Wavelet based Technique for Super Resolution Image Reconstruction

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ABSTRACT
The super resolution means the quality of the image to the extent of the maximum capability of the technology referring it. The image capturing devices have their hardware limitations to reach to the perfection. A technique for Reconstruction of super resolution image using low resolution natural color image has been developed. The presented technique identifies local features of low resolution image and then enhances its resolution appropriately. It is noticed that the higher PSNR is observed for the developed technique than the existing methods.

Keywords
resolution, super resolution, interpolation, image reconstruction, wavelet,

1. INTRODUCTION
Image processing is quite a mature field and has applications in diverse areas. The most significant and one of the desired features of all image processing applications is good quality of image. The quality of an image can be more appropriately evaluated on its spatial resolution. High resolution (HR) image along with a pleasing look, offers more details to viewer that are vital for the analysis in many applications. High resolution means pixel density within image is high. Primarily, the resolution of image depends on the resolution of image acquisition device. The current technology to obtain high resolution images mainly depends on sensor manufacturing technology that attempts to increase the number of pixels per unit area by reducing the pixel size and interpixel distance. But as the pixel size and interpixel distance decreases, the image quality is degraded due to decrease
in amount of light available and aggregation of shot noise [1]. Moreover the cost for high-precision optics and sensors may not be affordable for general-purpose applications. Thus there is room to improve the resolution of the captured image using software approach.

A resolution enhancement approach using signal processing technique has been a great concern in many areas, and it is called super resolution (SR) (or HR) image reconstruction or simply resolution enhancement [1,2,3]. The process of super resolution includes psampling the image, thereby increasing the pixel density, and processing one or more low-resolution images assist in enriching the information. Methods for digital image resolution enhancement have been the subject of research over the past decade. Today, super resolution image reconstruction is one of the most spotlighted research areas, because it can overcome the inherent resolution limitation of the imaging system and improve the performance of digital image processing applications. The research is confined at improving the spatial resolution of an image and avoiding drawbacks of existing techniques that are currently in use.

2. PRESENT SCENARIO
The smoothing and interpolation are the well-known software approaches for enhancing the visual quality of the still image. Smoothing is usually achieved by applying various spatial filters. The filtering of an image results in adding low frequency components and loosing the focus from high frequency components. Human eye is more sensitive to low frequency components than high frequency components. The results of the filtering apparently show enhancement in the visual quality of the image, but at the cost of loss of information.

Interpolation is a technique used for increasing the number of pixels in a digital image. The high resolution image is obtained by estimating the pixels in between original data based on continuous function constructed by the process of interpolation.

Usually all image editing softwares support one or more methods of interpolation. Commonly used interpolation methods are nearest neighbor, bilinear, and bicubic interpolation [4,5,6]. Nearest neighbor interpolation makes the pixels bigger. The value of a new pixel in the image is the value of the nearest pixel of the original image [7]. It is not suitable to super resolve the images because it increases the width of edges unnecessarily. In Bilinear interpolation value of a new pixel is calculated based on a weighted average of the 4 pixels in the nearest 2 x 2 neighborhood of the pixel in the original image [7]. The averaging produces relatively smooth edges than nearest neighbor interpolation. In Bicubic interpolation, the value of a new pixel is calculated based on a weighted average of the 16 pixels in the nearest 4 x 4 neighborhood of the pixel in the original image [7]. It produces smoother edges than bilinear interpolation. Interpolation methods usually give better performance than simple smoothing methods.

Researchers have claimed that these methods suffer from several types of the most noticeable visual degradations, and the zigzagging artifact [4,7,8]. Hence, currently used interpolation and smoothing techniques are inadequate to reconstruct high resolution image from low resolution image. So the recent research trend is confined to reconstruct high resolution image from low resolution image(s).Literature survey reveals that there are different techniques proposed to reconstruct the super resolution image such as reconstruction based, learning based and wavelet based by the researchers [1-25]. Each of these techniques has few limitations. And hence yet none of the technique has been fully developed so as to suit super resolution imaging.

3. NEED OF SUPER RESOLUTION IMAGES

The super resolution means the quality of the image to the extent of the maximum capability of the technology referring it. The image capturing devices have their hardware limitations to reach to the perfection. And the applications demand more and more details for accurate analysis; therefore there is a need to develop a technique for improving the resolution. Super resolution image reconstruction can overcome the inherent resolution limitation of the imaging system and provide a high resolution image to improve the performance of image processing applications. Offering the high resolution image in medical imaging adds precision to the diagnosis process and that may be decisive. Consequently there is need to develop the novel technique that improves the resolution of image.

