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Contrast Enhancement using Dominant Brightness Level Analysis and Adaptive Intensity Transformation for Medical Images

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ABSTRACT: This project presents a new medical image resolution enhancement technique based on the interpolation of the high-frequency subbands obtained by discrete wavelet transform (DWT) and the input image. The proposed resolution enhancement technique uses DWT to decompose the input image into different subbands. Then, the high-frequency subband images and the input low-resolution image have been interpolated, followed by combining all these images to generate a new resolution-enhanced image by using inverse DWT. In order to achieve a sharper image, an intermediate stage for estimating the high-frequency subbands has been proposed. The proposed technique has been tested on medical benchmark images. The visual results show the superiority of the proposed technique over the conventional and state-of-art image resolution enhancement techniques.

KEYWORDS: discrete wavelet transform (DWT), interpolation, medical images and resolution enhancement.

I. INTRODUCTION

Medical imaging techniques such as Magnetic Resonance Imaging (MRI) or Computed Tomography (CT) provide detailed images of internal organs. Quantitative information, like organ size and shape, can be extracted from these images in order to support activities such as disease diagnosis and monitoring and surgical planning. Medical images usually present characteristics like low signal-to-noise ratios and contrast-to-noise ratios. Image enhancement is a very powerful tool to improve the quality of a degraded image. In some cases a high spatial resolution and a high contrast are required, whereas in other cases more perceptual criteria may be favoured.

The resolution of an image has been always an important factor in many image processing and video processing applications, such as medical image resolution enhancement, feature extraction, satellite image resolution enhancement and video resolution enhancement. Interpolation in image processing is a method to increase number of pixels in a digital image. Interpolation has been widely used in many image processing applications, such as resolution enhancement, facial reconstruction and geometric transformations. Various interpolation techniques are often used to increase the resolution. There are three well known interpolation techniques are used, namely, nearest neighbour, bilinear and bicubic interpolation. Bicubic interpolation is more efficient than the other two techniques and also it produces smoother edges.

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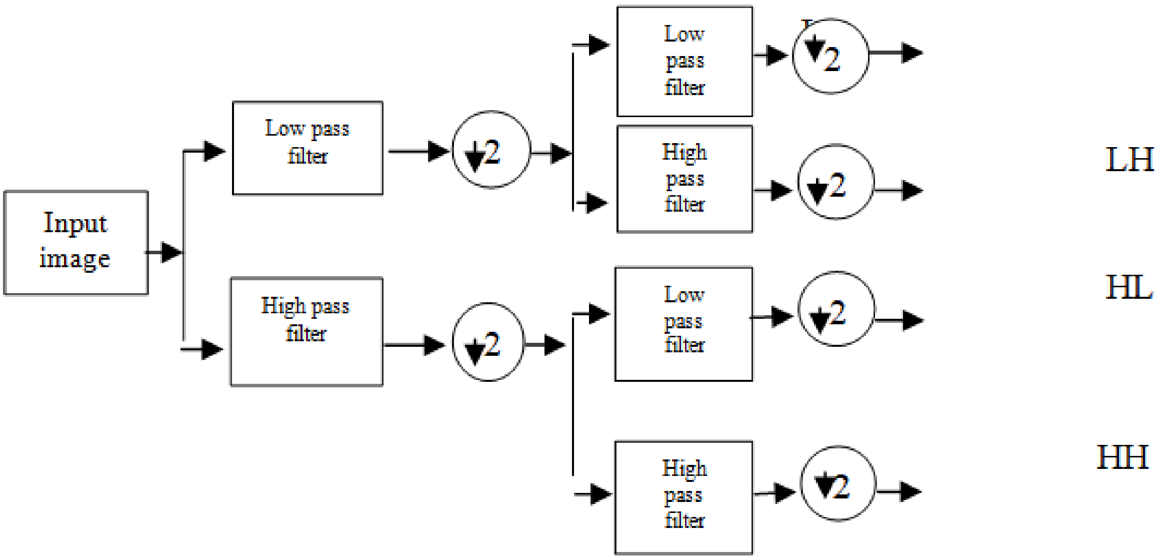

Fig 1.Block diagram of DWT filter bank of level 1.

