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Image processing: Image compression using compressed sensing, discrete cosine transform and wavelet transform.

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Abstract Recently, the image quality and the speed of acquisition are very studied, particularly in the medical field. We try to find in our paper the most efficient compression method, which allows having good image quality with a short compression period. Reducing the compression time amounts to reducing the acquisition time. In our article, we proposed three compression methods applied to the medical image: the discrete cosine transform (DCT) method, the wavelet transformation (DWT) and the compressed sensing method (CS). We studied also the acquisition time. In our results, we found that the DWT method gives better image quality compared to other methods. We found also that the CS method is faster than other methods. .

Keywords: Compression image, Discrete Cosine (DCT), Wavelet Transform (WT), compressed sensing (CS), medical image.

1 Introduction

Image quality is very important in the medical field. It gives more information to the physical, anatomical or functional data of a human. Good medical image quality helps radiologists and doctors to give the correct diagnosis. In addition, the acquisition time is very important in medical imaging .For faster decision

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about doctors and for the comfort of the patient, it is necessary to reduce the acquisition time.

Image compression is one of the most widely used in image processing techniques today. Its role is to reduce the size of the image in order to reduce the space. It facilitates processing with a reduced number of data in a short time. Different compression methods used such as the discrete cosine Transform (DCT) (Nasir Ahmed.1972), Wavelet transform (DWT) (Alfred Haar.1909)[2],JPEG2000 (the Joint photographic Experts Group working group.1997-2000)[10], etc.)

Unfortunately, the compressed image presents a loss of information, which degrades the image quality. In this article, we improved the image quality by using less data. We used compression methods to choose the most relevant data. We chose three compression methods: DCT, DWT and CS. In the following of this article, we presented compression methods used here and the different results obtained from the compression methods with discussion. We ended this article with a conclusion.

2 Methods

In our work, we used three compression methods: DCT, DCT and CS

2.1 Discrete Cousin Transform (DCT)

The Discrete Cosine Transform (DCT) is a type of fast computing Fourier transform, which maps real signals to corresponding values in frequency domain. The DCT method works on the real part of the complex signal because most of the real-world signals are real signals with no complex components[1]. We will discuss the implementation of DCT algorithm on medical Image Data The Figure 1 represent the diagram that explains the steps in reconstructed compressed image using DCT. The information in the frequency domain DCT (i, j) is obtained from the discrete data of the image img (x, y) where the X and Y axes are the horizontal and vertical dimensions of the image[3] ,[4],[11]. In this article, we applied the DCT line by line on our image. The compressed image img'(x, y) is obtained from the frequency data DCT (i, j) by applying the inverse transform DCT (i,j)-1 .

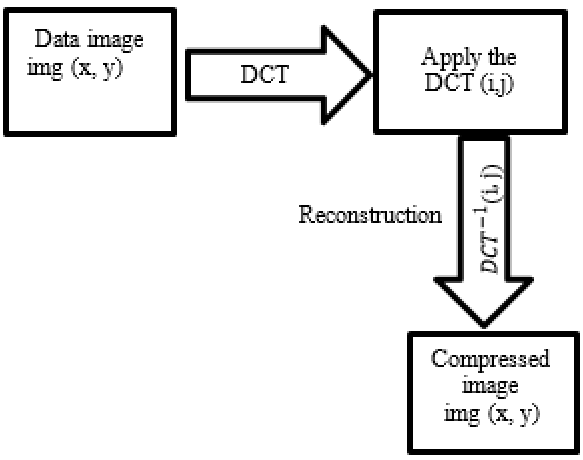

Fig. 1 Diagram for compressed image using DCT

2.2 Discrete wavelet transform (DWT)

The Discrete Wavelet Transform (DWT) is a representation of signals or images in a time-frequency form. The Figure 2 represents the diagram, which explains the reconstruction of the compressed image using wavelets [6], [12]. The time-frequency data obtained from the original image and the compressedimage reconstructed from the time-frequency data.