Today communication through web has become inseparable part of human lives. Many times pictorial information has to be accessed for study and analysis. The original image, if used for transmission takes more space, bandwidth and time. To save storage space, bandwidth and time for transmission, one solution is to transmit low resolution image by down-sampling it and then reconstructing the high resolution image at receivers end. Use of existing techniques to down-sample the image before transmission and reconstruction of high resolution image at receivers end suffers from loss of information. Thus there is need to develop a novel technique to reconstruct the high resolution image using single image that minimizes the loss. Recently desktop video conferencing has become popular in distant learning education programs. It is apparent that the quality of the frames is often poor due to limitations of low cost sensor devices, processing time of the frames and bandwidth available for transmission. Although quality of the frames is not important but good quality adds to effective interaction that is important for an impact of distant education programs. Therefore super resolution imaging is one of the solutions to improve the quality of picture frames with minimum response time.

Recently, the sensor networks are being used to collect secured information from remote sites. To collect the pictorial information, image capturing devices are part of these networks. Considering the low cost and low power consumption requirements, preference is given to low resolution image capturing devices. Low cost and low power devices have limitations over the resolution that in turn affects the quality of image. Thus there is need to develop a cost effective technique that offers an image comparable to high cost sensor network devices.

Super resolution images are expected to enhance the capability of detection and identification of details in the image, improve performance of pattern recognition algorithms, as well as the performance of automatic classification algorithms in computerized systems. Super resolution imaging has wide set of applications such as face recognition, Iris recognition, Network aware applications, video conferencing, High Definition Television (HDTV), reproduction of photographs, biomedical Imaging, telemedicine, medical imaging, military, space research, and satellite imaging among many others. The super resolution image is in demand for various applications. The objective of research work is to develop the novel algorithm to reconstruct the super resolution image which overcomes the limitations of current techniques in use and satisfies the need for different applications as discussed.

4. THE WAVELET BASED SR TECHNIQUE

A technique for reconstruction of super resolution image reconstruction using low resolution natural color image has been developed. The core aim of this research is to improve the spatial resolution of still image without losing high frequency components and avoiding smoothing of an image so as to preserve originality of an image.

The existing interpolation techniques are based on the assumptions that there exists interpixel redundancy and interpixel correlation in all directions. These assumptions are not fully true and hence results of interpolation show loss in high frequency information and introduces blurring effect. However, most of the natural images have correlation among neighboring pixels but in specific direction. Super resolution technique has been developed by exploiting well these local features inherent in natural images. Difficulty in identifying these regularities has been resolved by wavelet transform.

It is possible to avoid the smoothing of an image and removal of high frequency components using the wavelet transform. The wavelet transform helps to find the directional correlation among pixels within image. Since natural image has directional correlation it is possible to add the detail information by using the prediction technique and to reconstruct high resolution image from single low resolution image. For the correct prediction, the wavelet transform is used to decompose the image and the new value of the pixel is predicted according to the nature of the image.

Major class of super resolution methods utilizes frequency domain formulation of super resolution problem. The spatial domain image is transformed to frequency domain using Wavelet transform. The major wavelets are Daubechies Wavelet, Coiflets Wavelet and Biorthogonal Wavelet. Peak Signal to noise ratio, the objective measure is proposed by most of the researchers to measure quality of super resolution image. For the computations two images are needed: the reference high resolution image and the reconstructed image. In super resolution imaging, the original high resolution image reference does not exist. Hence new framework for quality performance measure for super resolution imaging is developed.

The final algorithm of reconstructing super resolution image using low resolution natural color image is implemented. Implementation includes conversion from RGB to YCrCb color subspaces, decomposition of each color subspace using bior2.2, processing each subimage independently to yield super resolved subimages based on its nature, reconstructing super resolved Y, Cr and Cb using them and conversion of YCrCb to RGB color subspace. Algorithm is tested over the set of natural and synthetic images and concluding remarks based on results are presented.

5. RESULTS

Sample results are given herewith in table 1 and 2. Figure 1 and 2 display the reconstructed images. Images are captured with camera with varying resolutions. The low resolution (LR) image is used as input image and higher resolution image is used as original HR reference. Table shows the resolutions of both input LR image and HR reference, PSNR for interpolation methods and for wavelet based SR techniques developed.

The results show that the technique have overcome the problems of blur and checker board effect; the edges are well preserved and the originality of images is preserved well. PSNR is used as quality measure. It is noticed that the higher PSNR is observed for the developed technique than the existing methods.

