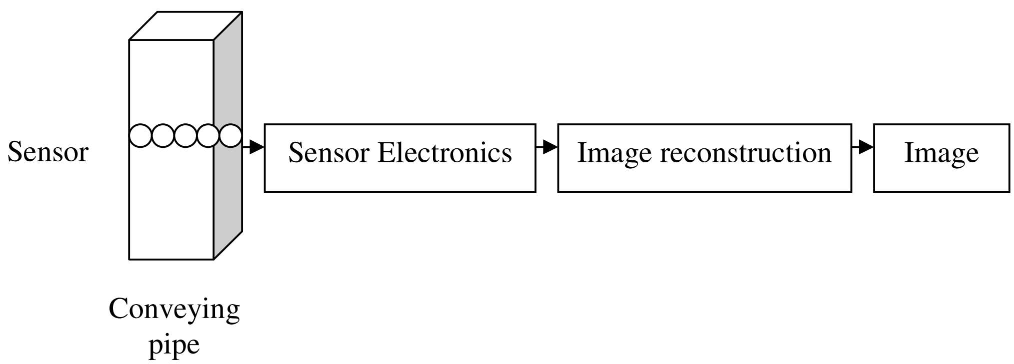

Figure 1.1 Basic schematic diagram of tomography system

1.2 Objectives of the Project

The aims of this project are to measure of concentration profile of Multiphase Flow based tomography proses. The objective of this project is:

1. To detect of Multiphase flow.

1.3 Scope of the project

This project is divided into two parts, which are the first parts is hardware development and the second part is software development and interfacing it with data acquisition system (DAQ).

For part one, firstly, literature study in the measurement of concentration profile of Multiphase Flow using laser based tomography. Second, selection of sensor and design a sensor's jig/fixture. Then, study the receiving circuit and testing the circuit. Lastly, the signal conditioning circuit are designed and tested.

For part two, Data Acquisition (DAQ) card are used as interface to collect the data before transfer it to computer. By using a Visual Basic, an image will be reconstruct with perform V_{LBP}.

1.4 Thesis Outline

Chapter 1 present an overview to process tomography, the objectives of the project, scope of the project and thesis outline.

Chapter 2 provides literature review which includes the tomography technique, Sensor type and selection, laser, photodiode, phototransistor and orthogonal projection technique

Chapter 3 explanation about methodology which it covers about emitter and receiver, The Design of Optical Receiving Circuit, DAQ card and Visual Basic (VB) and Linear back Projection (LBP) Algorithm

Chapter 4 shows a result for this project and discussion about result.

Chapter 5 is about conclusion and suggestion for future work.

CHAPTER 2

LITERATURE REVIEW

2.1 Tomography Technique

Tomography techniques vary widely in their instrumentation and application, all of them can be characterized by a common two-step approach to the imaging process: firstly gather projection data base on same 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 [5].

Projection can be referred as sensor arrangement. Projections are needed to reconstruct the interior volume or cross-section of an object. For this project, the two orthogonal projection will be use to measure a multiphase flow. For orthogonal projection, the number of emitter and receiver are the same and their transmitter and receiver is arranged in a straight line and just received signal only correspond to its emitter source. A two orthogonal projection will be shown in Figure 2.1.

