Image Compression Using Imaging Tomography Technique

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Abstract
Imaging Tomography is very powerful tool as a nondestructive imaging method, it use forward and back projection technique to create an image for a slice of an object. This technique had been simulated in this research on images as a compression method. The result shows that imaging Tomography technique has high compression ratio for large images and it has forward relationship with the image dimensions. The Fourier Slice Theorem filter used to retrieve the images from its 2-D projection, image quality was acceptable (5-7 dB) comparing with compression ratio that achieved, using another filter it could give better result.

كبس الصور بوساطة تقنية التصوير المقطعي

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الخلاصة
يعد التصوير المقطعي كأداة قوية جدا كوسيلة للتصوير غير ألإتلافي, فهو يستخدم الإسقاط الأمامي والعكسي لإنشاء صور لشرائح للجسم المطلوب. في هذا البحث تم محاكاة هذه التقنية باستخدام الصور كوسيلة لضغط الصور. بينت النتائج ان تقنية التصوير المقطعي تمتلك نسبة كبس عالية وهذه النسبة على علاقة طردية مع ابعاد الصورة. تم استخدام مرشح نظرية فورية للشرائح لاسترجاع الصور من مساقطها الثنائية, حيث كانت جودة الصور مقبولة (5–7dB) مقارنتا مع نسبة الضغط المتحققة, يمكن تحقيق نتائج أفضل باستخدام مرشحات أخرى.

Introduction
Tomography refers to the cross-sectional imaging of an object from either transmission or reflection data collected by illuminating the object from many different directions [1]. Imaging process done into two steps, the first by collect data from the object using waves forming a 2-D representation for a slice of the object, the data collected in this stage represent a sets of line integrals which usually called a 2-D projection (in some articles called the sinogram of the object) and this process called 'forward projection' [2]. The second step is to extract the sectional image from its 2-D projection this process called ‘back projection’ [2]. The transmission tomography imaging method usually uses the X-ray to form images for the internal structure of an object under interest [1]. The size of the projection is usually smaller than the section size. In this research we will show how to use this feature to use the forward and back projection as image compression method.

Forward Projection on Images
A 2-D projection formed from sets of line integrals from many different directions, line integrals, as the name implies, represent the integral of some parameter of the object along a line. By exchanging the object by an image the parameter that the line integral represent is the intensity.

We will use the coordinate system defined in Fig. 1 to describe line integrals and projections for an images. In this example the image is represented by a 2-D function f(x, y) and each line integral by the (r, θ) parameters [2][3].

$$x\cos\theta + y\sin\theta = t \quad \dots (1)$$

and we will use this relationship to define line integral $P_\theta(t)$ as

$$P_\theta(t) = \int_{(r,\theta)\,line} f(t,s)\, ds \quad \dots. (2)$$

using the delta function, this can be rewritten as

$$P_\theta(t) = \int_{-\infty}^{\infty}\int_{-\infty}^{\infty} f(x,y)\,\delta(x\cos\theta + y\sin\theta - t)\, dxdy$$

… (3)

the function $P_\theta(t)$ is known as Radon transform of the function f(x, y).

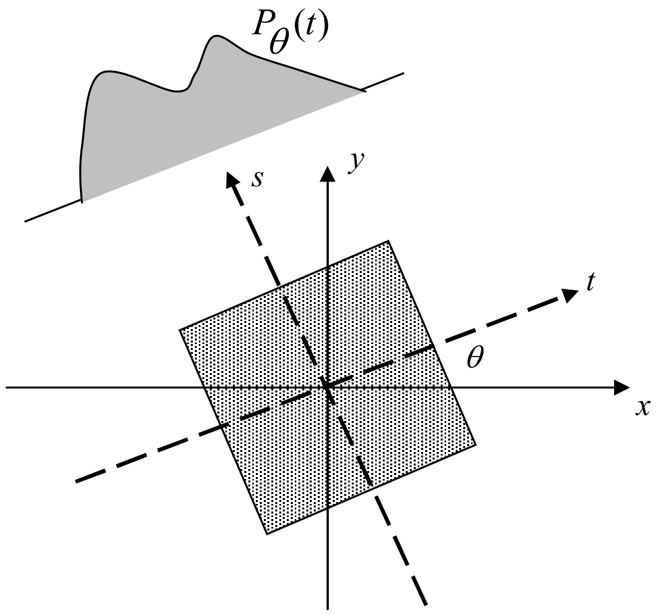


Figure 1- The Forward Projection Process For An Image

Back Projection Using Fourier Slice Theorem

Fourier Slices Theorem filter (FST) used to extract the image from its 2-Dprojections because it has high efficiency with low texture high contrast images which compatible with case that we used in this research with short computational time [4].

