MEDICAL IMAGE DENOISING BASED ON GAUSSIAN FILTER AND DWT SWT BASED ENHANCEMENT TECHNIQUE

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Abstract–Image pre-processing techniques are used to improve the quality of an image before processing into an appliance. These will improve visual quality of image for image interpretation. This paper proposes a pre-processing technique for noise removal and enhancement based on Gaussian filter and DWT, SWT based image interpolation method which gives better results compared to state-of-art criteria like DWT based enhancement technique.

Keywords - Image preprocessing, Noise, Denoising, Discrete Wavelet Transform, Peak Signal to Noise Ratio.

I. INTRODUCTION

The Magnetic Resonance Imaging (MRI) is to view the internal structures of the body in detail especially for imaging soft tissues and it does not use any radiations. Brain tumor is an abnormal growth of tissues in the brain and is mainly caused by radiation to the head, genetic risk, HIV infection, cigarette smoking and also due to environmental toxins. Major problem in image segmentation is inaccurate diagnosis of the tumor region which gets reduced mainly due to the contrast, blur, noise, artifacts, and distortion. No accurate detection of tumor region due to the presence of noise in MR image. Even small amount of noise can change the classification. Gray matter is made up of neuronal cell bodies. The Gray matter includes regions of the brain involved in muscle control, sensory perception such as seeing and hearing, memory, emotions, and speech. White matter is one of the two components of the central nervous system and consists mostly of glial cells and myelinated axons that transmit signals from one region of the cerebrum to another and between the cerebrum and lower brain centers. Noisy image can cause misclassifications of Gray Matter (GM) as White Matter (WM). So the noise is preprocessed using denoising technique. Resolution of an image is always an issue in medical image processing which means loss of quality at the image edges. Resolution enhancement is used to preserve the edges and contour information. The major application of these techniques is detection of tumor cells in human body [1, 2]. Improving the denoising along with the edges is not performed so well in this method [3]. In order to significantly accelerate the algorithm, the filters are introduced to eliminate unrelated neighborhoods from the weighted average used to denoise each image pixel. These filters are based on average gray values as well as gradients, pre-classifying neighborhoods and thereby reducing the quadratic complexity to a linear one and diminishing the influence of less-related areas in the denoising of a given pixel. Part of the ongoing efforts includes the investigation of image characteristics that provide good context classifications for image denoising [4]. Although the inverse filter works well when no noise is present, the Wiener filter performs much better and is more versatile. However, the Wiener filter assumes knowledge of the degradation function and the power spectra of both the noise and the original image. Most image restoration methods require some knowledge of the degradation function, but the Wiener filter in particular presents the additional difficulty of knowing the power spectra, the noise power spectrum can be effectively estimated by analyzing a relatively uniform region of interest in the degraded image. However, obtaining the spectrum of the original signal is more difficult. This requirement makes the Wiener filter less useful in many practical applications. Moreover, the Wiener filter provides a sound theoretical foundation upon which other restoration techniques [5]. Low and high frequency information is effectively extracted by using Haar wavelet transform but noises in the low frequency sub-band are smoothened and in the high frequency sub-bands are sharpened by using the smooth PWL (Piece Wise Linear) filter and another PWL filter respectively has a very satisfactory noise removing property as well as improves the visual quality of images that contain low contrast. The performance of both wavelet transform and PWL has been compared [6]. The image resolution enhancement method using Discrete Wavelet Transform (DWT) is giving better results than any other technique [7]. Resolution has been frequently referred as an important aspect of an image. Images are being processed in order to obtain more enhanced resolution. One of the commonly used techniques for image resolution enhancement is Interpolation. Interpolation has been widely used in many image processing applications such as facial reconstruction [1], multiple description coding [2], and super resolution [3]-[6]. There are three well known interpolation techniques, namely nearest...
neighbor interpolation, bilinear interpolation, and bicubic interpolation. Image resolution enhancement in the wavelet domain is a relatively new research topic and recently many new algorithms have been proposed [4]–[7]. Discrete wavelet transform (DWT) [8] is one of the recent wavelet transforms used in image processing. DWT decomposes an image into different subband images, namely low-low (LL), low-high (LH), high-low (HL), and high-high (HH). Another recent wavelet transform which has been used in several image processing applications is stationary wavelet transform (SWT) [9]. In short, SWT is similar to DWT but it does not use downsampling, hence the subbands will have the same size as the input image. In this work, we are proposing an image resolution enhancement technique which generates sharper high resolution image. The proposed technique uses DWT to decompose a low resolution image into different subbands. Then the three high frequency subband images have been interpolated using bicubic interpolation. The high frequency subbands obtained by SWT of the input image are being incremented into the interpolated high frequency subbands in order to correct the estimated coefficients. In parallel, the input image is also interpolated separately. Finally, corrected interpolated high frequency subbands and interpolated input image are combined by using inverse DWT (IDWT) to achieve a high resolution output image. The proposed technique has been compared with conventional and state-of-art image resolution enhancement techniques. The conventional techniques used are the following:

—interpolation techniques: bilinear interpolation and bicubic interpolation;
—wavelet zero padding (WZP). The state-of-art techniques used for comparison purposes are the following:
—regularity-preserving image interpolation [7];
—new edge-directed interpolation (NEDD) [10];
—hidden Markov model (HMM) [11];
—HMM-based image super resolution (HMM SR) [12];
—WZP and cycle-spinning (WZP-CS) [13];
—WZP, CS, and edge rectification (WZP-CS-ER) [14];
—DWT based super resolution (DWT SR) [15];
—complex wavelet transform based super resolution (CWT SR) [5]. According to the quantitative and qualitative experimental results, the proposed technique over performs the aforementioned conventional and state-of-art techniques for image resolution enhancement.

II. EXISTING METHOD

Denoising Mechanism

a) Averaging Filter

Mean filter or averaging filter is easy implementation method of sm filter is often used to reduce noise a of intensity variation from one pix take an average that is sum of the el by the number of elements. Next, image by the average of pixel surrounding this pixel behind the averaging filter.

b) Median Filter

median filter are there is no reduction in contrast across steps, since output values available consist only of those present in the neighborhood (no averages). The median is less sensitive than the mean to extreme values (outliers), those extreme values are more effectively removed. The disadvantage of median filter is sometimes this is not subjectively good at dealing with large amount of Gaussian noise as the mean filter.

c) Wiener Filter

The important use of wiener filter is to reduce the amount of noise present in an image by comparison with an estimation of the desired noiseless signal. It is based on a statistical approach. Wiener filters are characterized by three important factors. 1) Assumption: The stationary linear stochastic processes of image and noise with known spectral characteristics or known autocorrelation and cross-correlation 2) Requirement: the filter must be physically realizable/ causal 3) Performance criterion: minimum mean-square error (MMSE). This filter is frequently used in the process of deconvolution. The inverse filtering is a restoration technique for deconvolution, i.e., when the image is blurred by a known low pass filter, it is possible to recover the image inverse filtering or generalized inverse filtering. However, inverse filtering is very sensitive to additive noise. The approach of reducing degradation at a time induces to develop a restoration algorithm. The Wiener filtering executes an optimal tradeoff between inverse filtering and noise smoothing [13, 14, 15]. It removes the additive noise and inverts the blurring simultaneously.

III. PROPOSED IMAGE RESOLUTION ENHANCEMENT

In image resolution enhancement by using interpolation the main loss is on its high frequency components (i.e., edges), which is due to the smoothing caused by interpolation. In order to increase the quality of the super resolved image, preserving the edges is essential. In this work, DWT has been employed in order to preserve the high frequency components of the image. The redundancy and shift invariance of the DWT mean that DWT coefficients are inherently interpolable [9]. In this correspondence, one level DWT (with Daubechies 9/7 as wavelet function) is used to decompose an input image into different subband images. Three high frequency subbands (LH, HL, and HH) contain the high frequency components of the input image. In the proposed technique, bicubic interpolation with
enlargement factor of 2 is applied to high frequency subband images. Downsampling in each of the DWT subbands causes information loss in the respective subbands. That is why SWT is employed to minimize this loss. The interpolated high frequency subbands and the SWT high frequency subbands have the same size which means they can be added with each other. The new corrected high frequency subbands can be interpolated further for higher enlargement. Also it is known that in the wavelet domain, the low resolution image is obtained by lowpass filtering of the high resolution image [16]. In other words, low frequency subband is the low resolution of the original image. Therefore, instead of using low frequency subband, which contains less information than the original high resolution image, we are using the input image for the interpolation of low frequency subband image. Using input image instead of low frequency subband increases the quality of the super resolved image. Fig. 1 illustrates the block diagram of the proposed image resolution enhancement technique. By interpolating input image by, and high frequency subbands by 2 and in the intermediate and final interpolation stages respectively, and then by applying IDWT, as illustrated in Fig. 1, the output image will contain sharper edges than the interpolated image obtained by interpolation of the input image directly. This is due to the fact that, the interpolation of isolated high frequency components in high frequency subbands and using the corrections obtained by adding high frequency subbands of SWT of the input image, will preserve more high frequency components after the interpolation than interpolating input image directly.