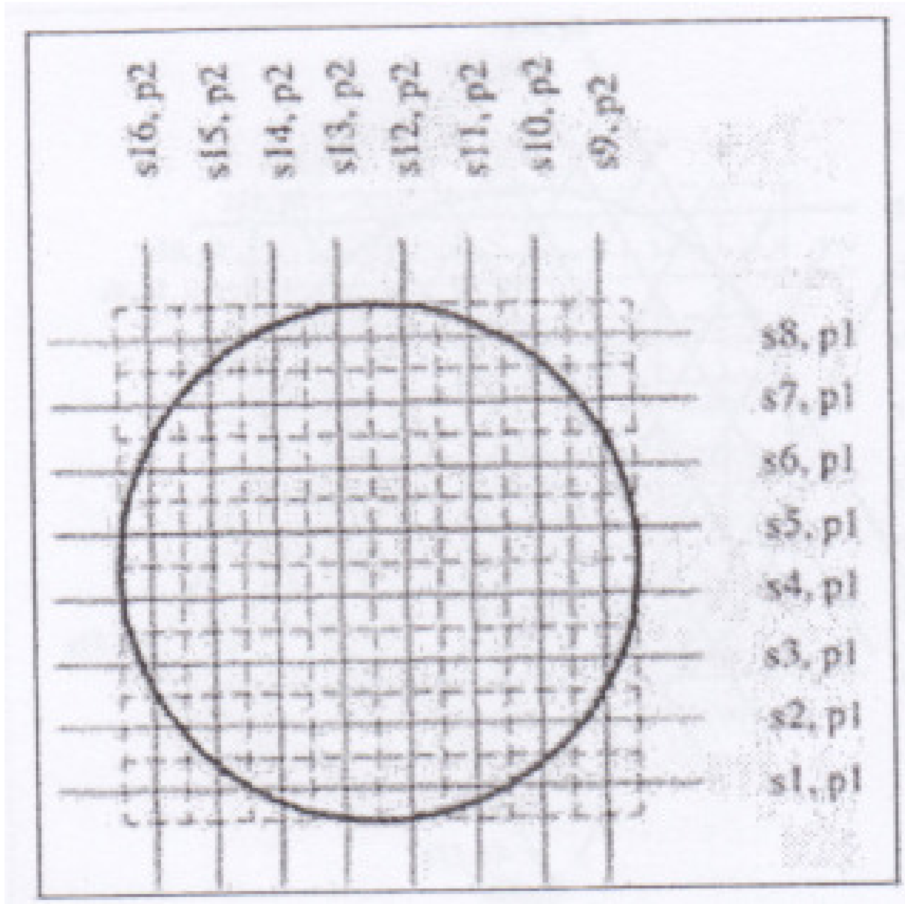

Figure 2.1 Two Orthogonal projection

The Figure 2.1 shown, it have sixteen sensors (s1 until s16) which for two orthogonal projections, each projection provides eight light beams which parallel to each other. Each emitter has a corresponding detector. The label s1,p1 is stands for sensor 1 which is located in the projection 1.

2.2 Sensor Type and Selection

Many type of sensors that can be used for the application of tomography, specifically to collect the projection data such as electrical sensors, optical sensor, gamma ray sensor, ultrasonic sensor, etc. sensor can be divide into two groups; soft field and hard field sensor as shown in Table 2.1 [1].

Soft field sensor generates a non-homogeneous field and the sensitivity distribution inside the field changes as the parameter distribution changes. On the other hand, hard field sensor is independent of the medium between source and the detector. Here, several types of tomography technique, including optical sensor will be introduced [1].

Table 2.1 Sensor Grouping

Sensor Type	Characteristic	Example
Soft Field	• Generates non-homogeneous field. • Sensitivity distribution inside the field change.	Electrical charge, capacitance, magnetic sensor
Hard Field	Independent of the medium between source and the detector	Optical sensor

2.2.1 Electrical Capacitance Tomography

Electrical capacitance tomography (ECT) is a method for determination of the dielectric permittivity distribution in the interior of an object from external capacitance measurements. It is a close relative of electrical impedance tomography and is proposed as a method for industrial process monitoring, although it has yet to see widespread use. Potential applications include the measurement of flow of fluids in pipes and measurement of the concentration of one fluid in another or the distribution of a solid in a fluid.

Although usually called tomography, the technique differs from conventional tomography methods, in which high resolution images are formed of slices of a material. The measurement electrodes, which are metallic plates, must be sufficiently large to give a measurable change in capacitance. This means that very few electrodes are used and eight or twelve electrodes are common. An N-electrode system can only provide N (N-1)/2 independent measurements. This means that the technique is limited to producing very low resolution images of approximate slices. However, ECT is fast, and relatively inexpensive.

The measurement principle of capacitance tomography is based on the fact that the capacitance of a capacity is a function of the permittivity of the medium between the electrodes. The capacitance transducer for tomography should have the following characteristics [1]:

1. Immunity to stray capacitance
2. Low drift
3. Good linearity
4. High sensitivity
5. Unaffected by loss conductance
6. Large signal to noise ratio
7. Adequate range, 0.1 ~ 10pF
8. short measurement time