DWT based Image Registration of Medical Images for efficient disease Diagnosis System

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ABSTRACT

An efficient architecture is proposed in this paper for high speed 3D - Discrete Wavelet Transform computing. volumetric data sets produced by various 3D image acquisition devices such as computed tomography (CT) and magnetic resonance imaging (MRI) are processed in the wavelet filters (3D-DWT) with a efficient PSNR and Compression ratio

Keywords:

Computed tomography (CT), Position emission tomography (PET), Magnetic resonance imaging (MRI), Discrete Wavelet Transform, PSNR, MSE.

1. Introduction

Image processing methods, which are possibly able to visualize objects inside the human body, are of special interest. Advances in computer science have led to reliable and efficient image processing methods useful in medical diagnosis, treatment planning and medical research. In clinical diagnosis using medical images, integration of useful data obtained from separate images is often desired. The images need to be geometrically aligned for better observation

3D DWT has been used in various image and video compression and processing applications. Encoding volumetric data sets produced by various 3D image acquisition devices such as computed tomography (CT), position emission tomography (PET) and magnetic resonance imaging (MRI) are a number of 3D DWT applications. Scalable video coding and noise reduction between frames of a video are the applications that we can name for 3D DWT in the field of video coding and processing. DWT is one of the most computationally intensive parts in these image and video coding applications.

The available DWT architecture can be divided broadly into two schemes named as convolution scheme and lifting scheme. Normally convolution scheme is used to implement DWT filters. But this scheme uses huge number of multipliers which is very difficult to implement and take a large amount of resources in hardware. To eliminate thoseproblems lifting schemes is used. This scheme uses the basic convolution equations in such way that the numbers of multipliers are drastically reduced. Due to this reason lifting scheme is widely used to build chip than convolution scheme.

In this paper, a novel approach for the fusion of computed tomography (CT) and magnetic resonance images (MR) images based on wavelet transform has been presentedThe rest of the paper is structured as follows. Section 2, computed tomography (CT) magnetic resonance imaging (MRI) with respect to DWT In section 3 and 4, the high efficient architecture for the (5, 3) filter based 3D - DWT followed by the implementation and performance analysis in section 5, and section 6 concludes the work.

2.Medical Imaging - Magnetic resonance imaging (MRI) and Computed tomography (CT)

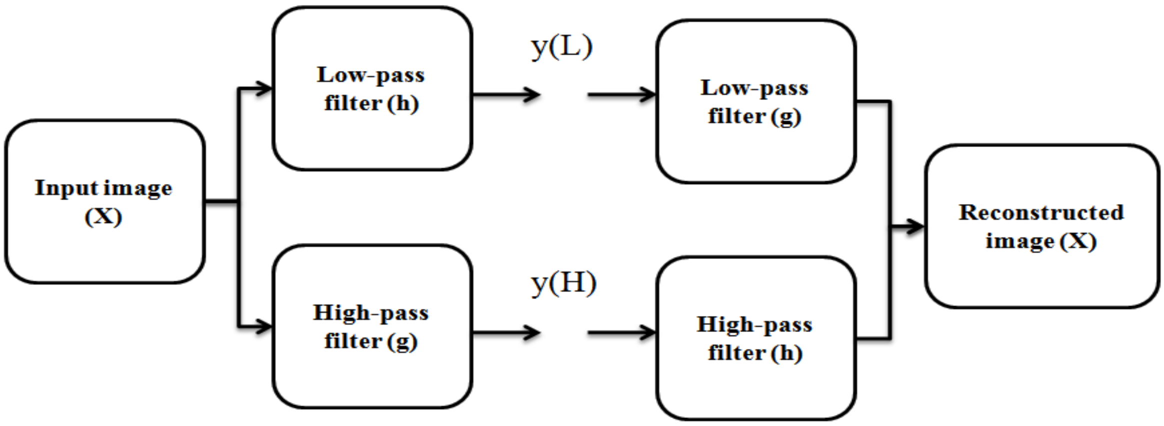
Magnetic resonance imaging (MRI) of the body uses a powerful magnetic field, radio waves and a computer to produce detailed pictures of the inside of your body. It may be used to help diagnose or monitor treatment for a variety of conditions within the chest, abdomen and pelvis. If you're pregnant, body MRI may be used to safely monitor your baby.

Computed tomography (CT) of the body uses special x-ray equipment to help detect a variety of diseases and conditions. CT scanning is fast, painless, noninvasive and accurate. In emergency cases, it can reveal internal injuries and bleeding quickly enough to help save lives.

Medical imaging provides a variety of modes of image information for clinical diagnosis, such as CT, X-ray, DSA, MRI, PET, SPECT etc. Different medical images have different characteristics, which can provide structural information of different organs. For example, CT (Computed tomography) and MRI (Magnetic resonance image) with high spatial resolution can provide anatomical structure information of organs. And PE (Positive electron tomography) and SPECT (Emission computed tomography) with relatively poor spatial resolution, but provides information on organ metabolism. Thus, a variety of imaging for the same organ, they are contradictory, but complementary and interconnected

3.Architecture of DWT – General structure

The best way to describe discrete wavelet transform is through a series of cascaded filters. We first consider the FIR based discrete transform. The input image X is fed into a low-pass filter h´ and a high-pass filter g´ separately. The output of the two filters are then sub sampled, resulting low-pass sub band y(L) and high-pass sub band y(H) as shown in the figure 1.



