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Image Resolution Enhancement: A Review

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Abstract—Resolution size of display is increasing day by day. Resolution of the imaging system is not able to catch up recent display technology. In satellite imaging and medical imaging, Resolution enhancement of the image is one of the essential step to extract out meaningful information. In the past few years, lots of algorithms have been proposed for enhancing the resolution of the image. This paper presents a review work in image resolution enhancement.

Keywords—Resolution, stationary wavelet transform, Discrete wavelet transform, Interpolation

1. INTRODUCTION

Resolution of the image is one of the key features which determine the quality of the image as well as its zooming capability without producing the blurred image. High resolution image can be zoomed to greater extent as compared to low resolution image and hence can be used to extract the detail portion of the image. This is very important in case of satellite image and medical images where some times details information of the image can be extracted out for better analysis of the image. Digital image sensor has its own limitation and cannot produce high resolution image. Therefore it is essential to increase the resolution of the image in many image processing application. High end Commercial camera are able to produce super resolution image. While most of the scientific camera are able to produce up to 512x 512 resolution. Interpolation is one of the image processing operation which is used for enhancing the resolution of the image. One of the drawbacks of the interpolation technique is that it increases the intensity of low frequency component. That means in interpolated image, sharp intensity transaction is very less.

Image resolution enhancement techniques can be divided into two domain i.e. spatial domain and frequency domain.

Interpolation method of resolution enhancement comes under the class of spatial domain technique because it works directly on the pixel. As mentioned earlier that spatial domain technique i.e. interpolation method is not able to preserve the high frequency component of the image.

This problem can be overcome by using frequency domain technique. In frequency domain techniques, first of all, image is broken in to various frequency bands and then interpolation is performed in the frequency domain and finally image is again converted back to the spatial domain.

Fourier, Cosine and wavelet transform are mostly used for spectral filtering or converting the image in to frequency domain. By spectral filtering, particular frequencies from the image can be extracted out. Wavelet domain [1] filter out frequency component in it different bands known as LL (Low frequency band), LH, HL (Mid frequency band) and HH (High frequency band.) as shown in figure 2.

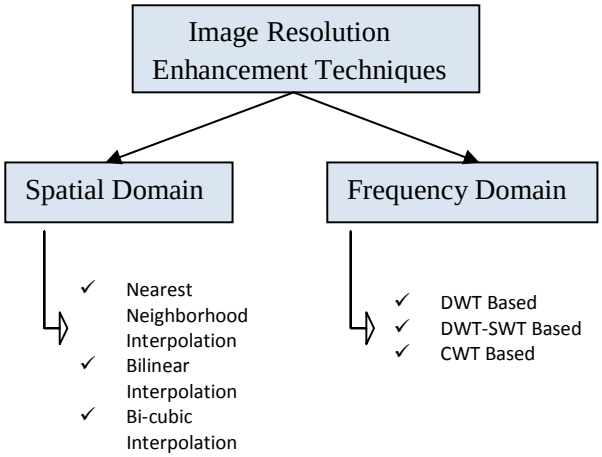

Figure 1 Classification of IR Enhancement Techniques.

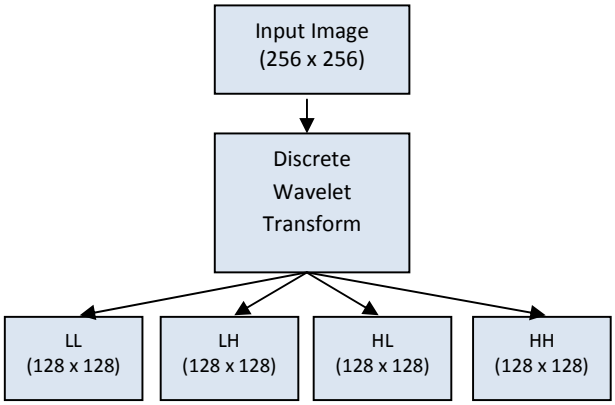

Figure 2 Frequency band Decomposition Using DWT

The dimension of all the four frequency band in wavelet domain decomposition is half of the dimension of the original image.
Stationary wavelet domain[2]also decompose the image in to four frequency sub-bands but in this case the dimension of all the four frequency bands are of size of the original image as shown in figure 3.

