

Modeling in An Optical Tomography System Using Different Pixel Configurations

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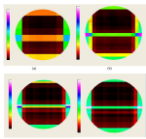
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Graphical abstract



Abstract

Pixel resolution is important in forming an image. The aim of this paper is to compare the reconstructed image of an array infra-red sensor by using different configurations of pixels. The different number of objects will be tested in this simulation. The dimension of pixel that uses to reconstruct the image is important to form a clear and accurate image.

Keywords: Pixel resolution; reconstructed image; simulation; infra-red sensor; accurate image

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1.0 INTRODUCTION

“Tomos” is the Greek word and its meaning “cutting section” and graph means picture. Tomography is a technique for digitally “cutting” a specimen to reveal its internal condition.[1] For example, a camera captured an image and then produced a picture. The process consists of converting an original image to a digital image which is composed of pixels.

Optical tomography system is widely applied in medical imaging for displaying the inner part of our body such as brain and bone structure. The optical tomography system is used in industrial process to display the cross-sectional images inside a vessel to ensure that the materials pass through the vessel is within specified dimension as the industrial needs.

The simulation for the optical tomography system is performed by using visual basic (VB). Visual basic is a software that can be used to create a graphical user interface (GUI). Therefore, end user can understand the operation of the system and apply the system in their factories.

For this project, there are a total of forty pairs of sensors. Therefore, there will be a total of forty receivers reading for the system to reconstruct the image. Different value for the receiver will give a significant change to the image.

The review for the image reconstruction method is done by some researcher and can be found in reference [2].

2.0 MODELING FOR OPTICAL TOMOGRAPHY SYSTEM

Modeling in process tomography is important to make qualitative or quantitative predictions about the future [3] as all the possibilities that the real system could exhibit cannot be imagined [4]. For optical tomography, to examine the process parameters or flow field, linear interaction is important [5, 6].

In this paper, the modeling is done by arranging the sensor’s light path according to the real dimension in the sensor jig system and the vessel (pipe). The diameter of the vessel that used is 100mm and there is a total of 40 pair of sensors for vertical and horizontal projection. Assume the sensor’s light path occupied the whole vessel with 100mm. There are a total of 20 sensors, therefore,

$$\frac{(100 \text{ mm})}{20} = 5 \text{ mm (each sensor)}$$

5 mm refers to the width of the light path in the system.

From Figure 1, each transmitter will transmit a light which occupied 5 mm inside the vessel. Therefore, a total of 20 sensors light path occupied the whole vessel with diameter of 100mm.



Figure 1 Light path for sensors

For an 8x8 sensitivity map

$$\frac{20 \text{ sensors}}{8 \text{ pixel}} = 2.5 \text{ of sensors value produce 1 pixel.}$$

That means five (5) sensors value is enough for data to reconstruct the image in 2 pixels. Therefore, five (5) sensors value is equal to two (2) pixels as shown in Table 1.

Table 1 The relationship between pixel and the number of sensors

	8 Pixel division			
Receiver location	2 pixels	2 pixels	2 pixels	2 pixels
Voltage value for receiver in horizontal projection (x)	5,5,5,5,5,5,5,5,5,5,5,5,5,5,5,5,5,5,5,5			
Voltage value for receiver in vertical projection (y)	5,5,5,5,5,5,5,5,5,5,5,5,5,5,5,5,5,5,5,5			

The representation of pixels for the whole vessel (100mm) is shown as Figure 2. For 8x8 pixel configurations, there have 8 pixels in projection X and 8 pixels in projection Y.

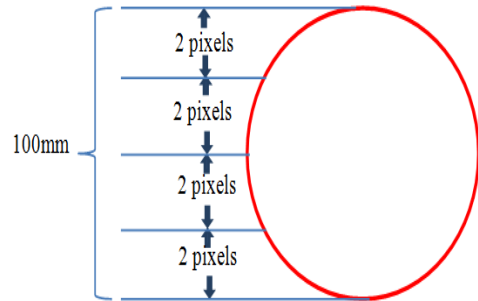


Figure 2 8 pixels in Y-projection

To form the image plane for 8x8 pixels, it means every pixel will contain a combination of light path between adjacent receivers. Table 2 shows the image plane for 8x8 resolutions.