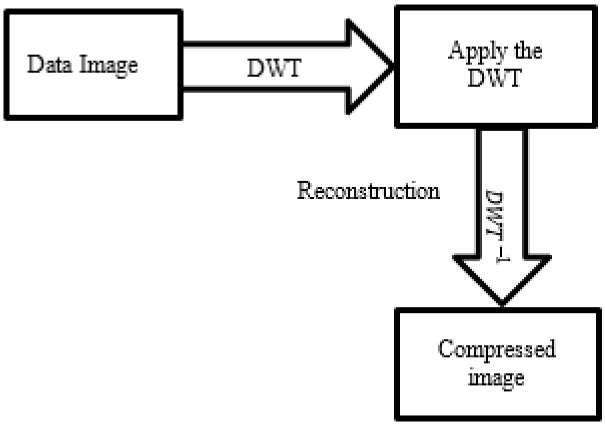

Fig. 2 Diagram for compressed image using DWT

2.3 Compressed Sensing (CS)

Compressed sensing (CS) is a newer compression method. It based on three essential points:

• Sparsity: the desired signal must have a sparse representation in a known transformation domain.

• Incoherency: The subsampled space should generate aliasing artifacts similar to noise in the compression transform domain.

• Nonlinear reconstruction: A nonlinear reconstruction is necessary to exploit the Sparsity while maintaining the consistency of the data acquires [7],[8] ,[9]To meet the need for the Sparsity, we applied a mask on our data[5]

The figure 3 represent the diagram, which explains the steps of reconstructed compressed image using CS.

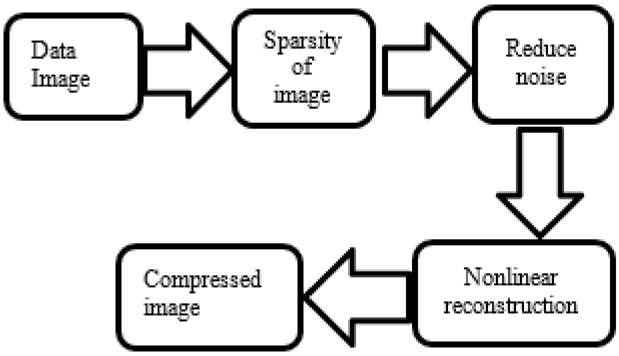

Fig. 3 Diagram for compressed image using CS.

3 Results and Discussions

In our applications, we used the Matlab 2014a language on a dual graphics card I5 PC. In order to study the performance of the compression methods, we chose a phantom image of size 512 * 512. The Figure 4 (a) shows the phantom image used. To improve our results, we used the real data image [6]. The Figure4 (b) shows the real image used in this work. It is a T1-weighted image acquired from 1.5 Tesla MRI machine (GE, Waukesha, WI) using an 8-channel head coil 3D and spoiled gradient echo sequence (SPGR). This image is acquired using the following parameters: TE = 8 ms, TR = 17.6 ms, an angle of 20°, and a field of view (FOV) of 20cm × 20cm × 20cm with a size of 200 × 200 × 200 for a isotropic resolution 1 mm3.

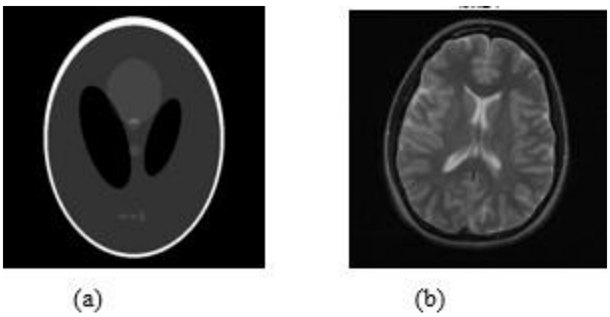

Fig. 4 (a) unreal data image, (b) real data image.

We applied the three compression methods: DCT, DWT and CS on images data used. We studied the results of the three compression methods by evaluating performance parameters such as PSNR and RLNE. We compared the three compression methods by studying the image quality and the compression time. We have chosen in the two compression methods: DCT and DWT different percentages in order to evaluate different thresholds. The goal is to choose the most correct threshold.