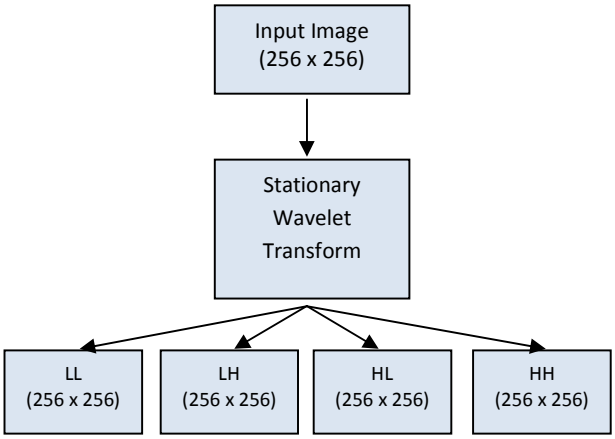

Figure 3 Frequency band Decomposition Using SWT

2. **LITERATURE REVIEW**

W.Knox in his paper [3] presented regularity preserving interpolation method which can be used to enhance the resolution of the image. In this method, single wavelet synthesis stage is used to get the low frequency component of the input image along with the corresponding high frequency component to get the image interpolated by factor 2.
Two step processes is applied to get the unknown high frequency component. At first, edges with significant correlation are detected. Then near these edges, the decay rate of wavelet coefficients are extrapolated to get the approximated high frequency sub band required for re-synthesizing. In the next step same procedure is adopted for each column of row interpolated image.

Xin. Li in his paper [3] suggested a new approach of interpolation which also consider the edge property of the image. He combined the bilinear interpolation with the covariance based adaptive interpolation method. This method reduced the overall computational complexity. Traditional interpolation method like bilinear used spatial model of the image for interpolating the missing pixel. This method do not consider the fast changing statistics around the edges and hence produce the blurred or hazy image.
Computationally, linear interpolation is very good but its performance is not satisfactory. This problem can be overcome largely by considering the statistics around the edge pixel.
Alptekin. Temizel and Theo. Vlachos presented a approach of resolution enhancement using WZP (wavelet zero padding) with cyclic spinning method [4]. This algorithm has two steps. In the first step, wavelet zero padding is used to get the initial approximation of the unknown high resolution image. In the next step cyclic spinning method is to get number of low resolution images. Numbers of high resolution images are obtained by applying WZP procedure to all the low resolution images. By averaging and realigning these high resolution intermediate images, final high resolution image is obtained.
Ozdogan M. (2014) presented a paper "Crop Type Classification by Simultaneous Use of Satellite Images of Different Resolutions".
This paper explained the method to identify the crop types in remotely sensed images. Since these remotely sensed images are of low spatial resolution which gives poor crop identification result, therefore in this paper a new method of improving the performance of identification is presented. In this method, High spatial resolution image is combined with low spatial resolution image with high time frequency to achieve better crop classification result.
Computational performance and requirement for ideal crop curve is the disadvantage of this method. This is hence a new algorithm to identify the crop from images of high resolution and low resolution. Simulation of this method is tested on synthetic as well as on real images. Results reveal that by combining the high resolution image with low resolution image give better identification than using high resolution image alone[1].
Ghafoor A. (2013) presented a paper "Satellite Image Resolution Enhancement Using Dual-Tree Complex Wavelet Transform and Nonlocal Means".
In this paper a wavelet domain approach is presented for enhancing the resolution of satellite images. This method is based on computing the dual-tree complex wavelet transform (DT-CWT) and non local means i.e NLM. In this method, first of all the input image is divided into different frequency band using DT-CWT which is shift invariants. High frequency sub bands obtained by DT-CWT and low resolution input image are interpolated with the help of Lanczos interpolator. DT-CWT has the advantage over DWT of having shift invariants property and produce least artifacts in the image. Non-local means filter is applied to overcome the artifacts produced by the DT-CWT[3].
Beom J. (2011) proposed a paper "Resolution Improvement of Infrared Images Using Visible Image Information".
In areas like remote sensing and Surveillance, Infrared images give valuable information.
This paper suggested a method of improving the spatial resolution of infrared image by utilizing the high resolution visible image resolution.
In this method, HF patches of IR edges which are correlated with edges in visible images are estimated

directly. Intensity correlation between the IR images and the visible image is used for estimation.Spatila resolution and the quality of the IR images is generally poor. Non-ideal optics and finite detector size causes a blurring effect in an IR images which degrades the quality and resolution of the image [5].