The Fourier Slices Theorem stated thatthe 1D Fourier transform of a projection taken at angle θ equals the central radial slice at angle θ of the 2D Fourier transform of the original object. Therefore to retrieve the image from its 2-D projection we will find the 1D Fourier transform using [1][3]:

$$S_\theta(w) = \int_{-\infty}^{\infty}\int_{-\infty}^{\infty} f(x,y)\, e^{2\pi i w(x\cos\theta + y\sin\theta)}\, dxdy$$

... (4)

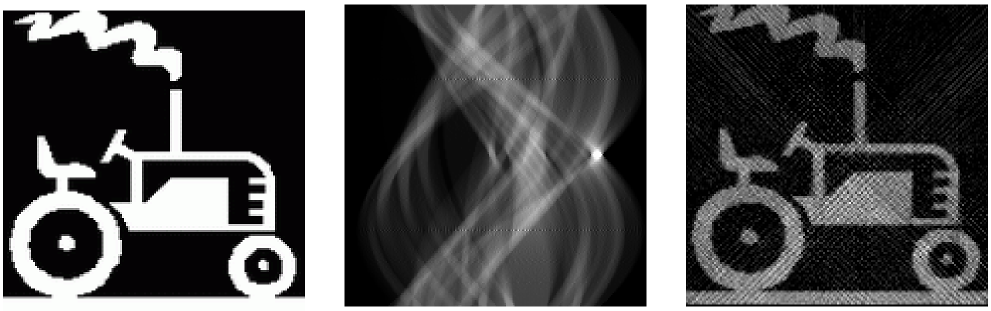
The inverse 2-D Fourier transform is applied to calculate the image using [1][3]:

$$f(x,y) = \int_{-\infty}^{\infty}\int_{-\infty}^{\infty} F(w,\theta)\, e^{2\pi i(wx+\theta y)}\, dw\, d\theta$$

… (5)

The Results

We used one image with three differ resolution (300×300,500×500, and 700×700), Fig. 2 shows the image and its 2D projection and the retrieved image. The2-Dprojection for different number of angle (180, 60) is calculated, the Peak Signal-to-Noise Ratio (PSNR) and the Compression Ratio (CR) calculated for each number of angles, as shown in Table 1. Since eq. 5 is defined for infinite period therefore when applied it for finite period (angles and line integrals) we should stop at cutoff frequencies because reconstruction images without determining the cutoff frequencies will results in some image degradation. The cutoff that determined manually in the research is 4.5 to have the best results.



Sample image Its 2-D Projection Retrieved image

Figure 2-One Of The Sampled Images With Its 2D Projection And The Retrieved Image (Angle Distance Is 1 Degree)

Table 1- The Compression Ratio And The PSNR Results

The samples	Image dimensions (pixel)	Image size (byte)	Angle space (degree)	Projection dimension (pixel)	Projection size (byte)	CR (%)	PSNR (dB)
1	300x300	90000	1	425x180	76500	15	6.349
			3	425x60	25500	71.7	6.003
2	500x500	250000	1	709x180	127620	49	6.776
			3	709x60	42540	83	5.670
3	700x700	490000	1	991x180	178380	63.6	6.662
			3	991x60	59460	87.9	5.363

The Discussion

Fig. 3 shows that the compression ratio for the sample images is not fixed value; in fact it increases with the increasing of the image dimensions, and with increasing of the angle space.

This increasing in the compression ratio with the increasing in the image dimensions is due to when the image dimension increase one of the projection dimension increases (the resolution dimension) while the other (the number of angles dimension) does not effect, even that increment in the one of the projection dimension is equal to the rote mean square of the increment in the images dimensions. Reducing the angle space will cause a reduction in the dimension the number of the angles, which will reduce the projection size, which will increase the compression ratio.

