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Optical Tomography: The Effect of Interpolation Technique towards Image Performance

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Abstract. In optical tomography Linear Back Projection (LBP) and Filtered Back Projection (FBP) algorithm are widely used. This paper will apply an interpolation technique to enhance the image quality of the image after the LBP and FBP algorithm take place in the image. The interpolation technique will be tested to see the minimum number that can produce the best image. From the result, it shows that the minimum number is 5. The interpolation technique can improve the image quality compared to LBP and FBP method.

Keywords: Interpolation, Optical Tomography, Linear Back Projection (LBP)

1. Introduction

Optical tomography is a unique technique where it uses low energy electromagnetic radiation for example infra red and ultraviolet wavelength range to measure the extinction profile from an object. This measurement will be manipulated to reconstruct the tomogram image at the PC. Optical tomography is suitable technique to visualize the object inside the pipeline or vessel without have to cut the pipe. This technique usually been applied in solid gas application such as sugar, rice and animal feed pellet to make sure the smoothness of the flow without any obstrcution and produce the needed amount of material as it can also be used to measure the mass flow rate [1]. In tomography, there are many image reconstruction algorithms that can be used to enhance the image quality. LBP become the popular algorithm as it has a capability to producing faster image and make it suitable for real time application. Interpolation will be applied in the post processing image as it can give a clearer image compared to LBP and FLBP.

In optical tomography, the nonlinearity effect such as reflection, refraction and deflection can cause a problem in the measurement. However these effect can be treated to some extend with dedicated reconstruction algorithm[2].

Many algorithm techniques has been used widely in tomography. Iterative method would be more typically be applied to such undetermined problems to enable the inclusion of a priori information. For the complete review regarding the algorithm being used by researcher in optical tomography area, it can be reffered in [3]. This paper will see the effect of applying interpolation technique to the image perforamance.

This paper is devided into several sections. First section explaining the introduction of the research, related works and the paper objective. Section 2 discover the method that is used in this research. Result is explained in section 3 and lastly section 4 conclude the research finding.

2. Method

Before applying the interpolation technique, the image will go through a process of reconstruction image using LBP and FLBP. The interpolation is take place in the two situations which is after LBP is being applied and second one is after FLBP algorithm is used in reconstructing the tomogram.

A. LBP

Most of the work in process tomography has focused on the use of Linear Back Projection (LBP) algorithm. It is originally developed for X-ray tomography and it also has the advantages of low computation cost. The LBP is computationally straightforward to implement and is a popular method for image reconstruction.

Sensitivity maps which were derived for the individual sensors are used by the LBP algorithm to calculate concentration profiles from measured sensor values [4]. The projection that been used in this experiment is parallel beam projection with 80 views that come from the light beam of the sensors arrangement.

The process of obtaining concentration profile using LBP can be expressed mathematically as follow:

$$V_{LBP}(x,y) = \sum_{Tx=0}^{79} \sum_{Rx=0}^{79} S_{Tx,Rx} \times \overline{M}_{Tx,Rx}(x,y) \tag{1}$$

where,

$V_{LBP}(x,y)$ = Voltage distribution on the concentration profile matrix for Parallel Beam

$S_{Tx,Rx}$ = The sensor loss value

$\overline{M}_{Tx,Rx}(x,y)$ = The normalized sensitivity matrices

B. FLBP

LBP will give a smearing effect to the tomogram. Therefore filtering will eliminate all the unwanted image and only display the needed one. FLBP will be used as a filter in this research. Once the voltage distribution from LBP technique is acquired, the filtered will take place by setting a threshold value for the voltage distribution. All the value that are below the threshold value will be set as zero, and the value higher than the threshold limit are remained the same. The threshold value is set to the maximum threshold value which is 1, where all the value below this limit will be set as zero. This value is selected as it can eliminate the smearing effect. If it is below the threshold limit, the smearing effects will occur. Therefore, the optimum value of the threshold must be set correctly. The comparison between phantoms must be made, and it will eliminate all the smearing effect and only leave the image for original phantom. The mathematical of FLBP can be expressed as

$$V_{FLBP}(x,y) = F_{Threshold} \times V_{LBP}(x,y) \tag{2}$$

where,

$V_{FLBP}(x,y)$ = Voltage distribution after filtering

$F_{Threshold}$ = Threshold value is a ratio value between the voltage sensor reading and the voltage when the full flow happen

C. Interpolation

Smoothing operation in interpolation technique is used primarily for diminishing spurious effects that may be present in an image as a result of a poor transmission channel. Interpolation, also known as neighborhood averaging is a straightforward spatial-domain technique for image smoothing. Given an r x r image $f(x,y)$, the procedure is to generate a smoothed image $g(x,y)$ whose values at every points (*x, y*) is obtained by averaging the values of the pixels of *f* contained in a predefined neighborhood of (*x, y*). In other words, the smoothed image is obtained by applying equation (3) and equation (4).

