Image enhancement using Wavelet transforms and SVD

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Abstract— Resolution and contrast are the two important attributes of an image. In this paper we developed a method to enhance the quality of the given image. The enhancement is done both with respect to resolution and contrast. The proposed technique uses DWT and SVD. To increase the resolution, the proposed method uses DWT and SWT. These transforms decompose the given image into four sub-bands, out of which one is of low frequency and the rest are of high frequency. The HF components are interpolated using conventional interpolation techniques. Then we use IDWT to combine the interpolated high frequency and low frequency components. To increase the contrast, we use SVD and DWT. The experimental results show that proposed technique gives good results over conventional methods.

Keywords— Discrete wavelet transform (DWT), Singular value decomposition (SVD), Stationary wavelet transform (SWT).

I. Introduction

I mage enhancement is the process of improving the quality of the digital image without knowledge about the source of degradation. The source may be a low resolution camera or aliasing due to improper selection of sampling rate or poor illumination. These sources affect the resolution and contrast of the image. Basically spatial resolution is the smallest discernible detail in an image. Sampling is the principal factor determining the spatial resolution. 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, multiple description coding, and super resolution. There are three well known interpolation techniques, namely nearest neighbor interpolation, bilinear interpolation, and bi-cubic interpolation. The main disadvantage in using interpolation the loss of HF components (Edges), which is due to the smoothing caused by interpolation. Preserving the edges is essential. To avoid this problem we use a new mathematical tool called wavelet transform. DWT and SWT are the recent transforms in image processing.

We use wavelet transforms because of their inherent property that they are redundant and shift invariant These transforms are used to decompose the given low resolution image into frequency components i.e.,

sub-bands. There are various applications of DWT in image processing, namely feature extraction [9], de-noising [10], face recognition [11], satellite image super resolution [2] and compression [12].

We can use 2-D discrete wavelet transform to decompose the image into four sub-bands, namely LL, LH, HL and HH bands. We know that the stationary wavelet transform can also be applied to the same image, whose result is also the frequency components of the image.

Here the LL sub-band consists of illumination information, where as the remaining sub-bands constitutes the information of edges. Manipulating these sub-bands gives the enhancement in resolution. Coming to the contrast enhancement we have some basic operations like general histogram equalization (GHE), Local histogram equalization (LHE) and brightness preserving Dynamic histogram equalization (BPDHE). General histogram equalization is one of the widely used and simple contrast enhancement techniques, in which the output histogram is uniformly distributed. One of the disadvantages of GHE is that the information laid on the histogram or probability distribution function (PDF) of the image will be lost. Similarly the other methods have their own disadvantages. In this paper, we use a combination of DWT and SVD algorithm. Singular value decomposition (SVD) of an image, which can be interpreted as a matrix, is written as follows:

$$A = U_A \Sigma_A V^T_A \quad \dashrightarrow (1)$$

Where U_A and V_A are orthogonal square matrices known as Hanger and aligner, respectively, and the Σ_A matrix contains the sorted singular values on its main diagonal. The idea of using SVD for image equalization comes from this fact that Σ_A contains the intensity information of a given image.

SVD can be used to deal with an illumination problem. The method uses the ratio of the largest singular value of the generated normalized matrix, with zero mean and unity variance of, over a normalized image which can be calculated according to

$$\xi = \frac{\max(\Sigma_N)}{\max(\Sigma_A)} \quad \dashrightarrow (2),$$

Where $\sum_N$ is the singular value matrix of the synthetic intensity matrix at zero mean and unity variance. This coefficient can be used to regenerate an equalized image using

$$\Xi equalized A = U_A (\xi \Sigma_A) V_A^T \quad \dashrightarrow (3)$$

Here we take the help of DWT to decompose this image into different sub-bands. The resultant can be obtained by combining the sub-band images using IDWT.

II.Proposed image enhancement technique

Basically there are two steps involved in this image enhancement operation. In the first step, we do resolution enhancement. And the second step is the contrast enhancement. Resolution enhancement uses the combination of DWT and SWT, and contrast enhancement uses the combination of SVD and DWT.