. Figure 2: DWT general structure

The original signal can be reconstructed by synthesis filters h and g which take the up sampled y(L) and y(H) as inputs. To perform the forward DWT the standard uses a 1-D sub band decomposition of a 1-D set of samples into low-pass samples and high-pass samples. Low pass samples represent a down sampled low-resolution version of the original set. High-pass samples represent a down sampled residual version of the original set, needed for the perfect reconstruction of the original set.

4. Proposed Architecture of 3D-DWT

The one-dimension (DWT) filter bank consists of two analysis filters, a low pass filter (LPF) and a high pass filter (HPF), which separate the frequency contents of input signal into the approximation (low frequency) coefficients and the details (high frequency) coefficients. The two dimensional (DWT) can be obtained by applying the one dimensional (DWT) along the rows and columns of the input image.

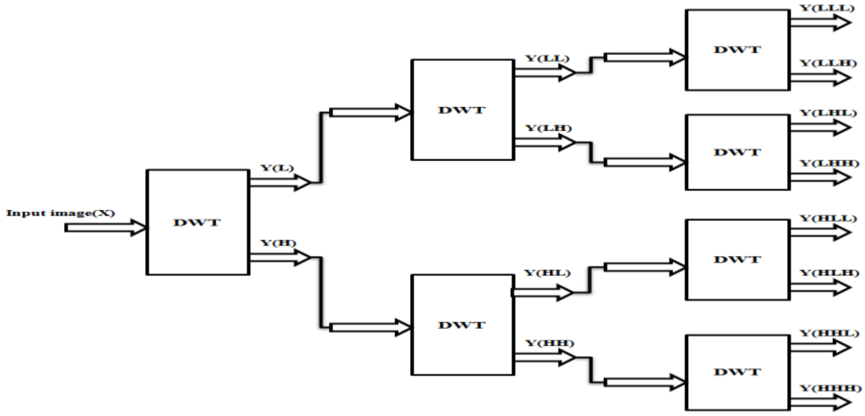


Figure 3: Architecture of 3D-DWT

the first level of computation, the input image is decomposed horizontally by applying one-dimensional (DWT) on each row to get two coefficients (y(L) and y(H)), then it is decomposed vertically by applying one-dimensional (DWT) on each column to get four wavelet coefficients y(LL), y(LH), y(HL), and y(HH). Further these co-efficient are processed for 3D-DWT and produce eight co-efficient as, y(LLL), y(LLH), y(LHL) , y(LHH), y(HLL), y(HLH), y(HHL) and y(HHH) as shown in Fig. 3.

5.Analysis of 3D - DWT design with medical imaging applications

PSNR is used to measure the quality of reconstruction compression codec. MSE is a measure of error between original I(i,j) and reconstructed image K(i,j). When comparing compression codecs, PSNR is an estimate to human perception of reconstruction quality.

$$PSNR = 10 \cdot \log_{10}\left(\frac{255^2}{MSE}\right)$$

Where

$$MSE = \frac{1}{m\,n}\sum_{i=0}^{m-1}\sum_{j=0}^{n-1}[I(i,j) - K(i,j)]^2$$

I (i,j) : Original Image
K (i,j) : Reconstructed Image and
m x n : Total number of Pixels in the Original image.

Table 1: Comparison of Quality of Reconstructed Images

Input Image	**PSNR for 3D-DWT in dB**	**MSE for 3D-DWT**
human_brain.jpg	53.0	0.2
elbow.jpg	52.3	0.3
ct_lungs.jpg	51.8	0.4
ct_neuro.jpg	53.0	0.3

6. Decomposition levels of image in 3D-DWT

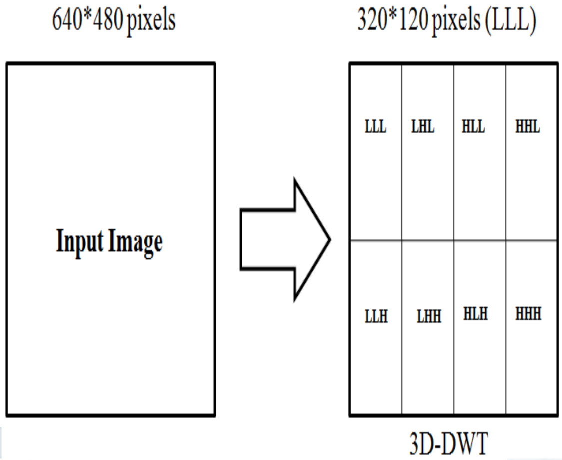
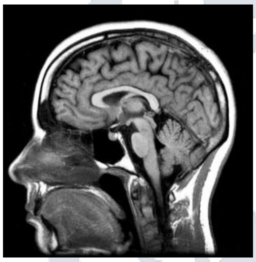
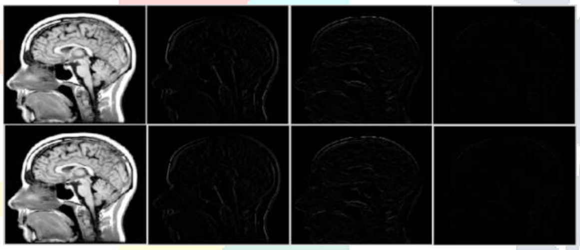


