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Analysis of methods in Wavelet Domain for Image Resolution

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***Abstract*--Resolution enhancement using wavelets is one of the most interesting research areas in image processing. Wavelet analysis is similar to Fourier analysis in the sense that it breaks a signal down into its component parts for analysis. It has been successfully applied in image analysis and communication systems. Many methods exist for increasing the resolution of an image in wavelet transformation. In this paper a review on the methods for wavelet based resolution enhancement is presented.**

***Keywords*: Resolution enhancement, Wavelet transforms,CWT**

1. Introduction

In recent years, the wavelet transform emerged in the field of image/signal processing as an alternative to the well-known Fourier Transform (FT) and its related transforms, namely, the Discrete Cosine Transform (DCT) and the Discrete Sine Transform (DST)[7].Image with higher resolution is desired for many image processing applications such as in satellite images, medical images and for surveillance .Interpolation is the popular technique for constructing high resolution images(HR). Fundamentally, the interpolation is the process of using known data to estimate values at unknown locations. It is used to increase the number of pixels per unit area. In image processing, four conventional interpolation techniques are used extensively in the field of resolution enhancement, namely, nearest-neighbor, bilinear, bicubic and lanczos [12].

The bilinear interpolation four nearest neighbours are used to estimate the intensity value of a given location. In the nearest neighbour interpolation the intensity of the nearest neighbour is assigned to the new location of an image. The bilinear interpolation gives better performance than nearest neighbour interpolation but increases computational overhead. More appropriate method is bicubic interpolation where sixteen neighbours are used to find the intensity of a specific location.The bicubic interpolation is the standard method for resolution enhancement in commercial image editing programs [12].

2. WT and HMT based enhancement

Hidden Markov Tree (HMT) is used to estimate high frequency subbands from the low frequency subbands. HMT models are used to find out the most feasible state for the coefficient to be estimated. These methods model the unknown coefficients as belonging to mixed Gaussian distributions[1].This model consist of sequence of state transition where the process is hidden but the parameters are visible[2].The figure 1 shows the HMT structure where the white nodes are hidden state variable and the black nodes are wavelet coefficients. The state probability, state transition probability, variance and mean value of state probability distribution are the four parameters of HMT .In [1] HMT based model where the sign of the coefficient is estimated as it affects the resulting image .In the proposed method the sign of the coefficient and the magnitude of the coefficient are estimated separately. The magnitude is estimated using HMT to find out the hidden parameters. The inter subband correlation is used to estimate the sign of the coefficient. The HMT image resolution method improves the resulting image compared to edge directed interpolation, bilinear and bi-cubic.

In [3] based on HMT model where cyclic optimization process is used to solve the problem related to linear constrained quadratic optimization. In this method randomly generated signs are applied to the estimated coefficients. In [4]Gaussian distribution is used as probability

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distribution to each state. Then expectation maximization (EM) algorithm is employed to train the HMT based on HR images. The algorithm works by taking the wavelet coefficients as input and produces all four parameters of HMT followed by iteration of the EM algorithm for the target low resolution (LR) image. It will produce necessary

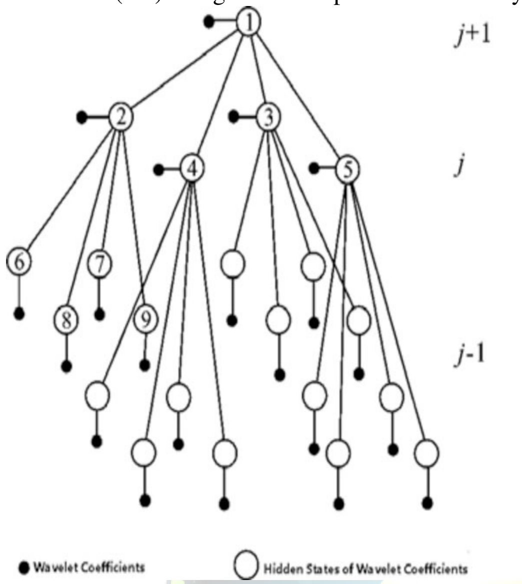

Figure 1 HMT Model

3. WT and CS based enhancement

The figure 2 shows resolution enhancement using CS and edge modelling. In [5] this technique as a first step the input image is enlarged using wavelet zero padding (WZP) and obtain ŷ0.The CS operator is applied as a second step. The high resolution y is constructed. A shift operator S_{ij} is applied for vertical and horizontal of (i , j) in the range i ,j belongs to the set {−k,−k+1, . . . ,k−1,k}.. It will produce N y_{ij} images where N= (2k+1) (2k+1) number of shifted images. For the shifted coefficients WT is applied and discards the HF coefficients. Finally the HR images are realigned and averaged to give the final HR reconstructed image. The edges are resolved by correcting their width obtained by processing the LR images.