A. Resolution enhancement:

We know that the low resolution image can be obtained by passing the high resolution image through a low pass filter in wavelet domain, which implicitly means that the LL sub-band is the low resolution of the original image.

The proposed enhancement process is based on the interpolation of HF sub-band images obtained by DWT and input image. The edge detail is enhanced by using intermediate stage using SWT. DWT can be used to decompose the input image into different sub-bands, and then the HF sub-bands are interpolated. HF sub-bands obtained by SWT of input are incremented into interpolated HF sub-bands in order to correct the estimated co-efficient. In parallel input image is also interpolated separately and corrected HF sub-bands and interpolated input image are combined through IWDT, to achieve high resolution output.

Here the main role of wavelet transforms is to preserve the HF components. One level DWT can be used to decompose the input image to different sub-bands. While interpolating the HF components, we used bi-cubic interpolation with enlargement factor of 2. Down sampling in each of DWT sub-bands causes information loss in respective sub-bands. So we use SWT to minimize the error. It can be observed that interpolated HF sub-bands and the SWT HF sub-bands have same size, and hence they can be added together.

Basically the LL sub-band is the illumination information of low resolution image. Instead of using LL sub-band, which contains less information than the original image we are using input image itself. Use of input image instead of LF sub-band increases the quality of super resolved image when compared with the conventional techniques. This is due to the fact that, the interpolation of HF components in HF sub-bands and using the corrections obtained by HF components of SWT of the input image will preserve more HF components than the ordinary interpolation.

B. Contrast enhancement:

The output of the resolution enhancement module will be taken as the input to this module. The main tools that we use here are SVD and DWT. It is already known that singular value matrix obtained by SVD contains the illumination information. So we have to change this matrix to change the contrast of the image. Any changes made to this matrix will not affect the other attributes of the image.

The DWT is used to divide the image into sub-bands. We know that the edges are concentrated on LH, HL, HH sun-bands. Hence even if we separate the HF components and apply some transformations on the LF will not cause any damage to the edge components.
Hence after reconstruction the image looks sharper too. The key steps involved in this process are as follows:

First we will apply DWT on the input image and in parallel we improve its contrast using GHE and find its DWT. Now calculate the hanger (U), aligner (V) and singular value matrix (SVM) for the LL sub-bands obtained above. Find the maximum element in both the SVMs and take their ratio (ξ).

Now calculate the new STM and estimate the new LL sub-band.

$$LL_{A(new)} = U_{LLA} \sum\nolimits_{LLA} V^{T}{}_{LLA}$$

The estimated LL sub- band and the HF components of actual input image are now used to re-produce the contrast enhanced image. From the close observation we can see that the HF components are not disturbed. We manipulated the illumination information alone. Hence we can be sure that there is no harm to edge components.

III. Applications

1. Satellite images are usually taken from low resolution cameras. They suffer from low illumination problem. We can apply this algorithm to compensate these effects.

2. Surveillance cameras cannot take accurate images due to the relative motion between camera and vehicle. In such cases this algorithm can be used