Gaussian Filter:
Gaussian filters are a class of linear smoothing filters with the weights chosen according to the shape of a Gaussian function. The Gaussian smoothing filter is a very good filter for removing noise drawn from a normal distribution! The zero-mean Gaussian function in one dimension is
\[ g(x) = e^{-\frac{x^2}{2\sigma^2}}, \]
where the Gaussian spread parameter \( \sigma \) determines the width of the Gaussian. For image processing, the two-dimensional zero-mean discrete Gaussian function,
\[ g[i, j] = e^{-\frac{(i^2+j^2)}{2\sigma^2}}, \]
is used as a smoothing filter. A plot of this function is shown in Figure 4.11. Gaussian functions have five properties that make them particularly useful in early vision processing. These properties indicate that the Gaussian smoothing filters are effective low-pass filters from the perspective of both the spatial and frequency domains, are efficient to implement, and can be used effectively by engineers in practical vision applications. The five properties are summarized below. Further explanation of the properties is provided later in this section.

1. In two dimensions, Gaussian functions are rotationally symmetric. This means that the amount of smoothing performed by the filter will be the same in all directions. In general, the edges in an image will not be oriented in some particular direction that is known in advance; consequently, there is no reason a priori to smooth more in one direction than in another. The property of rotational symmetry implies that a Gaussian smoothing filter will not bias subsequent edge detection in any particular direction.

2. The Gaussian function has a single lobe. This means that a Gaussian filter smoothes by replacing each image pixel with a weighted average of the neighboring pixels such that the weight given to a neighbor decreases monotonically with distance from the central pixel. This property is important since an edge is a local feature in an image, and a smoothing operation that gives more significance to pixels farther away will distort the features.

3. The Fourier transform of a Gaussian has a single lobe in the frequency spectrum. This property is a straightforward corollary of the fact that the Fourier transform of a Gaussian is itself a Gaussian, as will be shown below. Images are often corrupted by undesirable high-frequency signals (noise and fine texture). The desirable image features, such as edges, will have components at both low and high frequencies. The single lobe in the Fourier transform of a Gaussian means that the smoothed image will not be corrupted by contributions from unwanted high-frequency signals, while most of the desirable signals will be retained.

4. The width, and hence the degree of smoothing, of a Gaussian filter is parameterized by \( \sigma \), and the relationship between \( \sigma \) and the degree of smoothing is very simple. A larger \( \sigma \) implies a wider Gaussian filter and greater smoothing. Engineers can adjust the degree of smoothing to achieve a compromise between excessive blur of the desired image features (too much smoothing) and excessive undesired variation in the smoothed image due to noise and fine texture (too little smoothing).

5. Large Gaussian filters can be implemented very efficiently because Gaussian functions are separable. Two-dimensional Gaussian convolution can be performed by convolving the image with a one-dimensional Gaussian and then convolving the result with the same one-dimensional filter oriented orthogonal to the Gaussian used in the first stage. Thus, the amount of computation required for a 2-D Gaussian filter grows linearly in the width of the filter mask instead of growing quadratically. An odd-size
neighborhood is used for calculating the median. However, if the number of pixels is even, the median is taken as the average of the middle two pixels after sorting.

IV. EXPERIMENTAL RESULTS

This work proposed an image resolution enhancement technique based on the interpolation of the high frequency subbands obtained by DWT, correcting the high frequency sub band estimation by using

![Fig.1.Original Image](image1)

![Fig.2.Noisy Image](image2)

![Fig.3.Average Filter Image](image3)

![Fig.4.Histogram for mean Filter Image](image4)

![Fig.5.Median Filter Image](image5)

![Fig.6.Median Filter Image](image6)

![Fig.7.Image Denoising based on Gaussian filter](image7)
CONCLUSION

This work proposed an image resolution enhancement technique based on the interpolation of the high frequency sub bands obtained by DWT and SWT. The proposed technique uses DWT to decompose an image into different subbands, and then the high frequency subband images have been interpolated with SWT sub band values. Afterwards all these images have been combined using IDWT and ISWT to generate a super resolved image. The proposed technique has been tested on well-known benchmark images, where their PSNR and visual results show the superiority of proposed technique over the conventional and state-of-art image resolution enhancement techniques. Here for Denoising we use Gaussian filter which we compare with wiener filter and we show that our results will give better denoised image compared with state-of-art criteria.

REFERENCES