Algorithm 1 explains the different steps followed in each method:

Algorithm 1:

- Load image data (phantom or MRI).
- Apply the DCT (or DWT) on the data.
- Take the absolute value of the new data.
- Select data on a table in descending order.
- Choose different percentage of the most relevant data (1%, 5%, 10%,20%, 30% and 50%).
- Evaluate the threshold by eliminating unnecessary data.

Apply the DCT-1 (or DWT-1) on the data obtained after the threshold.

In the compressed sensing method, we used a mask to ensure the sparsity of the image. This mask chooses a large number of points at the centerof the frequency data. These points correspond to the most relevant points. Algorithm 2 explains the different steps followed.

Algorithm 2:

- Load image data (phantom or MRI)
- Apply a mask on the frequency data
- Nonlinear reconstruction to the new data.

In this part, we applied the DCT and DWT compression methods on the phantom and real images. We used different percentages: 1%, 5%, 10%, 20%, 30%, and 50% for both DCT and DWT methods. Figures 5 and 6 represent respectively reconstructed compression phantom and real images with DCT and DWT methods.

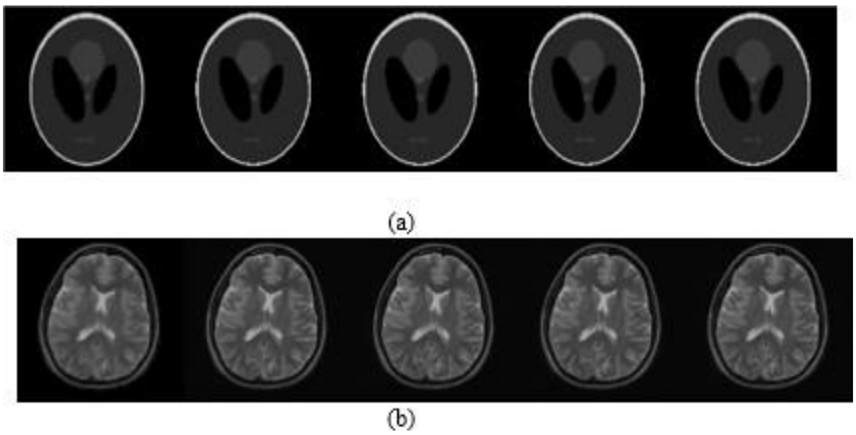

Fig. 5 Images compressed by the DCT method using different percentages 1%, 5%, 10%, 20%, 30%, and 50% (a) phantom (b) real.

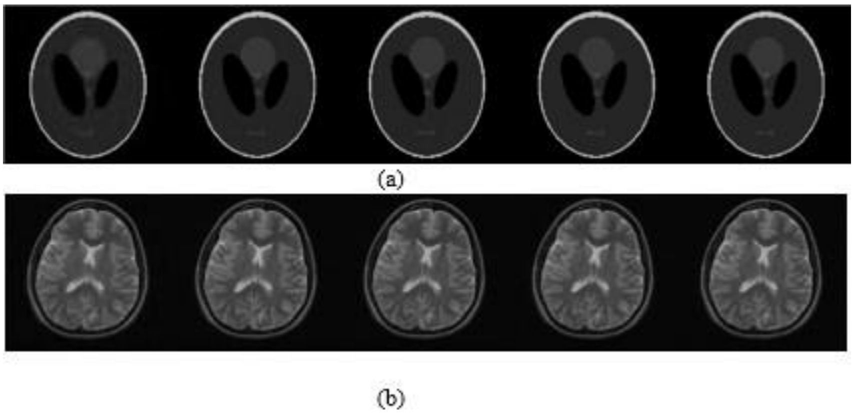

Fig. 6 images compressed by the DWT method using different percentages 1%, 5%, 10%, 20%, 30%, and 50% .(a) phantom (b)real.

In this part, we applied Compressed Sensing compression method on both phantom and real images, we used a mask showed by the Figure7 (a). Applying the CS method on both phantom and real images, Figures 7 (b) and (c) represent respectively phantom and real reconstructed images compressed with the CS method.