Table1. Results of selected images

Sl No	Image	Original HR Size	LR Image Size	PSNR in dB for Reconstructed HR Image			
				Nearest Neighbor	Bicubic	Bilinear	Wavelet based SR
1.	Budhha	864 x 1152	432 x 576	79.92	83.43	83.54	88.75
2.	Pink Rose	960 x 1280	480 x 640	92.98	97.40	97.50	97.58
3.	Boat Image	960 x 1280	480 x 640	81.34	81.05	81.59	81.87
4.	Birds Image	768 x 1024	384 x 512	81.74	84.52	84.00	86.35
5.	Church	960 x 1280	480 x 640	84.61	90.98	91.20	93.37
6.	Flower_ Butterfly	864 x 1152	432 x 576	90.25	94.25	94.34	95.51
7.	River Bridge	960 x 1280	480 x 640	76.56	82.82	82.92	85.16
8.	Twin tower	864 x 1152	432 x 576	72.14	76.30	76.33	76.83
9.	Tulips	978 x 1472	489 x 566	81.68	84.85	85.16	85.39
10.	Show Piece	864 x 1152	432 x 576	74.19	78.47	78.34	78.67

LR Image

Resolution = 480 x 640

Nearest Neighbor

PSNR=76.569 dB

Bilinear

PSNR=82.9293 dB

HR Image

Resolution = 960 x 1280

Bicubic

PSNR=82.8228 dB

Wavelet Based SR

PSNR=85.1649 dB

Figure 1. The River_Bridge Image Results

IMAGE

HR IMAGE

Resolution = 432 x 576

Resolution = 864 x 1152

Nearest Neighbor

Bicubic

PSNR=90.2576 dB

PSNR=94.1592 dB

Bilinear

Wavelet Based SR

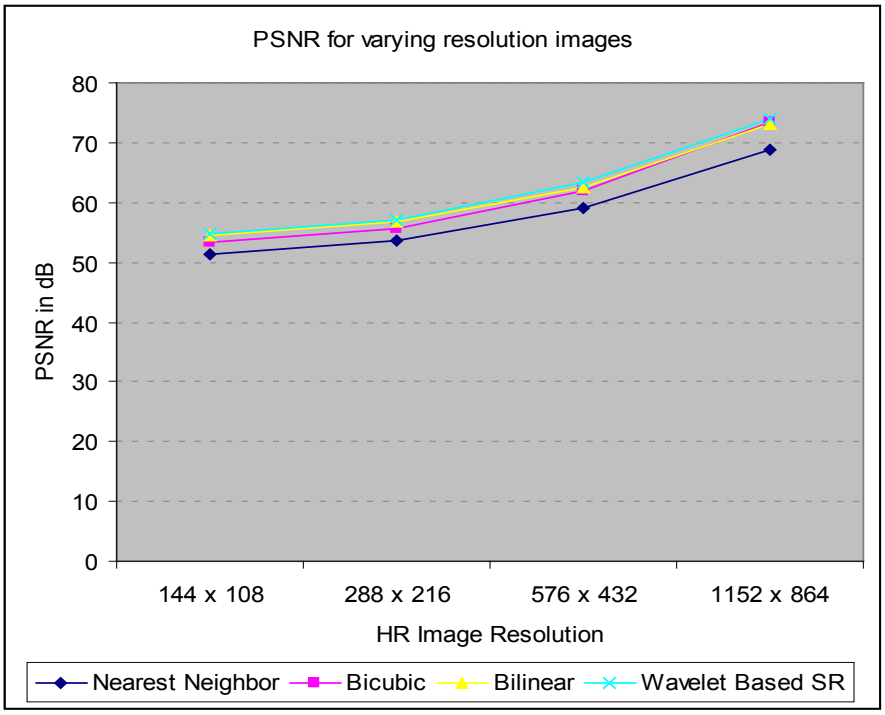
PSNR=94.347 dB

PSNR=95.5181 dB

Figure 2. The Flowers_Butterfly Image Results

Table 2. Results for Tigers Image with Varying Resolutions

Tigers Image					
LR Resolution	HR Resolution	PSNR (dB)			
		Nearest Neighbor	Bicubic	Bilinear	Wavelet SR
72 x 54	144 x 108	51.37	53.42	54.43	54.75
144 x 108	288 x 216	53.68	55.71	56.73	57.07
288 x 216	576 x 432	59.07	61.86	62.55	63.48
576 x 432	1152 x 864	68.79	73.30	73.20	73.89



6. CONCLUSION

A technique for Reconstruction of super resolution image using low resolution natural color image has been developed. The presented technique identifies local features of low resolution image and then enhances its resolution appropriately. Hence the problem of blurring that exists in interpolation techniques has been overcome. The technique has been tested against both set of synthetic images and natural color images of varying resolutions and varying frequency contents. The results show that the technique have overcome the problems of blur and checker board effect; the edges are well preserved and the originality of images is preserved well. PSNR is used as quality measure. It is noticed that the higher PSNR is observed for
the developed technique than the existing methods.

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