Table 2 Image plane for 8x8 resolutions

X1, Y1	X2, Y1	X3, Y1	X4, Y1	X5, Y1	X6, Y1	X7, Y1	X8, Y1
X1, Y2	X2, Y2	X3, Y2	X4, Y2	X5, Y2	X6, Y2	X7, Y2	X8, Y2
X1, Y3	X2, Y3	X3, Y3	X4, Y3	X5, Y3	X6, Y3	X7, Y3	X8, Y3
X1, Y4	X2, Y4	X3, Y4	X4, Y4	X5, Y4	X6, Y4	X7, Y4	X8, Y4
X1, Y5	X2, Y5	X3, Y5	X4, Y5	X5, Y5	X6, Y5	X7, Y5	X8, Y5
X1, Y6	X2, Y6	X3, Y6	X4, Y6	X5, Y6	X6, Y6	X7, Y6	X8, Y6
X1, Y7	X2, Y7	X3, Y7	X4, Y7	X5, Y7	X6, Y7	X7, Y7	X8, Y7
X1, Y8	X2, Y8	X3, Y8	X4, Y8	X5, Y8	X6, Y8	X7, Y8	X8, Y8

3.0 RESULTS AND DISCUSSION

3.1 Different Configurations for Pixel

There are four different configurations for pixels amount, which is: 8x8 pixels, 16x16 pixels, 32x32 pixels, and 64x64 pixels. The reconstructed images using different configurations are shown in Figure 3.

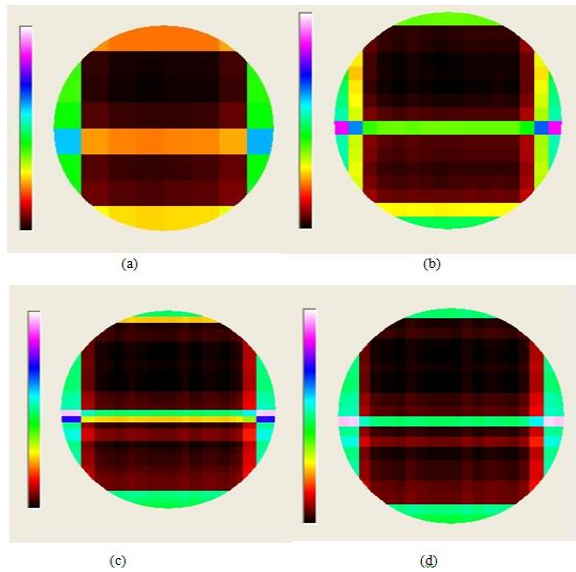


Figure 3 The reconstructed image using simulation for different pixel resolution (a) 8x8 (b)16x16 (c) 32x32 (d) 64x64

3.2 Multi Object

From Figure 3(a), 8x8 pixels will produce high density color (orange) in the middle of the image. Actually, there is nothing in the middle of the pipeline. Therefore, 8x8 pixels configuration cannot produce a very accurate image as occurred in the flow. The same reading of sensors value as shown in Figure 3(d), produce a very sharp image. As we can see, for 64x64 resolutions, it shows an identical two separated objects in the pipe (top and bottom).

By comparing the result of 8x8 pixels with 64x64 pixels, we know that the 64x64 pixels resolution can produce a clear and sharp image. Therefore, 64x64 pixels resolutions is the suitable resolution in this paper. The next subsection will differentiate between the results of different number of object which is 2, 3 and 4 objects.

3.2.1 Two Objects

In this simulation, two objects are located in the pipe as shown in Figure 4 as indicated by the red colors. The first object is situated at the light path between transmitter 4 and receiver 4. At the same time, transmitter 24 and receiver 24 also affected because of the location of this object. The same situations happen for the second object where two pairs of transmitter-receiver affected. (transmitter 16 and receiver 16 and transmitter 36 and receiver 36).