Fig. 7 CS method using (a) mask, reconstructed compressed image (b) phantom (c) real.

After the compression of images, we noticed that the quality of the phantom and real images reconstructed by the three methods is identical. Therefore, we choose in following applications the real image. Moving from one method to another, we noticed that the DCT and DWT methods give good quality images compared to the CS method. Quantitatively, we studied the quality of the real images by evaluating the two parameters: the PSNR and the RLNE. The Table 1 compares the different results obtained by the three compression methods DCT, DWT and CS. The Table2 shows the time required to compressed image for each method.

Table 1 Evaluation parameters obtained from compressed images by three compression methods: DWT and DCT using different percentages (1%, 5%, 10%, 30% and 50%) and CS.

		PSNR	RLNE
DCT	1%	27.6387	0.1837
	5%	33.4647	0.0939
	10%	35.2194	0.0767
	20%	37.7316	0.0575
	30%	40.0271	0.0441
	50%	44.8865	0.0252
DWT	1%	31.0985	0.1233
	5%	34.0302	0.0880
	10%	35.5564	0.0738
	20%	37.9702	0.0559
	30%	40.2243	0.0431
	50%	45.0828	0.0247
CS		30.9564	0.1254

Table 2 Compression times for the three methods

Method	DCT	DWT	CS
Compression time (s)	9.869361	5.707984	1.004419

From results obtained by the Table 1, we noticed that the DWT method improved compressed image quality with a high PSNR and a reduced RLNE compared to other compression methods. Qualitatively and quantitatively, the two images compressed by the two methods DWT and DCT give Approximately same results. We notice that 10% of information is sufficient to obtaina good compressed image quality witch is approximately the same of the original image. The Figure 8 shows correctly these images. Qualitatively, the DWT method improves the image quality much more with noise suppression.

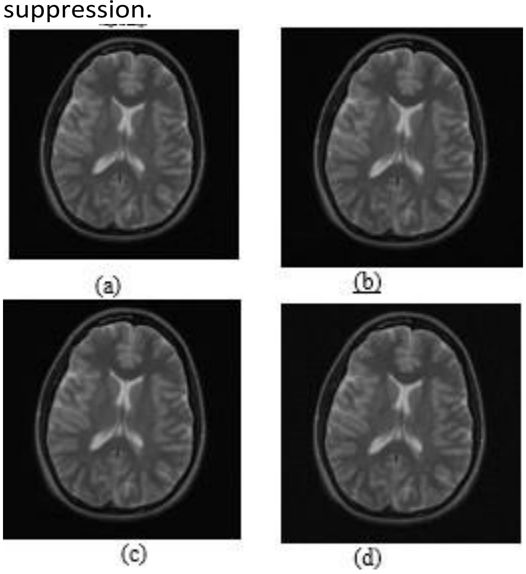

Fig. 8 (a) Original real data image, compressed image with 10% of data using (b) DCT and (c) DWT, (d) compressed image using CS.

In the CS method, the image quality degrades with noise occurring in the background of the image. It presents a reduced PSNR and high RLNE compared to parameters of the other methods.

We also noticed that the compression time by the CS method is reduced (approximately 1s) compared to the other methods (approximately 5s for WT and 9s for DCT). Reducing the compression time is very important in medical imaging; it will serve to reduce the acquisition time. Therefore, we noticed that the CS method is very important in medical applications

4 Conclusion

Image compression is a very large field that uses several methods. The difficulty is to choose the most efficient method. In this paper, we noticed that the DCT and DWT compression methods with the right choice of thresholding give better results. We also noticed that the CS method presents a degraded image quality but it allows a very fast compression time compared to other methods. These results have brought us to think of improving the CS method using different types of mask. We are also thinking of associating this method with other methods or with methods used in this article: CS-DWT or CS-DCT.

Acknowledgements

PSNR: Peak signal-to-noise ratio
RLNE: relative error between image original and image compression.
DCT: discrete cosine transforms.
DWT: Discrete wavelet transform.
CS: compressed sensing.

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