Fig. 4 shows that the retrieved image quality (PSNR) did not effected when the image dimension increase, because the Tomography imaging does not depend on the object dimensions (resolution). Beside that reducing the number of angles (increasing the angle space) will reduce the projection size and the quality of the retrieved image, even if the reduction in the retrieved image quality when we make the angle space equal to three (60 angle) the reduction in the retrieved image quality is insignificant while the projection size reduced one to third of its size.

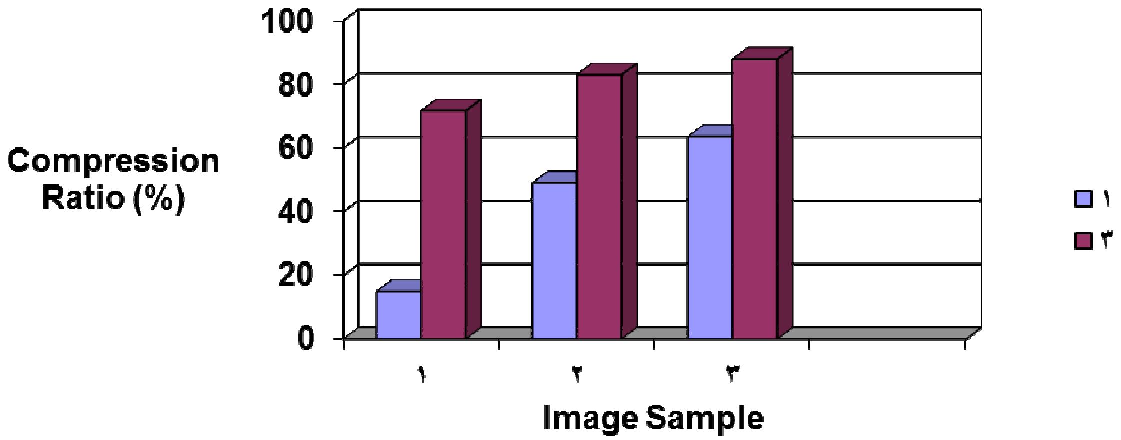


Figure 3- Compression Ratio For The Sample Images With Different Angle Spaces (1 And 3degrees)

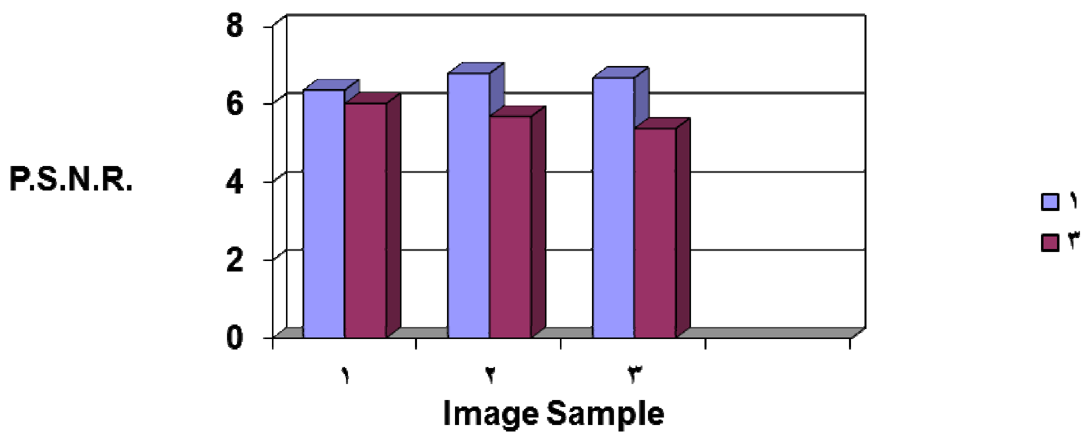


Figure 4- PSNR For The Image Samples With Different Angle Spaces

Conclusions

The compression ratio using the forward and back projection technique is not fixed value in fact it has forward relationship with the image dimensions therefore it is very good method to compress the large image (large than 500×500) with very high compression ratio (more than %80).

The image quality for the retrieved images using FST was acceptable comparing with the compression ratio that achieved (5-7 dB), the image quality that achieved is not the final image quality that this method can give, the imaging Tomography filters are wide area to research and other filter than FST can give better results.

References

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