Wavelets are also important in many image processing applications. The discrete wavelet transform has a huge number of applications in Image Processing, Science, Engineering, Mathematics and Computer Science. The 2-D wavelet decomposition of an image is performed by applying the 1-D discrete wavelet transform (DWT) along the rows of the image first, and then the results are decomposed along the columns. This operation results in four decomposed subband images called as, low-low (LL) subband, low-high (LH) subband, high-low (HL) subband and high-high (HH)

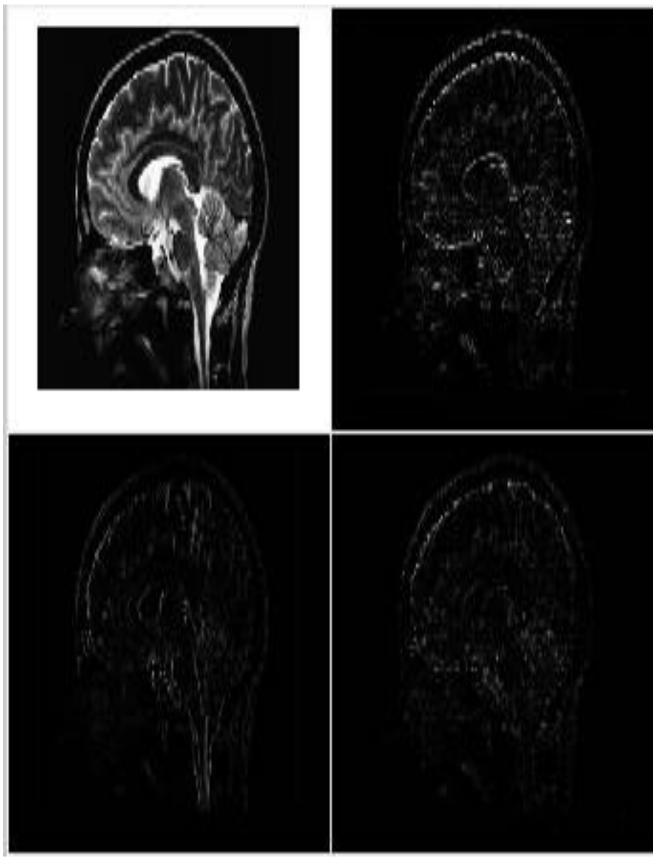

Fig 2. LL, LH, HL and HH subbands of a brain image obtained by using DWT.

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subband. The frequency components of those subbands cover the full frequency spectrum of the original image. Theoretically, a filter bank shown in Fig 1 should operate on the image in order to generate different subband frequency images. Fig 2, shows different subbands of a brain image, where the top left image is the LL subband, and the bottom right image is the HH subband.

This paper is organized as follows. Section II gives an overview on image interpolation techniques used for enhancement. Section III introduces the proposed wavelet based resolution enhancement technique. Section IV discusses the qualitative results of the proposed method. Section V gives the conclusions of proposed algorithm.

II. INTERPOLATION TECHNIQUES

Image resolution enhancement is the process of manipulating an image so that resultant image is more suitable than the original one for specific application. Image enhancement can be done in various domains. For image resolution enhancement there are many methods, out of which image interpolation scheme is one of the most effective method. Good quality image i.e. high resolution image produces better result in image processing applications.

Interpolation is the process of determining the values of a function at positions lying between its samples. It achieves this process by fitting a continuous function through the discrete input samples. This permits input values to be evaluated at arbitrary positions in the input, not just those defined at the sample points. While sampling generates an infinite bandwidth signal from one that is band limited, interpolation plays an opposite role: it reduces the bandwidth of a signal by applying a low-pass filter to the discrete signal. That is, interpolation reconstructs the signal lost in the sampling process by smoothing the data samples with an interpolation function. The process of interpolation is one of the fundamental operations in image processing. The image quality highly depends on the used interpolation technique. The interpolation techniques are divided into two categories, deterministic and statistical interpolation techniques. The difference is that deterministic interpolation techniques assume certain variability between the sample points, such as linearity in case of linear interpolation. Statistical interpolation methods approximate the signal by minimizing the estimation error. This approximation process may result in original sample values not being replicated. Since statistical methods are computationally inefficient, in this project only deterministic techniques will be discussed. This project mainly concerned about image interpolation.