$$g(x,y) = f\left(\frac{x}{2}, \frac{y}{2}\right) \tag{3}$$

$$x = \text{even number},\ y = \text{even number}$$

$$g(x,y) = \{ \frac{g(x,y-1) + g(x,y+1)}{2} \frac{g(x-1,y) + g(x+1,y)}{2} \} \quad (4)$$

3. Result

By using the LBP technique, the produce image has noise in the background and the shape cannot be predicted. After make interpolation, the noise effect disappear and the image become smoother and the shape can be seen. There are two types of interpolation that is implemented in this paper which is the interpolation before the filtering of LBP take place and the interpolation after the filtering was done to the tomogram.

Table 1 shows the sphere shape that is reconstructed using LBP algorithm. As can be seen here, the shape is not clear with a noise in the background where the noise has a same colour as the object.

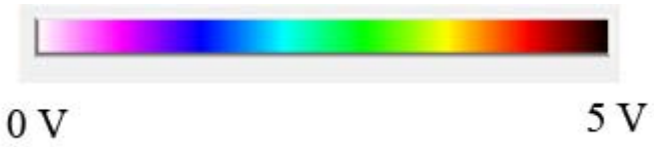
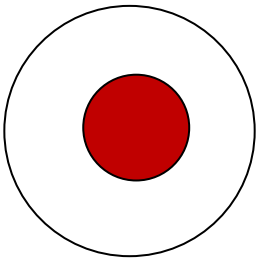
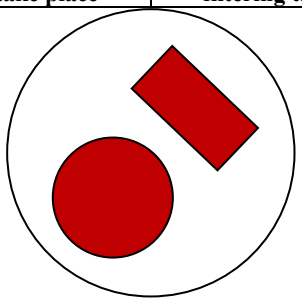
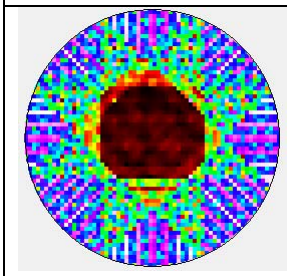
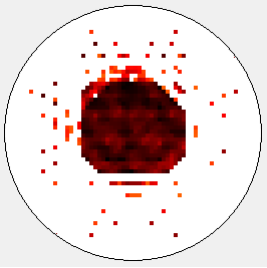
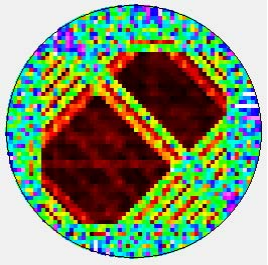
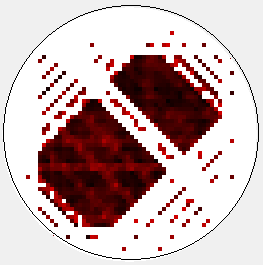
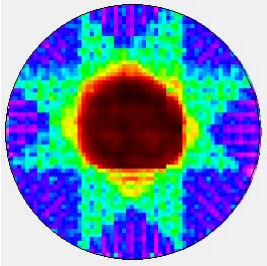
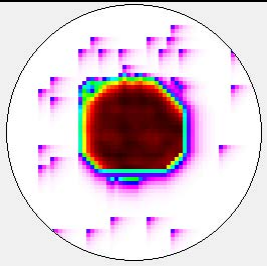
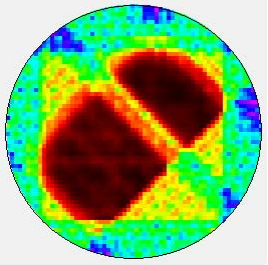
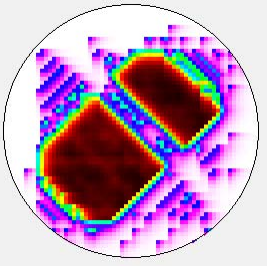
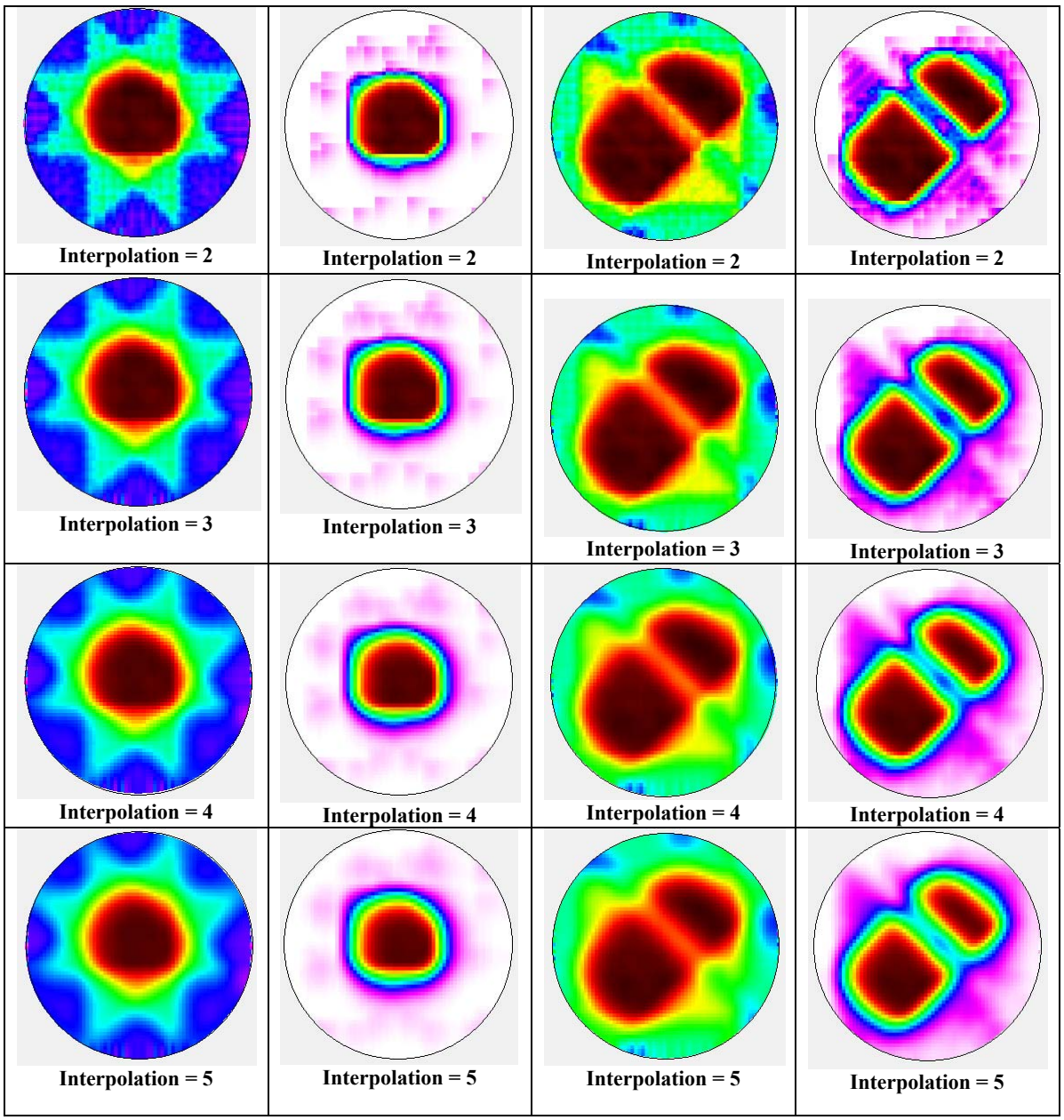