3. In many other applications like face detection, finger print reading we can use this technique.

4. Other applications include facial reconstruction [6], multiple descriptive coding [7] and super resolution [8].

VI. Block diagram

The block diagram presented below explains the major steps involved in the proposed technique. Initially we tool a low resolution image with poor resolution and poor illumination. The following steps are carried out to get a better version of the image.
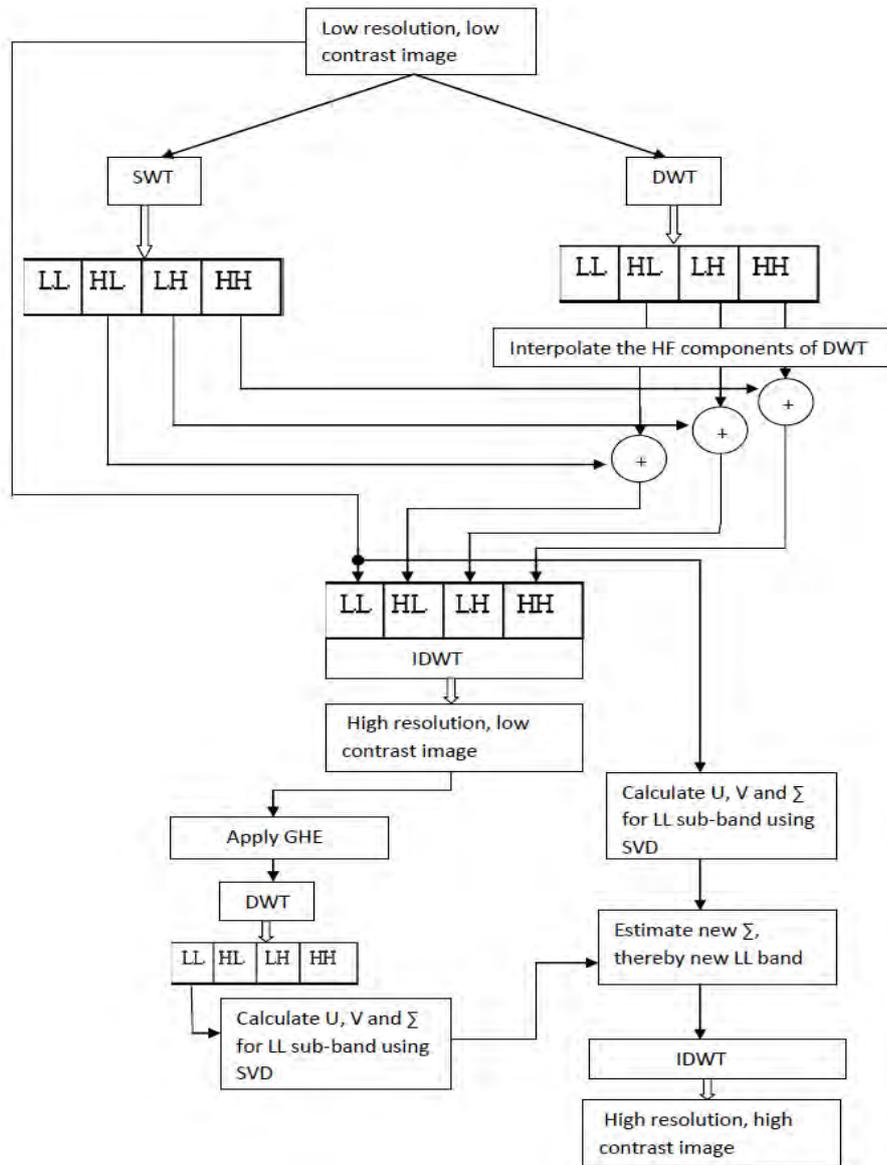
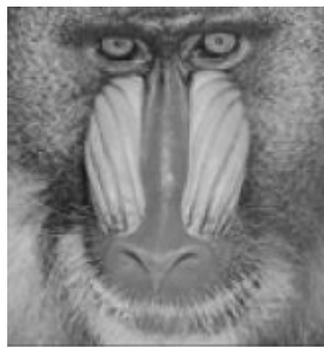Fig. Detailed steps in proposed technique

V. Results:

equalised image
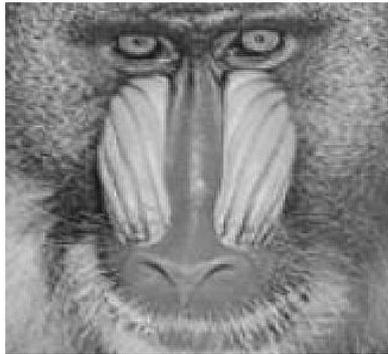

Original image

input

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V. Results:

PROCESSED IMAGE

Processed image

input

equalised image

The above figures show the application of the proposed techniques. Totally we are presenting our output for three different images. The first two are the standard images, baboon and Lena. We can observe a significant enhancement in contrast and resolution compared to the input images. The third one shows the typical application of the proposed technique. Here we took a satellite image and the resolution, contrast of the image has been improved significantly.