	T1	R2	T3	R4	T5	R6	T7	R8	T9	R10	T11	R12	T13	R14	T15	R16	T17	R18	T19	R20	
R21																					T21
T22																					R22
R23																					T23
T24																					R24
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R39																					T39
T40																					R40
	R1	T2	R3	T4	R5	T6	R7	T8	R9	T10	R11	T12	R13	T14	R15	T16	R17	T18	R19	T20	

Figure 4 The light that travel from transmitter to receiver

Both objects give a zero voltage reading in the receiver side. If there is no object, it gives 5V. This information is used to create the modeling for two objects for 8x8 and 64x64 pixel resolutions.

Table 3 Voltage value to be used for simulation in visual basic

Voltage value for receiver in horizontal projection(x)	5,5,5,0,5,5,5,5,5,5,5,5,5,5,5,5,5,5,5,5,5,5
Voltage value for receiver in vertical projection (y)	5,5,5,0,5,5,5,5,5,5,5,5,5,5,5,5,5,5,5,5,5,5

Figure 5 shows the reconstructed image for two objects. However, two more additional objects also created in the tomogram. This effect is called the smearing effect where the overlapping between transmitter T36 and receiver R36 and T4-R4 light path create the first extra object and the overlapping between T16-R16 and T24-R24 light path produce the second error object.

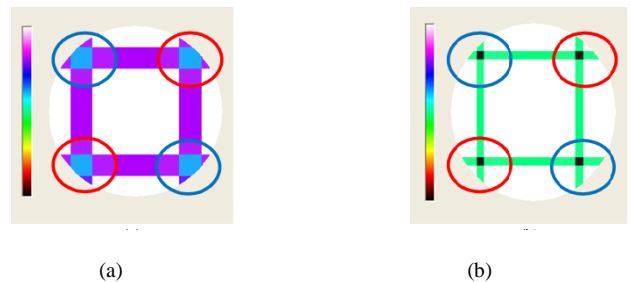


Figure 5 The tomogram for 2 objects, the red circle is an error object; the blue circle is the true object (a) 8x8 (b) 64x64

The scale that is used in Figure 5 has its own meaning. The upper side shows that this is for gas area and when it goes to the bottom, it will display a solid concentration.

3.2.2 Three Objects

The tomogram as shown in Figure 6 shows the resultant tomogram for three objects. In this case, more overlapping area is created and this produces a smearing effect more than two objects.

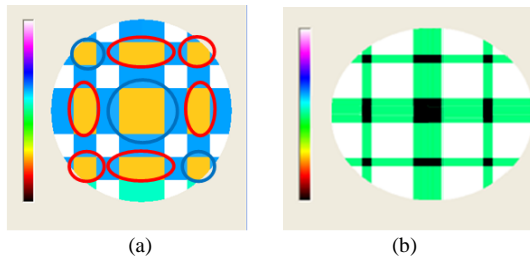


Figure 6 The tomogram for 2 objects, the red circle is an error object; the blue circle is the true object (a) 8×8 (b) 64×64

3.2.3 Four Objects

Figure 7 shows the resultant tomogram for four objects. It shows a correct tomogram compared to two and three objects previously. The correct result happened because of the location of the objects are located at the same line for every object. This is the advantages of this configuration. If the object is located at the different line of light path, the same thing will happen same as two and three objects previously.

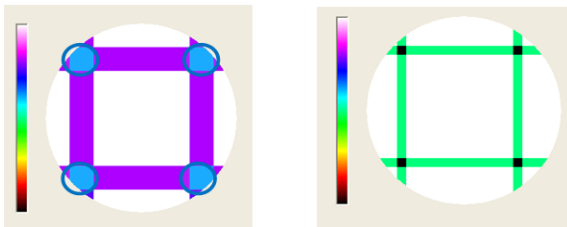


Figure 7 The tomogram for four objects (a) 8×8 (b) 64×64

4.0 CONCLUSIONS

Different configurations of pixels will give significant change in reconstructing image. For 8x8 pixels configuration, the setting is easier compared to 64x64 pixels. But the reconstructed image is not clear and accurate. Therefore, 64x64 pixels should be used for our project.

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