4. Complex WT based enhancement

CWT is the enhancement to the DWT .The CWT provides solution to the four shortcomings of DWT such as oscillations, shift variance, aliasing, and lack of directionality. The CWT is almost rotation and shift invariant and produces fewer artefacts than DWT.

state probabilities that can be used to predict state probabilities at high resolution (HR).The Gaussian probability distribution is used to randomly generate the values for wavelet coefficients. In the end to the resultant image a Gaussian low pass filter is applied to sharpen the image.

In [6] dual tree complex wavelet transform the estimation of wavelet coefficients is proposed .CS is used as a first step to create the initial estimate of y in DT-CWT domain. Then one level DT-CWT of the initial estimate y is used to extract the high pass coefficients for the input image. Finally the input image together with high pass subband extracted from 1DT-CWT decomposition of Y are used to create HR image by taking inverse DT-CWT .The estimation of high frequency image is obtained.

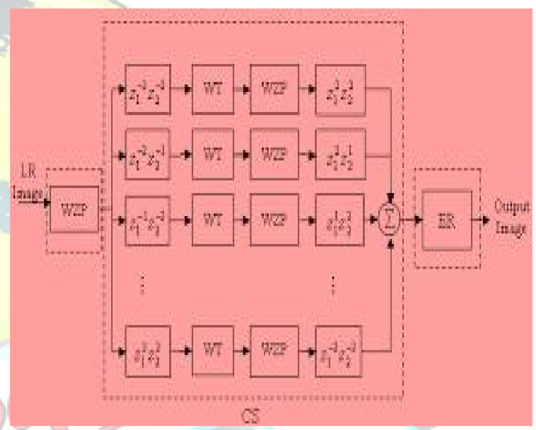

Figure 2 wavelet domain image resolution enhancement using cycle spinning and edge modelling

The two edge preserving smoothing filters are used on the high frequency image. This will produce two different images which further undergo CWT and then inverse CWT.Finally two HR images are averaged to get single HR image. The [8] proposed method applies bicubic interpolation to interpolate high frequency subbands with a factor of α.Two HR images are produced with the factor of α/2.Finally the inverse CWT is applied to get HR image.

Another DT-CWT [9] satellite based image resolution technique where non local means filter is used and lanczos interpolation. The DT-CWT causes artefact so NLM filter is applied on the interpolated image to reduce the artefact.

5. Discrete WT and stationary WT based enhancement

In DemirelAnbarjafari Super Resolution (DASR) [10] to separate the high frequency content, DWT

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is applied on the low resolution image. The three high frequency subbands, as well as, the original image isinterpolated using bicubic interpolation to produce higher resolution coefficients for the inverse DWT. Finally, inverse DWT will produce the high resolution image. A simple block diagram of the DASR technique is shown in Fig 3.The proposed [11] method for satellite image resolution enhancement where the four frequency subbands are interpolated with bicubic interpolation .The Interpolated LL subband is subtracted from theoriginal image and the resultant difference image is added with the three HF subbands .All the estimated high frequency subbands and the original image are placed into inverse DWT process to generate the final high resolution image. This technique gives better result than CS method. In DWT and CWT, a down sampling of the signal take place after passing through each of the filter.

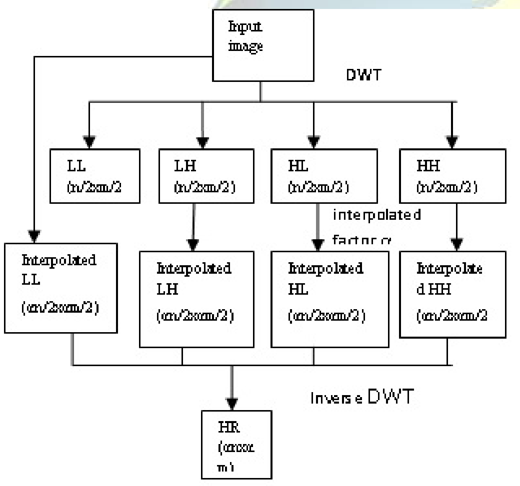

Figure 3 DASR Model

Because of this down sampling, information loss happens in each frequency subbands. But Stationary Wavelet transformation (SWT) have no down sampling. So,SWT can be used along with DWT to minimize the information loss due to down sampling [10].As because of no down sampling, four frequency subbands have the same resolution as the low resolution image after SWT. The inverse DWT is used at the end to reconstruct the high resolution image. So far, this technique produces best results in all types of images except satellite image [12].

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6. Conclusion

Resolution enhancement in wavelet domain is an emerging field. Many techniques are employed for enhancing the resolution of an image in wavelet domain. Some of the methods are exclusive and popular. In this paper the well performed resolution enhancement based on wavelets are analysed. The results are shown for each method.

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