PARAMETER	CONVENTIONAL TECHNIQUE	PROPOSED TECHNIQUE
PSNR	30.8	39.6197
MSE	1.2	0.0710
SSIM	0.18	1
DSSIM	5.555	0.81998

VI. Conclusions

From the results obtained it is clear that the application of the algorithm is successful. And this application is more prominent in satellite image processing .This procedure is successful in obtaining the enhanced images to obtain even the minute details when related to satellite images. We can uncover the hidden details from the given images. For the resolution enhancement, we corrected the HF components according to SWT components. For contrast enhancement we have taken the help of SVD, in which singular value matrix gives the illumination content. By modifying that value, we succeeded in improving the contrast of the given image.

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VII.Future scope

The combined use of wavelet transforms and SVD gives the promising applications in finger print reading, mine detection.etc. The application of m-band wavelet transforms may give the more accurate results, in which processing time is not a constraint.

VIII.   References

[1]   Hasan Demirel and Gholamreza Anbarjafari, "IMAGE Resolution Enhancement by Using Discrete and Stationary Wavelet Decomposition" IEEE transactions on IMAGE PROCESSING, VOL. 20, NO. 5
[2]   H. Demirel and G. Anbarjafari, "Satellite image resolution enhancement using complex wavelet transform," *IEEE Geosciences and Remote Sensing Letter*, vol. 7, no. 1, pp. 123–126, Jan. 2010.
[3]   Kirk Baker," *Singular Value Decomposition Tutorial*". March 29, 2005
[4]   T. K. Kim, J. K. Paik, and B. S. Kang, ''Contrast enhancement system using spatially adaptive histogram equalization with temporal filtering,'' *IEEE Trans. Consum. Electron.* vol. 44, no. 1, pp. 82--87, Feb. 1998.
[5]   H. Demirel, G. Anbarjafari, and M. N. S. Jahromi, ''Image equalization based on singular value decomposition,'' in *Proc. 23rd IEEE Int. Symp.Comput. Inf. Sci.*, Istanbul, Turkey, Oct. 2008, pp. 1--5.
[6]   L. Yi-bo, X. Hong, and Z. Sen-yue, "The wrinkle generation method for facial reconstruction based on extraction of partition wrinkle line features and fractal interpolation," in *Proc. 4th Int. Conf. Image Graph.*, Aug. 22–24, 2007, pp. 933–937.
[7]   Y. Rener, J. Wei, and C. Ken, "Down-sample-based multiple description coding and post-processing of decoding," in Proc. 27th Chinese Control Conf., Jul. 16–18, 2008, pp. 253–256.
[8]   Y. Piao, I. Shin, and H. W. Park, "Image resolution enhancement using inter-sub-band correlation in wavelet domain," in Proc. Int. Conf. Image Process., 2007, vol. 1, pp. I-445–448.
[9]   J. W. Wang and W. Y. Chen, ''Eye detection based on head contour geometry and wavelet sub-band projection,'' Opt. Eng., vol. 45, no. 5, pp. 057001-1--057001-12, May 2006.
[10] J. L. Starck, E. J. Candes, and D. L. Donoho, ''The curvelet transform for image de-noising,'' IEEE Trans. Image Process., vol. 11, no. 6, pp. 670-- 684, Jun. 2002.
[11] C. C. Liu, D. Q. Dai, and H. Yan, ''Local discriminant wavelet packet coordinates for face recognition,'' J. Mach. Learn. Res., vol. 8, pp. 1165-- 1195, 2007.
[12] M. Lamard, W. Daccache, G. Cazuguel, C. Roux, and B. Cochener, ''Use of a JPEG-2000 wavelet compression scheme forcontent-based ophthalmologic retinal images retrieval,'' in Proc. 27th IEEE EMBS, 2005, pp. 4010--4013.