The ideal image interpolation algorithm should preserve the qualitative characteristics of the output image since interpolated images suffer from artifacts, such as blurring, discontinuities in edges and checker-board effects. Furthermore, the applied methods should meet some quantitative attributes especially when they are oriented for real-time imaging applications such as mobile phones or digital cameras. The algorithms should introduce low computational cost and low memory requirements in order to meet the hard real-time requirements of such implementations. Widely used algorithms such as the nearest-neighbour and bilinear interpolation exhibit computational simplicity, but causes

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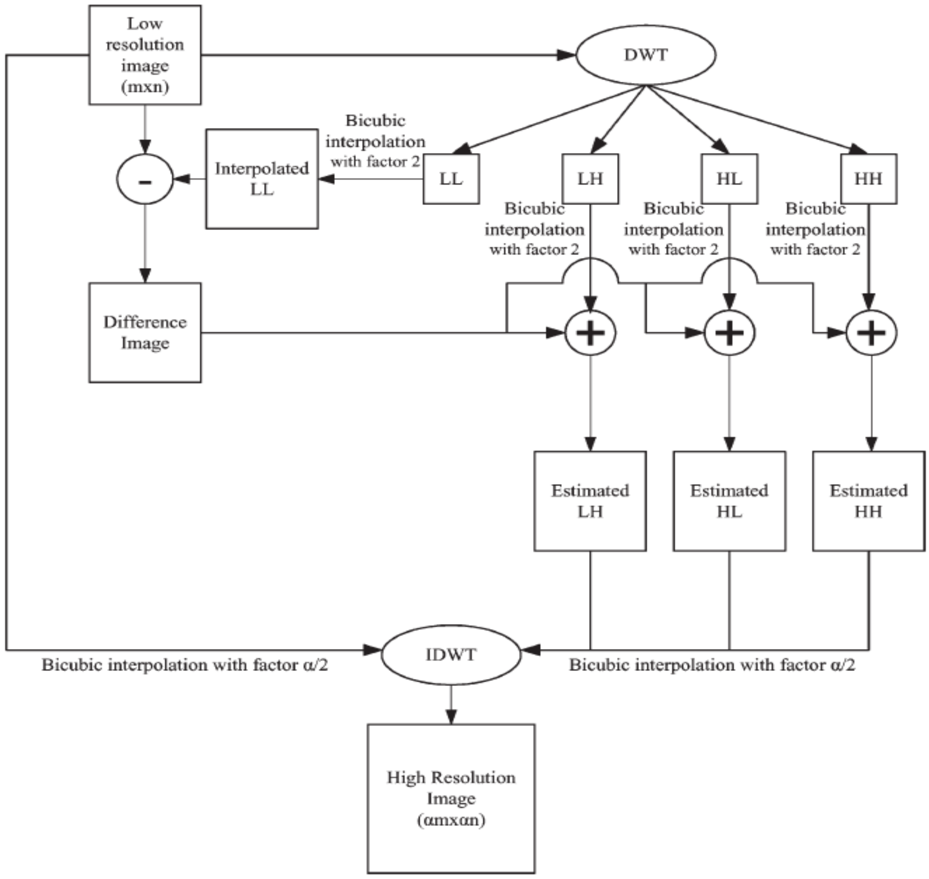

Fig 3. Block diagram of resolution enhancement algorithm.

severe blurring problems particularly in edge regions. Linear approaches are those most frequently used due to the fact that although nonlinear methods, such as bicubic interpolation, which produce better results than other techniques.

A.BICUBIC INTERPOLATION TECHNIQUE

Bicubic Interpolation determines the grey level value from the weighted average of the 16 closest pixels to the specified input co-ordinates, and assigns that value to the output coordinates. The image is slightly sharper than that produced by Bilinear Interpolation, and it doesnot have the disjointed appearance produced by Nearest Neighbour Interpolation. First, four one-dimensional bicubic interpolations are performed in one direction (horizontally) and then one more one-dimension bicubic interpolation is performed in the perpendicular direction (vertically). This means that to implement a two-dimension bicubic interpolation, a one-dimension bicubic interpolation is needed. For one-dimension bicubic interpolation, the number of grid points needed to evaluate the interpolation function is four, two grid points on either side of the point under consideration. For bicubic interpolation, the number of grid points needed to evaluate the interpolation function is 16, two grid points on either side of the point under consideration for both horizontal and vertical directions.