Fig. 1: Colour bar

TABLE I INTERPOLATION TECHNIQUE FOR SPHERE OBJECT

Interpolation before filtering take place	Interpolation after filtering take place	Interpolation before filtering take place	Interpolation after filtering take place
			
 Interpolation = 0	 Interpolation = 0	 Interpolation = 0	 Interpolation = 0
 Interpolation = 1	 Interpolation = 1	 Interpolation = 1	 Interpolation = 1



By applying the interpolation, the noise can be erased from the image as shown in Table 1. In the sphere object, for one time interpolation, all the noises are erased but the image is not smooth. The sphere shape also improves. The increasing number of interpolation make the image smoother but the region that has a dense color image becomes small. In this research there is only two phases that involve which is solid and gas, therefore, the dense color is not a problem as it can be differentiated clearly between the two phase flows using the color bar as shown in Fig.1. For example, for interpolation equal to five, the gas is green and blue while for the solid color is start from yellow until black. For two objects in the pipe which is a sphere and rectangle the noise is everywhere in the image and it also not smooth. By applying the interpolation technique the noise problem can be solved. The interpolation for both cases is restricting to 5 as this is the best setting that can produce a better image.

4. Conclusion

LBP and FLBP is a norm algorithm to reconstruct the image. LBP gives smearing result in the tomogram image but it is faster algorithm in real time situation. FLBP improve the image by filtering all the smearing effect. Interpolation improves the performance of LBP and FLBP respectively but it only can be used in offline technique as it need time to process the image depends on the number of interpolation that is selected.

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6. Reference

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