Figure 4: Image decomposition in 3D-DWT

The one-dimension (DWT) filter bank consists of two analysis filters, a low pass filter (LPF) and a high pass filter (HPF), which separate the frequency contents of input signal into the approximation (low frequency) coefficients and the details (high frequency) coefficients. The two dimensional (DWT) can be obtained by applying the one dimensional (DWT) along the rows and columns of the input image. At the first level of computation, the input image is decomposed horizontally by applying one-dimensional (DWT) on each row to get two coefficients (y(L) and y(H), then it is decomposed vertically by applying one-dimensional (DWT) on each column to get four wavelet coefficients (y(LL), y(LH), y(HL), and y(HH)). Further these co-efficient are processed for 3D-DWT and produce eight co-efficient as, y(LLL), y(LLH), y(LHL), y(LHH), y(HLL), y(HLH), y(HHL) and y(HHH) as shown in Fig. 4.

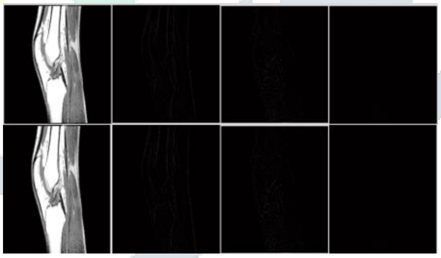


(a)

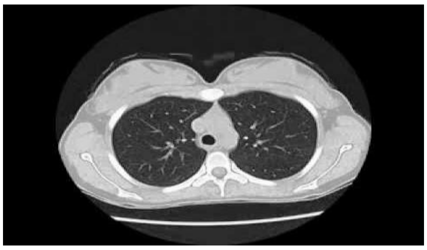


(b)

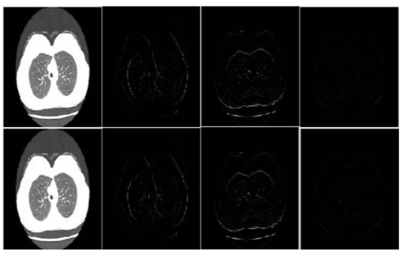
(c)



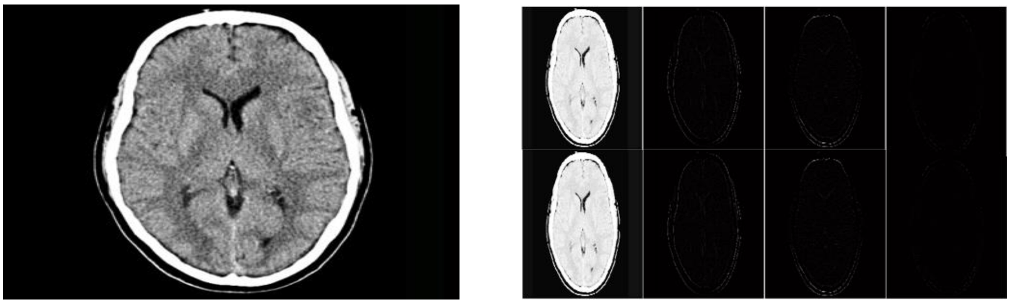
(d)



(e)



(f)



(g) (h)

Figure 5: Decomposition of images (MRI and CT) in 3D-DWT

(a) MRI - Human brain(500*500) (b) Decomposition of human brain(250*125)
(c) MRI – Elbow(1280*720) (d) Decomposition of elbow (640*180)
(e) CT – Lungs (480*360)
(f) Decomposition of lungs (240*90)
(g) CT – neuro (960*720) (h) Decomposition of neuro (480*180)

The Block based scheme was implemented in Matlab. As examples, four "standard" test images were chosen for the experiment. All these test images have different dimensions. As per the requirements of JPEG2000 standard, one can select blocks of size 4x4 pixels or more. Smaller the block size, smaller will be the computation time required for processing transforms DWT and IDWT.

7.Conclusion

We successfully implemented the 3D- discrete wavelet transformation on the DSP as applied to lossless image compression. We also implemented the transformation and its inverse in Matlab and compared the results to verify that our algorithm was working correctly. PSNR and Mean square error (MSE) for the Human brain, elbow, lungs and neuro system has been tabulated for the quality of the image reconstructed. Image compression and de-compression levels of MRI and CT images with respect to its size are described.

8. References

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