III. DWT–BASED RESOLUTION ENHANCEMENT

As it was mentioned before, resolution is an important feature in medical imaging, which makes the resolution enhancement of such images to be of vital importance as increasing the resolution of these images, will directly affect the performance of the system using these images as input. The main loss of an image after being resolution enhanced by applying interpolation is on its high-frequency components, which is due to the smoothing caused by interpolation. Hence, in order to increase the quality of the enhanced image, preserving the edges is essential. In this paper, DWT has been employed in order to preserve the high-frequency components of the input image. DWT separates the image into different subband images, namely, LL, LH, HL, and HH. A high-frequency subband contains the high frequency

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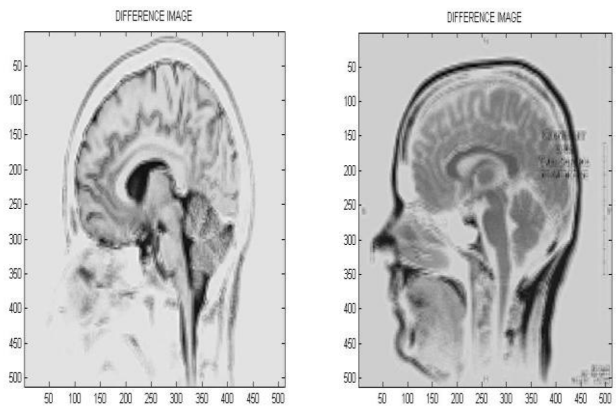
component of the image. The interpolation can be applied to these four subband images. In the wavelet domain, the low-resolution image is obtained by low-pass filtering of the high-resolution image. The low resolution image (LL subband), without quantization is used as the input for the resolution enhancement process. In other words, low-frequency subband images are the low resolution of the original image. Therefore, instead of using low-frequency subband images, which contains less information than the original input image, we are using this input image through the interpolation process. Hence, the input low-resolution image is interpolated with the half of the interpolation factor, $\alpha/2$, used to interpolate the high-frequency subbands, as shown in Fig 3. In order to preserve more edge information, i.e., obtaining a sharper enhanced image, we have proposed an intermediate stage in high frequency Subband interpolation process. As shown in Fig 3, the low-resolution input medical image and the interpolated LL image with factor 2 are highly correlated. The difference between the LL subband image and the low-resolution input image are in their high-frequency components. Hence, this difference image can be use in the intermediate process to correct the estimated high-frequency components. This estimation is performed by interpolating the high-frequency subbands by factor 2 and then including the difference image into the estimated high-frequency images, followed by another Interpolation with factor $\alpha/2$ in order to reach the required Size for IDWT process. The intermediate process of adding the difference image, containing high-frequency components, generates significantly sharper and clearer final image.

IV. RESULTS AND DISCUSSION

The resolution enhancement algorithm has been tested on different brain images. The following figure shows the low-resolution input medical images and the enhanced output images by using bicubic interpolation technique. It is clear that the resultant image, enhanced by using the proposed technique, is sharper and clearer than the input images. The simulated result shows the input image, difference image and enhanced output image of various brain images. The results show the enhanced

(a)



(b)

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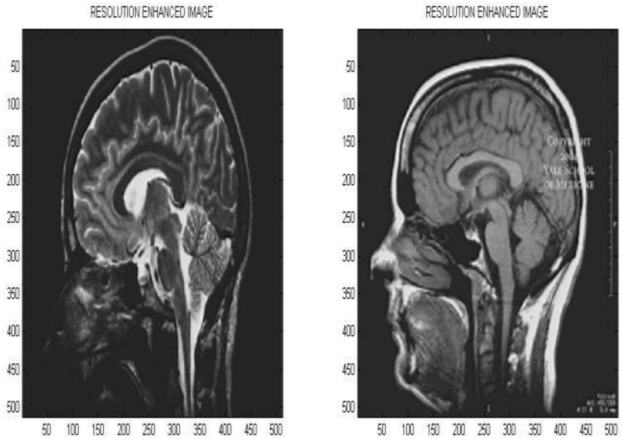

(c)

Fig 4. (a) Low resolution input brain images, (b) Difference images and (c) enhanced output brain images.

output brain images without causing any blurring effects, which was occurred in ordinary imaging techniques. And also the visual appearance of output images is higher than the input images, which gives more information for further analysis.

V. CONCLUSION

This paper has proposed a new resolution enhancement technique for medical images, based on the interpolation of the high-frequency subband images obtained by DWT and the input image. Finally, the inverse DWT is performed to produce the original resolution enhanced output image. The proposed technique has been tested on well-known benchmark medical images. Experimental results demonstrate that the proposed algorithm can enhance the low-contrast medical images and make the image suitable for further processing.

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