Anbarjafari G. (2011) proposed a paper "Discrete Wavelet Transform-Based Satellite Image Resolution Enhancement".

In many image and video processing application, Resolution play very important role. Interpolation one of the method which is widely used in image processing to increase the number of pixel in an image. Wavelet transform in also used in various application of image processing.

2-D wavelet transform is used to decompose the image into different frequency component. This operation is achieved by applying 1-D DWT in Image row first and then along the column.

Proposed method has been tested on some satellite test-bench images. For quantitative analysis, parameter PSNR (Peak signal to Noise ratio) and RMSE (Root mean square error) are computed and tabulated. Visual results and computed parameter shows the improvement over the results obtained by conventional state-of art resolution enhancement algorithm [6].

Demirel H. (2011) proposed a paper "IMAGE Resolution Enhancement by Using Discrete and Stationary Wavelet Decomposition". In this techniques first of all, low resolution input image is decomposed in to different frequency band using Discrete Wavelet Transform (DWT). Then all the high frequency sub bands are interpolated to get the interpolated frequency band of double dimension. Stationary wavelet transform is used in this method to enhance the edges in the image. Stationary wavelet transforms. Sub-bands obtained by DWT and SWT is combined to gather and then inverse discrete transform is applied to get the final high resolution image [7].

Tjahjadi T. (2010) proposed a paper "Image Resolution Enhancement Using Dual-Tree Complex Wavelet Transform".

Image resolution algorithm can be classified in to two groups as per the domain on which these algorithm are applied

1. Image domain
2. Transform Domain

In image domain, Statistical and geometric data extracted directly from the image is used for for resolution enhancement. While in transform domain, Some transformation like discrete cosine transform , discrete wavelet transform etc. are used for resolution enhancement.

In this method, forward and reverse dual tree complex wavelet transform is used to achieve high resolution digital image from the low resolution input image.

Low resolution image along with the set of wavelet coefficients are used to construct the high resolution image using inverse DT-CWT

The HR image is reconstructed from the LR image, together with a set of wavelet coefficients, using the inverse DT-CWT [8].

Demirel H. and Anbarjafari G. (2010) proposed a paper "Satellite Image Resolution Enhancement Using Complex Wavelet Transform".

Geo science studies, geographical information system and astronomy are some area where satellite images are used frequently. These satellite images are of low resolution and hence carry unambiguous information. It is very important to analyse these satellite images for obtaining right information from it. Therefore it is necessary to enhance the resolution of the satellite images before analysis phase. Interpolation is one of the image processing operations which is widely used to increase the resolution of the image. Nearest neighbourhood, Bilinear and Bicubic are three well known interpolation methods which are used for this very purpose.

Among the three interpolation methods, bicubis method gives the best result and produce sharper images. Complex wavelet transform is one of the variants of wavelet transform family and used in many images processing application.

One level complex wavelet transform decomposition produce two complex-valued low frequency sub-band coefficients while six complex –valued high frequency sub-band coefficients[9].

Yang J. (2010) presented a paper "Image Super-Resolution via Sparse Representation".

This method uses the sparse signal representation to produce high resolution images. In this approach, sparse representation of each patches of low resolution input is computed and the coefficients of this representation are used to produce high resolution image. Sparse representation of low resolution image is processed with high resolution patch dictionary to get the high resolution patch [10].

3. CONCLUSION

Image resolution enhancement is an important application in image processing which meant to increase the resolution of the image. These techniques find very critical and important application in satellite image and medical imaging. Interpolation is one of the oldest methods addressing these problems. It ha many disadvantages which compelled the researchers to explore some other way of enhancing the resolution without degrading the important aspect of the image. In this paper, a review on the work accomplished in this field has been done. How different techniques of resolution enhancement evolved and its advantages and disadvantages have also been discussed in this paper.

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